

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

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## 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

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Signature

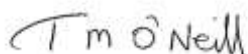
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Date .....17 May 2011.....

# CONTENTS

<b>GROWER SUMMARY .....</b>	<b>1</b>
Headline.....	1
Background and expected deliverables.....	1
Summary of the project.....	1
Financial benefits .....	9
Action points for growers.....	9
<b>SCIENCE SECTION .....</b>	<b>10</b>
Introduction .....	10
Materials and methods.....	11
Bare root potted experiment .....	11
Module root potted experiment.....	14
Results.....	16
Discussion .....	26
Conclusions .....	26
Technology transfer .....	27
References .....	28
Appendix 1: Experimental layouts .....	29
Appendix 2: Trial diaries.....	31

# **GROWER SUMMARY**

## **Headline**

- A number of residual herbicides (the most promising being Dual Gold and Springbok) were assessed for crop safety when applied to newly potted and established container grown herbaceous perennials.
- A number of currently used herbicides including Ronstar 2G, Flexidor 125, Devrinol and Venzar Flowable were assessed for crop safety over a wider range of newly potted and established container grown herbaceous perennials.

## **Background and expected deliverables**

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

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

The HDC project HNS 139 (Control of problem weeds in hardy nursery stock) identified herbicides, new to the UK, which appeared 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 was required specifically on herbaceous perennial and grass crops.

This project has evaluated several new herbicides for safety for use on a wide range of container-grown herbaceous subjects as well as extending the range of species specific phytotoxicity information for currently used herbicides

## **Summary of the project**

In 2008, an experiment was undertaken to investigate the phytotoxicity of six herbicide treatments on a range of container-grown herbaceous species in a commercial nursery situation. A further summer experiment examined treatments

applied immediately after potting. Full results were presented in the 2009 annual report.

In 2009, two further experiments were undertaken, similar to those conducted in 2008, on a different range of herbaceous species. One experiment was set up at Howard Nurseries using newly potted 9 cm plants, the other at Hawkesmill Nurseries using established 2 or 3 litre container plants. Full results were presented in the 2010 annual report.

In 2010, the final year of the trial, experiments were carried out on a further group of herbaceous species at Hawkesmill Nurseries with module potted and bare-root potted plants in early spring and summer of 2010. Full results are detailed in the Science Section of the full version of this report. The herbicides used during this project are summarised in Table 1.

**Table 1.** Herbicides used in herbaceous plant nursery experiments with rates of use and approval status on outdoor ornamentals as of May 2011

<b>Product</b>	<b>Active ingredient</b>	<b>Rate of use</b>	<b>Approval status</b>
Ronstar 2G	oxadiazon (2 % w/w)	200 kg/ha	Label
Teridox <sup>1</sup>	dimethachlor (500 g/L)	3.0 L/ha	Not in UK
Lenacil 80W <sup>2</sup> or Venzar Flowable	lenacil (80 % w/w) lenacil (440 g/L)	2.8 kg/ha 4.0 L/ha	Not approved LTAEU <sup>4</sup>
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	LTAEU <sup>4</sup>
Devrinol <sup>3</sup>	napropamide (450 g/L)	9.0 L/ha	Label
Dual Gold	s – metolachlor (960 g/L)	0.7 -1.4 L/ha	Not approved <sup>5</sup>
New Code A <sup>1</sup>	not disclosed	2.8 kg/ha	Not in UK

<sup>1</sup>These herbicides were not included in the final year of the project as their future availability was uncertain. <sup>2</sup>Lenacil 80W was no longer available and replaced with Venzar Flowable in the final year of the project. <sup>3</sup>Devrinol was only used in one set of trials due to doubts about future availability. <sup>4</sup>LTAEU indicates that the product can be used off-label at grower's own

risk under the Revised Long Term Arrangements for Extension of Use. <sup>5</sup>HDC is in the process of submitting an Extension of Authorisation for minor use (EAMU) (previously called a SOLA).

## Susceptibility to herbicide damage

Plant susceptibility to herbicides is displayed in Table 2 using a categorisation system based on all three years of phytotoxicity testing. A green colour (tolerant) indicates a treatment was found to be safe, although a slight check may be possible. An orange colour (moderately susceptible) indicates that a more severe check or stunting occurred, although recovery normally occurs by the end of the growing season. A red colour (susceptible) indicates that this species should not be treated. A blank cell indicates that the treatment combination was not trialled and phytotoxicity information is not known.

'Size Category' provides information on the stage at which the treatment was first applied: 1 = newly potted module into 9 cm pot; 2 = newly potted module into 2 – 3 L pot; 3 = 9 cm liner newly potted into 1 – 3 L pot; 4 = Bare root newly potted into 2 – 3 L pot; 5 = Established 1 – 3 L pot;

**Table 2.** Herbicide tolerance of herbaceous perennials and grasses: summary of three years' experiments

Plant species	Size category	Devrinol	Dual Gold	Flexidor 125	Flexidor 125 + Dual Gold	Lenacil 80 W or Venzar Flow	Ronstar 2G	Springbok
<i>Acanthus spinosus</i>	5							
<i>Achillea</i> 'Moonshine'	2							
<i>Achillea</i> 'Salmon Beauty' ('Lachsshönheit')	1							
<i>Agapanthus</i> 'Headbourne Hybrids'	5							
<i>Agapanthus</i> 'Headbourne Hybrids'	4							
<i>Ajuga reptans</i> 'Catlin's Giant'	5							
<i>Ajuga reptans</i> 'Sugar Plum'	2							
<i>Alstroemeria lutea</i>	3							
<i>Anthemis tinctoria</i> 'Charme'	2							

Plant species	Size category	Devrinol	Dual Gold	Flexidor 125	Flexidor 125 + Dual Gold	Lenacil 80 W or Venzar Flow	Ronstar 2G	Springbok
<i>Artemesia absinthium</i> 'Lambrook Mist'	1							
<i>Artemesia</i> 'Powis Castle'	2							
<i>Aster x fricartii</i> 'Monch'	2							
<i>Astilbe x arendsii</i> 'Fanal'	4							
<i>Astilbe x arendsii</i> 'White Gloria' ('Weisse Gloria')	4							
<i>Athyrium</i> 'Ghost'	5							
<i>Bergenia</i> 'Baby Doll'	3							
<i>Bergenia</i> 'Bressingham Ruby'	2							
<i>Bergenia</i> 'Eroica'	5							
<i>Brunnera macrophylla</i>	1							
<i>Brunnera macrophylla</i>	5							
<i>Campanula glomerata</i> 'Superba'	1							
<i>Campanula lactiflora</i> 'White Pouffe'	2							
<i>Centaurea montana</i> 'Parham'	1							
<i>Centranthus ruber</i> 'Albus'	1							
<i>Coreopsis verticillata</i> 'Moonbeam'	2							
<i>Coreopsis</i> 'Rum Punch'	5							
<i>Coreopsis verticillata</i> 'Zagreb'	1							
<i>Crambe cordifolia</i>	1							
<i>Crocsmia x crocosmiiflora</i> 'Babylon'	4							
<i>Crocsmia x crocosmiiflora</i> 'James Coey'	1							
<i>Crocsmia</i> 'Kathleen'	1							
<i>Crocsmia</i> 'Lucifer'	4							
<i>Crocsmia masoniorum</i>	5							
<i>Dahlia</i> 'Rosalind'	4							
<i>Delphinium</i> 'Galahad'	4							
<i>Delphinium</i> 'Guinevere'	4							
<i>Dicentra</i> 'Spring Morning'	1							
<i>Dryopteris affinis</i> 'Crispa Congesta'	5							
<i>Dryopteris affinis</i> 'Crispa Congesta'	2							
<i>Dryopteris goldinia</i>	3							



Plant species	Size category	Devrinol	Dual Gold	Flexidor 125	Flexidor 125 + Dual Gold	Lenacil 80 W or Venzar Flow	Ronstar 2G	Springbok
<i>Echinacea purpurea</i> 'Bressingham Hybrid'	4							
<i>Erysium</i> 'Bowles Mauve'	2							
<i>Fragaria x ananassa</i> 'Pink Panda'	1							
<i>Gaura lindheimeri</i>	2							
<i>Geranium x cantabrigiense</i> 'Biokovo'	4							
<i>Geranium</i> 'Brookside'	5							
<i>Geranium</i> 'Rozanne'	4							
<i>Geranium nodosum</i>	3							
<i>Geranium sanguinuen var. striatum</i>	1							
<i>Hakonechola macra</i> 'Aureola'	5							
<i>Helenium</i> 'Bruno'	1							
<i>Helenium</i> 'Moerheim Beauty'	2							
<i>Helleborus orientalis</i> (pink/white)	5							
<i>Hemerocallis</i> 'Catherine Woodbery'	5							
<i>Hemerocallis</i> 'Stafford'	3							
<i>Hemerocallis</i> 'Stella d'Or'	1							
<i>Hemerocallis</i> 'Stella d'Or'	4							
<i>Heuchera</i> 'Chocolate Ruffles'	5							
<i>Heucherella</i> 'Stoplight'	2							
<i>Hosta</i> 'Albomarginata'	3							
<i>Iris germanica</i> 'Jane Philips'	3							
<i>Iris pallidis</i> 'Aureo variegata'	4							
<i>Iris pseudoacorus</i>	4							
<i>Kniphofia</i> 'Tetbury Torch'	1							
<i>Lamium maculatum</i> 'Beacon Silver'	2							
<i>Leucanthemum x superbum</i> 'Agalia'	2							
<i>Leymus arenaria</i>	3							
<i>Lilium</i> 'Silver Gazer'	4							
<i>Liriope muscari</i> 'Blue'	5							
<i>Lobelia cardinalis</i> 'Queen Victoria'	3							
<i>Lobelia x speciosa</i> 'Russian Princess'	1							
<i>Lobelia x speciosa</i> 'Russian Princess'	5							

Plant species	Size category	Devrinol	Dual Gold	Flexidor 125	Flexidor 125 + Dual Gold	Lenacil 80 W or Venzar Flow	Ronstar 2G	Springbok
<i>Lupinus</i> 'Galaxy mixed'	3							
<i>Matteuccia struthiopteris</i>	5							
<i>Millium effusum</i> 'Aureum'	2							
<i>Monarda</i> 'Cambridge Scarlet'	2							
<i>Ophiopogon planiscapus</i> 'Nigrescens'	5							
<i>Papaver orientale</i> 'Pattys Plum'	4							
<i>Penstemon</i> 'Sour Grapes'	3							
<i>Peonia</i> 'Prima Verde'	3							
<i>Phlox paniculata</i> 'Purple Eye Flame'	5							
<i>Phlox paniculata</i> 'White Admiral'	4							
<i>Polypodium vulgare</i>	5							
<i>Polystichum setiferum</i> 'Herrenhausen'	5							
<i>Pulmonaria</i> 'Cotton Cool'	1							
<i>Pulmonaria saccharata</i> 'Dora Bielefeld'	4							
<i>Rhodohypoxis milloides</i>	4							
<i>Rudbeckia fulgida</i> var. <i>deamii</i>	1							
<i>Salvia nemerosa</i> 'East Friesland' ('Ostfriesland')	2							
<i>Schizostylis coccinea</i> 'Sunrise'	3							
<i>Sedum</i> 'Autumn Joy' ('Herbstfreude') ('Herbstfreude')	3							
<i>Sedum</i> 'Autumn Joy' ('Herbstfreude') ('Herbstfreude')	2							
<i>Sisyrinchium striatum</i>	1							
<i>Stachys byzantina</i> 'Silver Carpet'	1							
<i>Symphytum</i> 'Wisley Silver'	3							
<i>Teucrium hircanicum</i> 'Purple Tails'	5							
<i>Tradescantia</i> 'Bilberry Ice'	4							
<i>Tradescantia</i> 'Zwanenburg Blue'	1							
<i>Verbena bonariensis</i>	1							
<i>Verbena rigida</i>	5							
<i>Veronica spicata</i> 'Red Fox'	2							
<i>Zantedeschia aethiopica</i> 'Crowborough'	5							

## Key features of the herbicides tested

**Ronstar 2G** granules proved to be one of the safest treatments, as in previous herbaceous weed control projects. Most subjects tolerated treatment applied after potting. Ronstar 2G can cause temporary foliar scorch if granules are allowed to lodge in soft foliage. Normally, plants grow away from this satisfactorily. Ronstar 2G did however cause a more severe scorch to *Penstemon* and severely stunted two *Campanula* varieties, *Millium* and *Dryopteris*. In one trial a *Crocsmia* suffered yellowing following treatment but the effect was not seen subsequently in other varieties. *Sedums* were not damaged by Ronstar 2G applied in the summer in this project but a spring application caused temporary damage. Previous studies have shown that *Sedum* can be vulnerable to damage.

**Flexidor 125** proved safe on a range of species but with damage occurring to some. Generally damage took the form of stunting sometimes with leaf yellowing and twisting. For *Penstemon* and *Delphinium* developing flower spikes were killed out. In less severe cases (e.g. *Phlox*), slight leaf yellowing was only temporary and the plants grew away normally.

**Dual Gold** has just become available on the UK market and, if authorised for use (HDC is in the process of submitting an Extension of Authorisation for minor use - EAMU), will be a useful additional product for herbaceous producers being suitable for a number of subjects that are normally susceptible to herbicides. It has proved to be relatively safe. Only a few subjects such as *Campanula*, *Echinacea*, *Monarda*, *Rudbeckia*, *Stachys* and *Tradescantia* were damaged. Where damage occurred it took the form of stunting (e.g. *Echinacea*) with leaf twisting and in some cases (e.g. *Phlox* and *Delphinium*) bleaching. In most case plants did recover.

Although Dual Gold could be used on its own, there are gaps in the weed control spectrum (e.g. bittercress). Results from HNS 139 showed that it does give good control of willowherb and grasses and some control of groundsel so it could be a useful supplement to Flexidor 125 which gives poor control of these weeds. The safety of this tank mix was compared with the products applied separately. Generally the tank mix was safe but in cases where there was marginal susceptibility to

Flexidor 125, the addition of Dual Gold increased susceptibility. For example *Anthemis* and *Salvia* were stunted by the tank mix, whereas when the herbicides had been applied individually they had proven to be relatively safe.

**Springbok** appeared safe on a limited range of subjects but some (e.g. *Campanula* and *Tradescantia*) suffered severe stunting or leaf distortion and, for *Bergenia*, veinal yellowing. Unfortunately recently applied label restrictions for metazachlor, one of the components of Springbok, limiting application on the same site to one year in three, will make the use of this herbicide impractical in most nursery situations.

Other herbicides **Devrinol** and **Venzar Flowable** have a place in nursery production but mainly for winter use either due to label restrictions (Devrinol) or crop safety issues, particularly on newly potted plants (Venzar Flowable).

This project has focused on crop safety rather than weed control, as the HDC project HNS 139 (Control of problem weeds in hardy nursery stock) provided information about efficacy of most of these herbicides against common weeds of nursery stock. For completeness, results from HNS 139 are summarised below (Table 3).

**Table 3.** Herbicide efficacy against some common nursery stock weeds (results from HNS 139)

Weed	Dual Gold	Flexidor 125	Ronstar 2G	Springbok
Bittercress	R	S	S	mS
Groundsel	mS	mR	S	mS
Mouse ear	mS	S	R	-
Pearlwort	S	S	R	S
Willowherb	S	R	S	S

R = resistant, mS = moderately susceptible and S = susceptible

## **Financial benefits**

The benefits from extending the range of crops to which Ronstar 2G and Flexidor 125 can be applied over can be estimated to save around £2,500/ha in hand-weeding costs for those crops, less the cost of the herbicide around £55/ha for Flexidor 125, £82/ha for Venzar Flowable and £1,182/ha for Ronstar 2G. The use of Dual Gold will similarly enable a further range of crops to be treated. For Dual Gold used at 1.4 L/ha the cost is relatively low at £28/ha.

## **Action points for growers**

- The crop safety matrix presented in this Grower Summary should be used alongside the information contained in the HDC Practical weed control for nursery stock handbook when planning herbicide programmes for herbaceous crops.
- If a EAMU is successfully obtained for its use in outdoor ornamental production, undertake test applications of Dual Gold if improved control of groundsel, grasses and willowherb is required.

## **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 evaluates new and current herbicides for crop safety on a wide range of container-grown herbaceous subjects to extend the range of crop species phytotoxicity information.

## 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. A further two trials were carried out in 2009 similar to those conducted in 2008 but with a different range of herbaceous species. One using newly potted 9 cm plants, the other using established 2 or 3 litre plants. Results were reported in the 2010 annual report.

In 2010, two further experiments were set up, both at Hawkesmill Nurseries one using bare root potted plants and one using module root potted plants.

### ***Bare root potted experiment***

Twenty herbaceous species were used (Table 4). All plants were supplied from Hawkesmill Nurseries own stock. Plants were bare root potted on 20<sup>th</sup> June 2010 into 2 and 3 litre pots.

**Table 4.** Plant species used in bare root potted herbaceous plant experiments, 2010 Hawkesmill Nurseries

<i>Agapanthus</i> 'Headbourne Hybrids'	<i>Geranium</i> 'Rozanne'
<i>Astilbe x arendsii</i> 'Fanal'	<i>Hemerocalis</i> 'Stella de Oro'
<i>Astilbe x arendsii</i> 'White Gloria' ('Weisse Gloria')	<i>Iris pallida</i> 'Aureo Variagata' *
<i>Crocasmia x crocosmiiflora</i> 'Babylon' *	<i>Iris pseudacorus</i> *
<i>Crocasmia</i> 'Lucifer' *	<i>Lilium</i> 'Star Gazer' *
<i>Dalia</i> 'Rosalinde' *	<i>Papaver orientale</i> 'Patty's Plum'
<i>Delphinium</i> 'Galahad'	<i>Phlox paniculata</i> 'White Admiral'
<i>Delphinium</i> 'Guinevere'	<i>Pulmonaria saccharata</i> 'Dora Bielefeld'
<i>Echinacea purpurea</i> 'Bressingham Hybrid'	<i>Rhodyhypoxis milloides</i>
<i>Geranium x cantabrigiense</i> 'Biokovo'	<i>Tradescantia</i> 'Bilberry Ice'

All 2 litre plants except \* 3 litre.

### Potting Mix:

PH value 4.0 – 5.0, EC value 800-1200  $\mu\text{Sm}^{-3}$ . Peat composition: 30% Dark, 60% Light and 10% Sod all 18 mm. Nutrients added per  $\text{m}^3$ : 2 kg Nutricote (140 day 16-10-10), 2 kg Nutricote (100 day 16-10-10), 1.5 kg Base (15-10-20 TE), 1 kg Suscon Green, 200 L Forest Gold Plus, 0.25 kg Nitrochalk, 4.5 kg Lime/Dolodust and 0.4 L wetting agent.

### 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 woven plastic ground cover container beds over sand with overhead irrigation.

### Herbicide treatments

The herbicide treatments used are given in Table 5. Treatments were applied on 19<sup>th</sup> May 2010 as a single application. All treatments were applied in 1,000 L/ha water at 1.8 bar pressure using a  $\text{CO}_2$ -pressurised Oxford Precision Sprayer with a 1.5 m boom and F03-110 spray nozzles, except treatment 2, Ronstar 2G granules which were applied with a pepper pot shaker.

**Table 5.** Treatments used in the bare-root potted herbaceous plant nursery experiments

<b>Product name</b>	<b>Active ingredients</b>	<b>a.i. content</b>	<b>Rate</b>	<b>Approval status</b>
1. Untreated				
2. Ronstar 2G	oxadiazon	2% w/w	200.0 kg/ha	On label
3. Devrinol	napropamide	450 g/L	9.0 L/ha	On label
4. Flexidor 125	isoxaben	125 g /L	1.0 L/ha	On label
5. Springbok	metazachlor + dimethenamid-p	200 g/L + 200 g/L	2.5 L/ha	LTAEU
6. Dual Gold	s-metolachlor	960 g/L	1.4 L/ha	Not approved



LTAEU indicates that the product can be used off-label at grower's own risk under the Revised Long Term Arrangements for Extension of Use.

No other herbicides were applied to the experimental area during the experiment. Full details of the crop husbandry can be found in Appendix 4.

### Assessments

Observations for phytotoxicity symptoms were made on, 4<sup>th</sup> June, 29<sup>th</sup> June and 23<sup>rd</sup> July 2010. Where significant damage was noted the symptoms were assessed using a scoring system (Table 6).

**Table 6.** Quality scoring system used to assess herbicide damage to plant subjects

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

### 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.

### **Module root potted experiment**

Twenty herbaceous species were used (Table 7). All plants were supplied from Hawkesmill Nurseries own stock, supplied as module root potted plants in 2 and 3 litre pots, potted on 6<sup>th</sup> July 2010.

**Table 7.** Plant species used in the module-potted herbaceous plant experiments 2010 Hawkesmill Nurseries

<i>Achillea</i> 'Moonshine'	<i>Gaura lindheimii</i>
<i>Ajuga reptans</i> 'Sugar Plum'	<i>Helenium</i> 'Moerheim Beauty'
<i>Anthemis tinctoria</i> 'Charme'	<i>Huecherella</i> 'Stoplight'
<i>Artemisia</i> 'Powis Castle'	<i>Lamium maculatum</i> 'Beacon Silver'
<i>Aster frikartii</i> 'Mönch'	<i>Leucanthemum</i> 'Aglaia'
<i>Bergenia</i> 'Bressingham ruby'	<i>Millium effusum</i> 'Aureum'
<i>Campanula lactiflora</i> 'White Pouffe'	<i>Monarda</i> 'Cambridge Scarlet'
<i>Coreopsis verticillata</i> 'Moonbeam'	<i>Salvia nemerosa</i> 'East Friesland' ('Ostfriesland')
<i>Dryopteris crispera</i> 'Congesta' *	<i>Sedum</i> 'Autumn Joy' ('Herbstfreude')
<i>Erysimum</i> 'Bowles Mauve'	<i>Veronica spicata</i> 'Red Fox'

All 2 litre plants except \* 3 litre

#### Potting Mix:

PH value 4.0 – 5.0, EC value 800-1200  $\mu\text{Sm}^{-3}$ . Peat composition: 30% Dark, 60% Light and 10% Sod all 18 mm. Nutrients added per  $\text{m}^3$ : 2 kg Nutricote (140 day 16-10-10), 2 kg Nutricote (100 day 16-10-10), 1.5 kg Base (15-10-20 TE), 1 kg Suscon Green, 200 L Forest Gold Plus, 0.25 kg Nitrochalk, 4.5 kg Lime/Dolodust and 0.4 L wetting agent.

#### 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 woven plastic

ground cover over sand, container beds with overhead irrigation. This trial had to be moved in autumn 2010 due to building works on site.

### Herbicide treatments

The herbicide treatments used are given in Table 8. Treatments were applied on 19<sup>th</sup> July 2010 and 2<sup>nd</sup> February 2011. All treatments were applied in 1,000 L/ha water at 1.8 bar pressure using a CO<sub>2</sub>-pressurised Oxford Precision Sprayer with a 1.5 m boom and F03-110 spray nozzles, except treatment 2, Ronstar 2G granules which were applied with a pepper pot shaker.

**Table 8.** Treatments used in summer potted herbaceous plant nursery experiments

<b>Treatment</b>	<b>July application</b>		<b>January application</b>	
	<b>Chemical</b>	<b>Rate</b>	<b>Chemical</b>	<b>Rate</b>
1	Untreated control	-	Untreated control	-
2.	Ronstar 2G	200 kg/ha	Ronstar 2G	200 kg/ha
3	Dual Gold	1.4 L/ha	Venzar Flow	4.0 L/ha
4	Flexidor 125	1.0 L/ha	Flexidor 125 + Devrinol	1.0 L/ha 9.0 L/ha
5	Flexidor 125 + Dual Gold	1.0 L/ha 1.4 L/ha	Flexidor 125	1.0 L/ha
6	Flexidor 125 + Dual Gold	1.0 L/ha 0.7 L/ha	Flexidor 125 + Devrinol	1.0 L/ha 9.0 L/ha

<b>Product name</b>	<b>Active ingredients</b>	<b>a.i. content</b>	<b>Approval status</b>
Dual Gold	s-metolachlor	960 g / litre	Not approved
Flexidor 125	isoxaben	125 g / litre	On label
Ronstar 2G	oxadiazon	2% w/w	On label
Devrinol	napropamide	450 g/litre	On label
Venzar Flowable	lenacil	440 g/litre	LTAEU

LTAEU indicates that the product can be used off-label at grower's own risk under the Revised Long Term Arrangements for Extension of Use.

No other herbicides were applied to the experimental area during the experiment, full details of crop husbandry is detailed in Appendix 4.

### Assessments

Observations for phytotoxicity symptoms were made on, 6<sup>th</sup> August, 3<sup>rd</sup> September, 2<sup>nd</sup> October 2010 following the first treatment and 23<sup>rd</sup> March and 21<sup>st</sup> April 2011 following the second treatment. Where significant damage was noted the symptoms were assessed using a scoring system (Table 6).

### 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.

## **Results**

### Bare root potted trial

Table 9 shows susceptible varieties' average scores by assessment date. In the 2010 bare root potted trial there was relatively little damage from treatments applied. *Astilbe x arendsii* 'Fanal', *Agapanthus*, *Crocasmia*, *Geranium*, *Hemerocalis*, *Iris*, *Lilium*, and *Pulmonaria* were not affected by any treatment.



**Figure 1.** *Phlox* treated with Springbok showing distortion, growing away



**Figure 2.** *Tradescantia* treated with Springbok showing severe distortion

*Astilbe x arendsii* 'White Gloria' ('Weisse Gloria'), *Dahlia*, *Echinacea* and *Phlox* (Fig.1) were slightly distorted by Springbok, subsequently plants grew away normally. *Tradescantia* suffered more severe distortion (Fig. 2) and did not recover. Devrinol caused tip distortion to *Delphinium* (Fig.3), *Echinacea*, *Papaver* and *Phlox* and apart from *Echinacea* the plants were slow to recover. Ronstar 2G was very safe, only *Rhodohypoxis* suffered slight scorch and the plants recovered quickly. Flexidor 125 was safe to most species except for *Delphinium* (Fig. 4), *Papaver* and *Phlox* where it caused leaf yellowing, the *Phlox* recovered quickly. Dual Gold was also safe to most species except for *Echinacea*, *Phlox* and *Tradescantia* where it caused tip distortion. Apart from the *Tradescantia*, plants recovered by the end of July.



**Figure 3.** *Delphinium* treated with Devrinol showing distortion and bleaching



**Figure 4.** *Delphinium* treated with Flexidor 125 showing flower stem death

### Module root potted trial

In the 2010 module potted trial more damage occurred than in the bare root trial (Tables 10, 11) possibly because the plants were smaller with softer growth. Ronstar 2G was again the safest treatment with only *Dryopteris* and *Leucanthemum* (Fig.6) showing significant and lasting damage. In this case the Ronstar granules had lodged in the foliage. *Leucanthemum* was scorched and flowering was delayed.



**Figure 5.** Dual Gold temporary leaf hardening on *Campanula*



**Figure 6.** Ronstar 2G scorch to *Leucanthemum*

Dual Gold was safe to the majority of species but caused temporary damage to *Bergenia* (smaller), *Campanula* (leaf hardened) (Fig. 5), *Lamium* (tips damaged) and more lasting damage to *Monarda* (stunting) (Fig. 7). In the case of *Bergenia*, *Campanula* and *Lamium*, Dual Gold could still be considered an acceptable treatment as the plants recovered quickly.



**Figure 7.** Dual Gold stunting on *Monarda*



**Figure 8.** Flexidor 125 leaf yellowing on *Campanula*

Flexidor 125 was more damaging in this trial with the majority of species suffering at least a slight loss of vigour. Damage was greatest on *Campanula* and *Monarda* where the flower spikes were killed and on *Lamium*, *Leucanthemum* and *Veronica* where growing points were damaged. The *Campanula*, *Leucanthemum* and *Veronica* recovered by the end of the season. Flexidor 125 caused only temporary damage to *Artemisia*, *Anthemis*, *Erysimum*, *Salvia* and some other species mainly by leaf yellowing. *Achillea*, *Ajuga*, *Aster*, *Coreopsis*, *Dryopteris*, *Gaura*, *Heucherella*, *Millium*, and *Sedum* were all unaffected by Flexidor 125.

As might be expected the tank mixture of Dual Gold + Flexidor 125 was more damaging than the treatments applied separately with little difference between the high and low rates of Dual Gold used in the mix. Nevertheless, *Aster*, *Coreopsis*, *Dryopteris*, *Heucherella*, *Millium*, and *Sedum* were all unaffected by the treatment and *Ajuga*, *Artemesia*, *Bergenia* and *Gaura* recovered well from an initial check. *Anthemis*, *Erysimum* and *Salvia* (Fig. 9, 10) took longer to recover. For *Campanula*, *Helenium*, *Lamium*, *Leucanthemum*, *Monarda* and *Veronica* this treatment might not be acceptable because the initial check was too severe and plants did not recover sufficiently. Symptoms were similar to Flexidor 125 damage, yellowing and/or tip damage. Generally, any species showing some susceptibility to Flexidor 125 was more affected when Dual Gold was tank mixed with it.



**Figure 9.** *Salvia* treated with Flexidor 125 showing slight yellowing/purpling



**Figure 10.** *Salvia* treated with Flexidor 125 + Dual Gold showing more severe yellowing/purpling

A further herbicide application was made to the module potted trial in February. However by the 23 March 2011 assessment it was apparent that *Ajuga*, *Anthemis*, *Artemesia*, *Campanula*, *Dryopteris*, *Gaura*, *Heucherella* and *Leucanthemum* were all dead following the unusually cold winter so no further assessments were possible. *Millium* were also affected but sufficient plants remained for assessment. Of the remaining species *Achillea*, *Aster*, *Bergenia*, *Coreopsis*, *Erysium* and *Helenium* were unaffected by any of the February treatments. *Sedum* was checked by all herbicide treatments but recovered satisfactorily by the April assessment. *Lamium*, *Monarda* and *Veronica* however were unacceptably damaged by a further application of Flexidor 125 either alone or with Devrinol (Table 11). This is not surprising as all three had shown previous sensitivity to Flexidor 125. No species were particularly damaged by Ronstar 2G at this stage. Only *Monarda* and *Veronica* were slightly checked by Venzar Flowable applied in February but plants recovered. *Millium* was severely stunted by Flexidor 125 + Devrinol but not by Flexidor alone so it can be assumed that it is susceptible to Devrinol. Devrinol is known to have some post emergence effect on grasses so this result is not surprising.



**Table 9.** Plant quality score, (0 – 5 index) on herbaceous plant species bare root potted – Hawkesmill Nursery, 2010

		<i>Astilbe x arendsii</i> 'White Gloria'			<i>Dahlia</i> 'Rosalind'			<i>Delphinium</i> 'Galahad'			<i>Delphinium</i> 'Guinevere'		
Treatment		4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul
1	Untreated	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2	Ronstar 2G	5.00	5.00	5.00	4.67	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
3	Devrinol	5.00	5.00	5.00	4.33	4.67	5.00	3.00	2.67	3.00	3.33	3.00	3.33
4	Flexidor 125	5.00	5.00	5.00	4.67	5.00	5.00	4.00	4.00	4.00	4.67	5.00	5.00
5	Springbok	3.67	5.00	5.00	3.00	4.33	5.00	5.00	5.00	5.00	5.00	5.00	5.00
6	Dual Gold	5.00	5.00	5.00	4.33	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	<i>P</i> (ANOVA)	<0.001	*	*	0.048	0.119	*	0.026	0.018	0.026	<0.001	<0.001	<0.001
	df	10			10	10		10	10	10	10	10	10
	LSD (5%)	0.429			1.198	0.575		1.286	1.396	1.286	0.575	0.743	0.429

		<i>Echinacea purpurea</i> 'Bressingham Hybrid'			<i>Papaver</i> 'Patty's Plum'			<i>Phlox paniculata</i> 'White Admiral'			<i>Rhydohypoxis milloides</i>		
Treatment		4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul	4 Jun	29 Jun	23 Jul
1	Untreated	5.00	5.00	4.33	5.00	5.00	5.00	5.00	5.00	4.33	5.00	5.00	5.00
2	Ronstar 2G	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00	4.00	4.33	4.33
3	Devrinol	2.00	3.00	5.00	2.33	3.00	3.33	2.67	3.00	5.00	5.00	5.00	5.00
4	Flexidor 125	4.67	4.67	5.00	2.00	2.33	2.33	3.00	4.00	5.00	5.00	5.00	5.00
5	Springbok	3.67	4.33	4.00	5.00	5.00	5.00	3.00	4.33	3.00	5.00	5.00	5.00
6	Dual Gold	3.33	3.67	4.67	5.00	5.00	5.00	3.00	4.00	4.00	5.00	5.00	5.00
	<i>P</i> (ANOVA)	<0.001	0.038	NS	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	*	0.030	0.030
	df	10	10		10	10	10	10	10	10		10	10
	LSD (5%)	0.718	1.315		0.429	0.791	0.542	0.429	0.429	0.429		0.429	0.429

**Table 10.** Plant quality score, (0 – 5 index) on herbaceous plant species module potted – Hawkesmill Nursery, 2010

Treatment	<i>Aster frikartii</i> 'Mönch'			<i>Artemesia</i> 'Powis Castle'			<i>Bergenia</i> 'Bressingham ruby'			<i>Campanula lactiflora</i> 'White Pouffe'		
	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct
1 Untreated	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2 Ronstar 2G	5.00	5.00	5.00	4.67	4.67	4.67	4.33	4.33	4.00	4.67	5.00	5.00
3 Dual Gold	5.00	5.00	5.00	4.33	5.00	5.00	3.67	4.00	4.30	3.00	4.33	5.00
4 Flexidor 125	5.00	5.00	5.00	2.67	4.00	4.33	4.33	4.33	5.00	2.00	3.00	5.00
5 Flexidor 125 + Dual Gold high	3.33	4.33	5.00	2.00	4.00	4.00	3.67	4.33	4.67	2.00	3.00	5.00
6 Flexidor 125 + Dual Gold low	4.00	4.67	5.00	2.00	3.67	4.33	3.33	4.00	3.67	2.00	2.67	5.00
<i>P</i> (ANOVA)	0.008	0.119	*	<0.001	0.098	0.353	0.003	0.055	0.606	<0.001	<0.001	*
df	10	10		10	10	10	10	10	10	10	10	
LSD (5%)	0.92	0.5753		1.033	1.135	1.135	1.356	1.546	1.984	0.428	0.879	

\*Absolute values, no variability

Treatment	<i>Dryopteris crisper</i> 'Congesta'			<i>Erysium</i> 'Bowles Mauve'			<i>Helenium</i> 'Moerheim Beauty'			<i>Lamium maculatum</i> 'Beacon Silver'		
	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct
1 Untreated	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2 Ronstar 2G	2.67	2.00	2.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
3 Dual Gold	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00	4.67	4.67
4 Flexidor 125	4.67	5.00	5.00	4.33	5.00	5.00	4.00	4.33	5.00	2.00	2.33	3.35
5 Flexidor 125 + Dual Gold high	4.67	4.67	4.67	2.67	4.00	4.67	3.67	4.33	5.00	2.00	2.33	4.33
6 Flexidor 125 + Dual Gold low	4.33	4.67	5.00	2.00	4.00	5.00	3.00	3.00	5.00	2.00	2.33	3.00
<i>P</i> (ANOVA)	0.008	<0.001	<0.001	<0.001	*	0.465	0.01	0.036	*	*	<0.001	0.085
df	10	10	10	10		10	10	10			10	10
LSD (5%)	1.135	0.636	0.4288	0.996		0.4288	1.135	1.272			0.636	1.65

\*Absolute values, no variability

Treatment	<i>Leucanthemum</i> 'Agliaia'			<i>Millium effusum</i> 'Aureum'			<i>Monarda</i> 'Cambridge Scarlet'			<i>Veronica spicata</i> 'Red Fox'		
	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct	6 Aug	3 Sept	2 Oct
1 Untreated	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2 Ronstar 2G	2.67	3.33	3.67	5.00	5.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00
3 Dual Gold	4.67	4.67	4.00	4.33	4.33	5.00	2.00	3.33	3.00	5.00	5.00	5.00
4 Flexidor 125	3.33	3.67	4.33	5.00	5.00	5.00	2.00	2.33	2.30	2.00	3.67	4.33
5 Flexidor 125 + Dual Gold high	2.67	3.00	3.33	5.00	5.00	5.00	2.00	2.00	2.00	2.00	2.33	5.00
6 Flexidor 125 + Dual Gold low	2.33	3.00	3.33	5.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00	3.67
<i>P</i> (ANOVA)	<0.001	<0.001	<0.001	0.03	0.03	*	*	<0.001	<0.001	<0.001	<0.001	0.119
df	10	10	10	10	10			10	10	10	10	10
LSD (5%)	1.033	0.542	0.542	0.429	0.429			0.542	0.542	0.743	0.575	1.151

\*Absolute values, no variability

**Table 11.** Plant quality score, (0 – 5 index) on herbaceous plant species module root potted after second herbicide application February 2011 – Hawkesmill Nursery, 2010 potted

Treatment Jul	Treatment Jan	<i>Lamium maculatum</i> <i>'Beacon Silver'</i>		<i>Millium effusum</i> <i>'Aureum'</i>		<i>Monarda</i> <i>'Cambridge Scarlet'</i>	
		23 March	21 April	23 March	21 April	23 March	21 April
1 Untreated		5.00	5.00	5.00	5.00	5.00	5.00
2 Ronstar 2G	Ronstar 2G	4.33	5.00	3.50	3.50	4.00	5.00
3 Dual Gold	Venzar Flow	4.33	5.00	2.67	4.00	3.67	5.00
4 Flexidor 125	Flexidor 125 + Devrinol	3.67	5.00	2.00	2.00	2.67	3.33
5 Flexidor 125 + Dual Gold high	Flexidor 125	2.67	5.00	3.50	3.50	2.00	3.00
6 Flexidor 125 + Dual Gold low	Flexidor 125 + Devrinol	3.33	5.00	2.50	2.00	2.00	3.33
<i>P</i> (ANOVA)		0.003	*	0.237	0.220	<0.001	0.152
df		10		10	10	10	10
LSD (5%)		0.92		2.571	3.767	0.791	2.144

Treatment Jul	Treatment Jan	<i>Salvia nemerosa</i> <i>'East Friesland'</i> <i>('Ostfriesland')</i>		<i>Sedum</i> <i>'Autumn Joy'</i> <i>('Herbstfreude')</i>		<i>Veronica spicata</i> <i>'Red Fox'</i>	
		23 March	21 April	23 March	21 April	23 March	21 April
1 Untreated		5.00	5.00	5.00	5.00	5.00	5.00
2 Ronstar 2G	Ronstar 2G	3.67	5.00	3.00	5.00	4.67	5.00
3 Dual Gold	Venzar Flow	5.00	5.00	3.00	5.00	3.67	5.00
4 Flexidor 125	Flexidor 125 + Devrinol	4.67	5.00	2.67	5.00	3.33	5.00
5 Flexidor 125 + Dual Gold high	Flexidor 125	3.33	5.00	3.00	5.00	3.67	5.00
6 Flexidor 125 + Dual Gold low	Flexidor 125 + Devrinol	4.33	5.00	2.67	5.00	3.00	5.00
<i>P</i> (ANOVA)		0.254	*	<0.001	*	0.122	*
df		10		10		10	
LSD (5%)		1.758		1.616		1.616	

## Discussion

Taking into account results from the three years of this project, the main new herbicide to emerge for herbaceous growers has been Dual Gold. Dual Gold has proved safe to a wide range of herbaceous subjects and has the advantage that it is relatively safe even when applied over foliage during the growing season. In addition it has been possible to increase the information in plant susceptibility lists for existing commonly used herbicides such as Ronstar 2G, Flexidor 125, Devrinol and Venzar Flowable. Plant susceptibility lists have been included in the Grower Summary section using a simple categorisation system based on the three years of testing and scoring phytotoxicity for each species.

## Conclusions

As in previous herbaceous weed control projects, Ronstar 2G granules proved to be one of the safest treatments. Most subjects tolerated treatment applied after potting. Ronstar 2G can cause temporary foliar scorch if granules are allowed to lodge in soft foliage. Normally, plants grow away from this satisfactorily. Ronstar 2G did however cause a more severe scorch to *Penstemon* and severely stunted two *Campanula* varieties, *Millium*, and *Dryopteris*. In one trial a *Crocasmia* suffered yellowing following treatment but the effect was not seen subsequently in other varieties. *Sedums* were not damaged by Ronstar 2G applied in the summer in this project but a spring application caused temporary damage. Previous studies have shown that *Sedum* can be vulnerable to damage.

Flexidor 125 proved safe on a range of species but with damage occurring to some. Generally damage took the form of stunting sometimes with leaf yellowing and twisting. For *Penstemon* and *Delphinium* developing flower spikes were killed out. In less severe cases (e.g. *Phlox*), slight leaf yellowing was only temporary and the plants grew away normally.

Dual Gold has just become available on the UK market and will be a useful additional product for herbaceous producers (once a EAMU for its use has been obtained) being suitable for a number of subjects that are normally susceptible to herbicides. It has proved to be relatively safe. Only a few species such as *Campanula*, *Echinacea*, *Monarda*, *Rudbeckia*, *Stachys* and *Tradescantia* were damaged. Where damage occurred it took the form of stunting (e.g. *Echinacea*) with leaf twisting and in some cases (e.g. *Phlox*, and *Delphinium*) bleaching. In most case plants did recover.

Although Dual Gold could be used on its own, the weed control spectrum complements that of Flexidor 125, so the safety of this tank mix was compared with the products applied separately. Generally the tank mix was safe but in cases where there was marginal susceptibility to Flexidor 125, the addition of Dual Gold increased susceptibility. For example *Anthemis* and *Salvia* were stunted by the tank mix whereas the herbicides applied individually had been relatively safe.

Springbok appeared safe on a limited range of subjects but some (e.g. *Campanula*, *Tradescantia*) suffered severe stunting or leaf distortion and, for *Bergenia*, veinal yellowing. Unfortunately recently applied label restrictions for metazachlor, one of the components of Springbok, limiting application to the same site to one year in three, will make the use of this herbicide impractical in a nursery situation.

Other herbicides Devrinol and Venzar Flowable have a place in nursery production but mainly for winter use either due to label restrictions (Devrinol) or crop safety issues particularly on newly potted plants (Venzar Flowable). Venzar in fact proved relatively safe when applied in June in one experiment although the plants used were well established and consequently may have been less vulnerable to damage. A treatment in February also proved safe to a range of species potted the previous summer. Devrinol was also used in one experiment on bare root plants potted in May. It proved safe to a range of species but *Delphinium* suffered stunting and distortion. *Millium* also appeared susceptible to damage.

This project has focused on crop safety rather than weed control, as project HNS 139 (Control of problem weeds in hardy nursery stock) has already provided information about efficacy of these herbicides against common weeds of nursery stock.

## **Technology transfer**

HDC News article March 2009

Presentation to HDC herbaceous perennial technical discussion group, February 2009

Growers' walk to view trials at Howards Nursery for the HDC herbaceous perennial technical discussion group, July 2009

Interim results included in three Weed Control in Nursery stock Workshops held in Kent (August 2009), Norfolk (August 2009) and Worcestershire (September 2009)

Interim results used in plant susceptibility tables in Practical Weed Control for Nursery Stock – an HDC growers' handbook, August 2010

Presentation to HDC herbaceous perennial technical discussion group, February 2011

HDC News article April 2011

## **References**

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

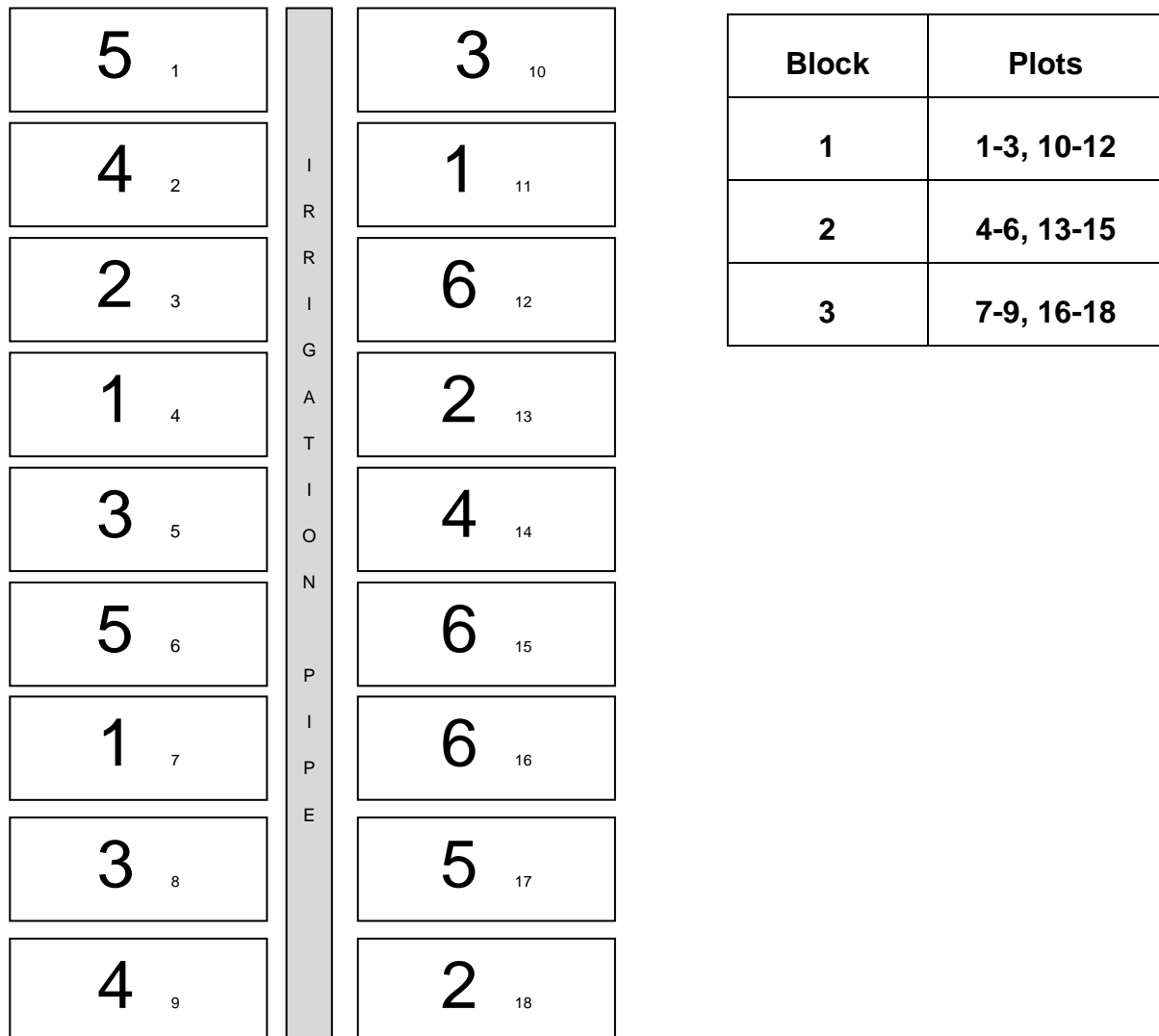
Atwood, J., (2007). HDC Handbook 'Practical weed control for nursery stock – An HDC growers' handbook

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



## Appendix 1: Experimental layouts

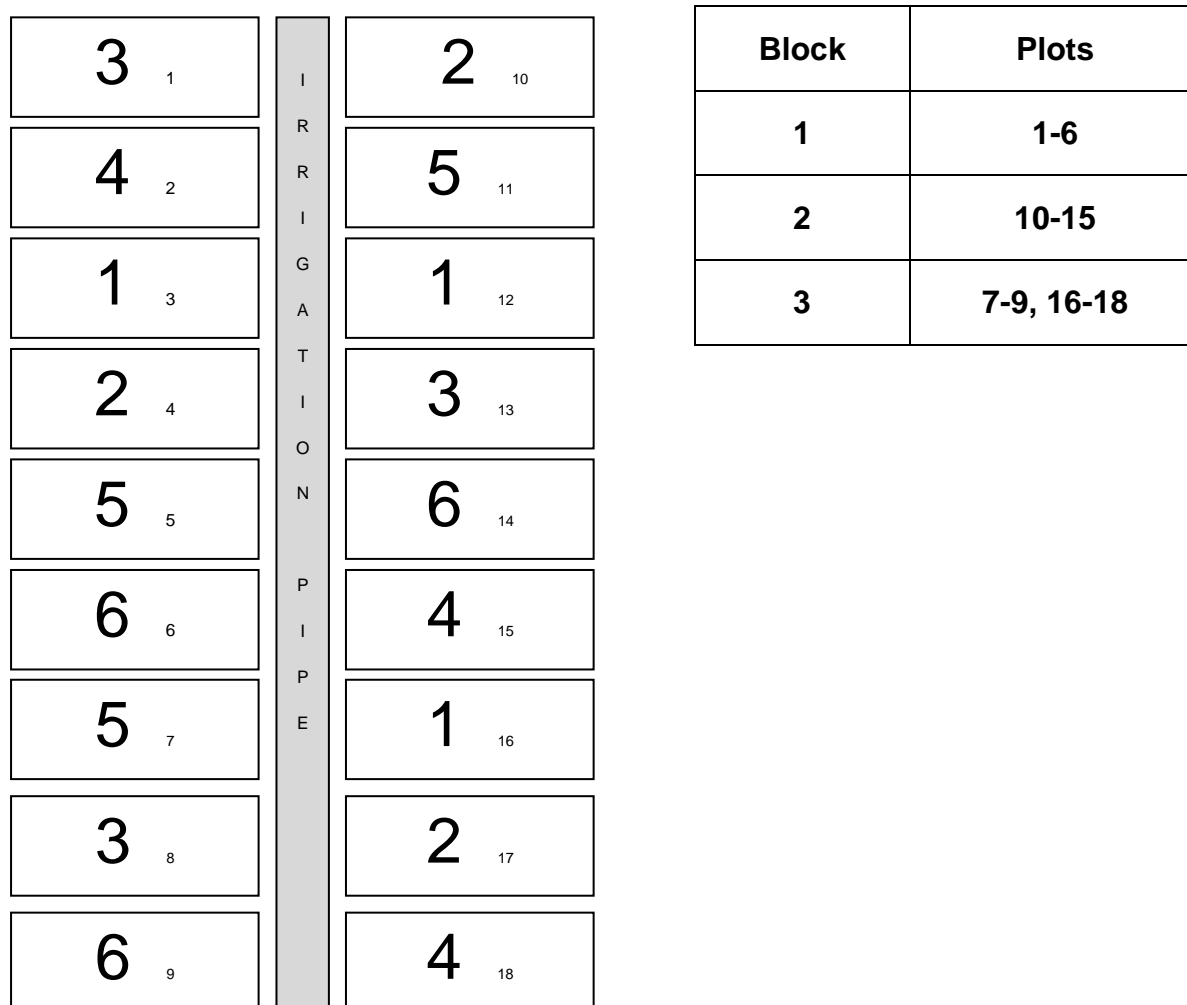
### Layout: Bare root potted trial - Hawkesmill nursery 2010



**Table 12.** Treatments bare root potted trial

Treatment	Chemical	Rate
1	Untreated control	-
2	Ronstar 2G	200.0 kg/ha
3	Devrinol	9.0 L/ha
4	Flexidor 125	1.0 L/ha
5	Springbok	2.5 L/ha
6	Dual Gold	1.4 L/ha

## Layout module root potted trial - Hawkesmill nursery 2010



**Table 13.** Treatments module root potted trial

Treatment	<i>July application</i>		<i>January application</i>	
	Chemical	Rate	Chemical	Rate
1	Untreated control	-	Untreated control	-
2	Ronstar 2G	200 kg/ha	Ronstar 2G	200 kg/ha
3	Dual Gold	1.4 L/ha	Venzar Flow	4.0 L/ha
4	Flexidor 125	1.0 L/ha	Flexidor 125 + Devrinol	1.0 L/ha 9.0 L/ha
5	Flexidor 125 + Dual Gold full rate	1.0 L/ha 1.4 L/ha	Flexidor 125	1.0 L/ha
6	Flexidor 125 + Dual Gold half rate	1.0 L/ha 0.7 L/ha	Flexidor 125 + Devrinol	1.0 L/ha 9.0 L/ha

## Appendix 2: Trial diaries

### *Bare root potted trial diary*

DATE	TRIAL DIARY ENTRY
07/05/10	Trial laid out
20/05/10	Herbicides applied. 10 mm of irrigation applied to water herbicides in
04/06/10	First score carried out
29/06/10	Second score carried out
23/07/10	Third and final score carried out

### *Module root potted diary*

DATE	TRIAL DIARY ENTRY
19/07/10	Laid out trial, too windy to apply herbicides
23/07/10	Applied herbicides. 10 mm of irrigation applied to wash in
06/08/10	First score carried out
03/09/10	Second score carried out. Heleniums cut back after scoring as no damage would be evident at next score. Plants were top heavy and were blowing over which may have resulted in desiccation had corrective action not been taken
02/20/10	Third score carried out. Sedum cut back
24/11/10	Cut back remaining plants and moved trial to Temple site due to building works. Weeded all plots. Anthemis removed from trial due to losses caused by root pathogens.
29/11/10	Standing down within plots completed
07/02/11	Weeded plots and stood down ready for herbicide application. Removed Ajuga from the trial due to winter damage. Winter damage suspected in Heucherella, Campanula, Leucanthemum. Some damage also noted on ferns and Salvia. Low winter temperatures have resulted in 20% losses in Erysimum
10/02/11	Applied spring herbicide top up. Foliage slightly damp at time of application. Ronstar 2G granules stuck to Monarda foliage and a few other species but was brushed off to minimise damage. Ronstar 2G was applied to the compost rather than over the plants where possible as this product would normally be applied on a dry day.