FINAL REPORT

Container HNS: Herbicides for shrubs and herbaceous perennials - for use in the growing crop

HNS 111
Year 1 - 2001 / 02
Year 2 – 2002 / 03

Project title:	Container HNS: Herbicides for shrubs and herbaceous perennials - for use in the growing crop.
Project number:	HNS 111
Project leaders:	C M Burgess, HRI Efford (responsible for Year 1 trials) J Atwood, ADAS (responsible for Year 2 nursery trials)
Report:	Final Report, August 2003
Previous reports:	Annual Report, August 2002
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Date project commenced: April 2001

Completion due: August 2003

Key words: Container nursery stock, chemical weed control, mulch, phytotoxicity

Principle worker

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Mr C Burgess	Research Leader	HRI Efford

Authentication

I declare that this work was undertaken either, directly by me, or under my personal supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

……. Mr J Atwood

Date……

Report authorised by: ……

David Lancaster
Managing Director – ADAS Horticulture

Date ……..

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Appendices

This final report covers the two season's results of a two-part project. The first part carried out at HRI Efford, the second part carried out on two commercial nurseries with hardy shrubs and herbaceous crops. Data should be applied with caution at this stage as crop safety information is still based on either one or two season's results depending on species. Most of the herbicide treatments are off-label permitted under the revised Long Term Arrangements for Use and are used entirely at grower's risk.

GROWER SUMMARY

Headline

- Helmsman (carbetamide + diflufenican + oxadiazon) shows potential for its use to be extended from amenity plantings to container nursery stock when used both during the growing season and in winter. It has a wide weed control spectrum and was safe over the 25 woody plant species tested. It is less safe, however, on herbaceous perennials.
- Ronstar liquid (oxadiazon) shows good potential for use as a winter contact/residual treatment on both deciduous and selected evergreen woody plant species. It was completely safe on 17 of the 20 species tested and only one species suffered long term damage. Both contact and residual control was good.
- Mulches suppressed weeds but were not as effective as the best herbicides. Biotop was the most practical material for commercial scale use.

Background and expected deliverables

Good weed control continues to be important for maintaining plant quality and achieving accreditation standards. Deficiencies in weed control programmes have to be resolved by expensive and inefficient hand weeding. Several new herbicides have become available on the amenity and agricultural market since the last HDC project, HNS 35f, on pre-emergence chemicals, and some non-chemical (mulch) alternatives need assessing. It is important to continue to assess new products to help combat weed species and extend the range of subjects screened.

This project aims to evaluate several new herbicides for efficacy and safety for use on a wide range of both container-grown woody and herbaceous subjects. Emphasis was placed on their use through the growing season to give an extended period of control. The new herbicides were tested against a range of problem weeds: American willowherb, mouse-eared chickweed, annual meadow grass, groundsel and hairy bittercress. In addition, three mulch products were tested to see if they are a cost-effective alternative to herbicides.

The main expected deliverable from the project would be an extension to weed control measures for woody and herbaceous nursery stock. These will be made available as updates to the HDC grower's handbook 'Practical weed control for nursery stock'.

Summary of the project and main conclusions

The first part of the project was undertaken at HRI Efford in two experiments:
Shrub - 9 herbicide + 3 mulch treatments were tested on 5 woody nursery stock subjects for crop safety. Efficacy against 5 weed species was tested using a parallel set of 'blank' containers sown with weed seeds just before or after applying herbicides at three timings. Seeds were also sown on top of the mulches.
Herbaceous - 8 herbicide treatments tested for crop safety on 16 subjects.
Herbicides were applied in mid June 2001, early October 2001 and late February 2002.

Herbicide treatments

Product name	Chemical name and a.i. conc.	Rate of product used	Woody	Herb.
Untreated	water		□	□
Debut	trisulfuron methyl 50% w/w	0.003 g / m^2	□	
Helmsman	oxadiazon + diflufenican + carbetamide 1:0.1:2% w/w	150 g / m^2	□	□
Katamaran	metazachlor + quinmerac 375:125 g/l	0.2 ml / m^2	□	□
Lexone 70DF	metribuzin 70% w/w	0.075 g / m^2	□	□
Monitor	sulfosulfuron 80% w/w	0.0025 g / m^2	□	
Stomp 400SC	pendimethalin 400 g/l	0.33 ml / m^2	□	
Titus	rimsulfuron 25% w/w	0.005 g / m^2	□	□
Ronstar 2G	oxadiazon 2% w/w	20 g / m^2	□	□
Flexidor 125	isoxaben 125 g/l	0.1 ml / m^2	*	□
Venzar Flowable	lenacil 440 g/l	0.3 ml / m^2		□

* Flexidor 125 replaced Ronstar 2G for the second (autumn) application to the shrub trial

Mulch treatments

Mulch	Contains	Depth / mm	Source / Supplier
Biotop	starch + *Miscanthus* fibres	5	East Riding Horticulture Ltd, York
Enviroguard	recycled paper	20	Tascon Inc., Houston, Texas USA
Terrastar	wheat straw + iron sulphate + lignosulphate	20	Strawproducts c.v., Tienen, Belgium

Weed species

Common name	Latin name
American willowherb (paraquat resistant clone)	*Epilobium ciliatum*
Hairy bittercress	*Cardamine hirsuta*
Groundsel (simazine resistant)	*Senecio vulgaris*
Mouse-ear chickweed	*Cerastium fontanum*
Annual meadow grass	*Poa annua*

Subjects tested for phytotoxicity

Woody subjects	Herbaceous perennial subjects
Buddleia davidii 'Harlequin'	*Anemone* 'Prince Henry'
Chamaecyparis lawsoniana 'Elwoodii'	*Aster* 'Wartburgstern'
Euonymus fortunei 'Sunshine'	*Astilbe chinensis pumila*
Philadelphus 'Virginal'	*Delphinium* 'Guinevere'
Viburnum tinus	*Geranium* 'Patricia'
	Hosta krossa 'Regal'
	Leucanthemum 'Esther Read'
	Lupinus 'Chandelier'
	Origanum vulgare 'Aureum'
	Papaver 'Matador'
	Penstemon 'Black Bird'
	Potentilla 'Ron Mc Beath'
	Primula 'Double Big Red Giant'
	Pulmonaria 'Roy Davidson'
	Stachys lanata
	Verbascum 'Helen Johnson'

The second part of the project was undertaken on two commercial nurseries:

Shrub – 8 herbicide + 1 mulch treatment were tested on 20 woody nursery stock subjects for crop safety.
Herbaceous – 5 herbicide treatments tested for crop safety on 25 subjects
Herbicides were applied on:
31May 2002, 10 September 2002, shrub trial growing season treatments
17 December 2002, shrub trial winter treatments
7 June 2002, 11 September 2003, herbaceous trial

Herbicide treatments

Product name	Chemical name and a.i. conc.	Rate of product used	Woody	Herb.
Untreated			□	□
Butisan S	Metazachlor 500 g/l	0.25 ml / m^2	□	
Helmsman	oxadiazon + diflufenican + carbetamide 1:0.1:2% w/w	150 g / m^2	□	
Katamaran	metazachlor + quinmerac 375:125 g/l	0.2 ml / m^2	□	□
Lexone 70DF	metribuzin 70% w/w	0.075 g / m^2	□	
Ronstar liquid	oxadiazon 250 g/l	0.4 ml / m^2	□	
Butisan S +Flexidor 125	metazachlor 500 g/l + isoxaben 125 g/l	0.25ml / m^2 0.2ml / m^2	□	
Titus	rimsulfuron 25% w/w	0.005 g / m^2		□
Ronstar 2G	oxadiazon 2% w/w	20 g / m^2	□	□
Flexidor 125	isoxaben 125 g/l	0.1 ml / m^2		□

Mulch treatment

Mulch	Contains	Depth / mm	Source / Supplier
Biotop	starch + *Miscanthus* fibres	5	East Riding Horticulture Ltd, York

Subjects tested for phytotoxicity

Woody subjects	Herbaceous perennial subjects
Buddleia davidii 'Pink Delight'	*Achillea* 'Terracotta'
Chamaecyparis lawsoniana 'Elwoodii'	*Aconitum* 'Sparks Variety'
Choisya tenata	*Anemone* 'Montrose'
Ceanothus 'Blue Mound'	*Aster* 'Purple Dome'
Clematis montana 'Rubens'	*Astilbe* 'Sprite'
Deutzia 'Mont Rose'	*Campanula* 'Blue Waterfall'
Erica darleyensis	*Crocosmia* 'Irish Flame'
Escallonia 'Golden Ellen'	*Delphinium* 'Blue Jay'
Euonymus fortunei "Emerald Gaiety'	*Digitalis grandiflora* 'Ambigua'
Forsythia spectablis 'Lynwood'	*Euphorbia amygdaldides* 'Rubra'
Hebe 'Red Edge'	*Geranium* 'Bressingham Delight'
Lavatera olbia 'Rosea'	*Geum borisii*
Lavender 'Hidcote'	*Hemerocallis* 'Frans Hals'
Lonicera 'Baggesons Gold'	*Hosta* 'Wide Brim'
Pontilla fruticosa 'Red Ace'	*Iris foetidissima*
Prunus rotundifolia	*Lupinus* 'Russell Hybrids'
Spiraea 'Gresham'	*Miscanthus sinensis* 'Sirene'
Viburnum tinus 'Eve Price'	*Monarda* 'Garden View Scarlet'
Vinca Minor 'Atropurpurea'	*Oreganum* 'Pilgrim'
Weigela 'Purpureus'	*Papaver orientalis* 'Allegro'
	Phlox 'May Breeze'
	Potentilla 'Yellow Queen'
	Pulmonaria 'Roy Davidson'
	Schizostylis 'Maidens Blush'
	Tradescantia 'Pauline'

Table 1
Summary of herbicide efficacy against weeds tested

	American willowherb	Hairy bittercress	Groundsel	Mouse-ear chickweed	Annual meadow grass	Liverwort
Butisan S	***	***	***			***
Butisan S + Flexidor 125	**	***	***			***
Debut	*	*	*	-	*	
Ronstar 2G/ Flexidor 125 programme	***	***	***	*	***	
Helmsman	***	***	**(*)	***	***	**
Katamaran	** (*)	*	*	**	***	**
Lexone 70DF	(**)	**	*	(**)	***	***
Monitor	*	*	*	*	*	
Ronstar 2G	***	***	***	-	**	*
Ronstar liquid	***	***	***	-		**
Stomp 400SC	*	-	*	**	*	
Titus	**	**	**	*	*	

- = nil
* = slight
** = moderate
*** = good
( ) = variable

Where no rating is given, insufficient weed was present for testing

Table 2
Summary of herbicide safety – shrubs

	Growing Season							Winter		
	Butison S	Flexidor 125	Helmsman	Katamarn	Lexone 70DF	Ronstar 2G	Stomp 400SC	Butison S + Flexidor 125	Lexone 70DF	Ronstar liquid
Buddleia	MS	MS	T	MS	S	T	T	S	S	T
Chamaecyparis	T	T	T	T		T		T	T	T
Choisya	T	T	T	T		T		T	S	S
Ceanothus	T	T	T	T		T		T	S	MS
Clematis	T	T	MS	T		T		T	T	T
Deutzia	T	T	T	T		T		T	T	T
Erica	MS	T	T	T		T		T	T	T
Escallonia	T	T	T	T		T		T	S	T
Euonymus	T	T	T**	T	S	T	T	T	T	T
Forsythia	T	T	T	T		T		T	T	T
Hebe	T	T	T	T		T		T	T	T
Lavatera	MS	T	T	MS		T		T	T	T
Lavandula	T	T	T	T		T		T	S	T
Lonicera	T	T	T	T		T		T	T	T
Philadelphus	T	T	T	T	S	T	T	T	T	T
Pontilla	T	T	T	T		T		T	T	T
Prunus	T	T	T	T		T		T	T	T
*Spiraea**	T	T	T	T		T*		T	T	T
Viburnum	MS	T	T	MS		T		T	S	T
Vinca	T	T	T	T		T		T	T	T
Weigela	T	T	T	T		T		T	T	T

T = Tolerant
MS = Moderately susceptible
S = Susceptible

* Previous trials have shown this species to be susceptible so this result should be treated with caution.

** French product recommendation suggests DO NOT TREAT

Table 3
Summary of herbicide safety – herbaceous

	Flexidor 125	Helmsman	Katamaran	Ronstar 2G	Titus	Venzar Flowable
Achillea	T		T	T	S	
Aconitum	-		-	MS	S	
Anemone	S	S	T	T	S	T
Aster	T	T	S	MS	S	T
Astilbe	MS	T	MS	T	S	S
Campanula	MS		T	T	S	
Crocosmia	T		T	T	S	
Delphinium	MS	S	S	S	S	S
Digitalis	S		S	T	T	
Euphorbia	T		-	T	S	
Geranium	MS	T	S	T	S	T
*Geum**	T		S	T*	S	
Hemerocallis	T		S	T	T	
Hosta	T	T	T	T	T	T
Iris	T		T	T	T	
Leucanthemum	T	T	T	T	T	S
Lupinus	-		S	T	S	
Miscanthus	T		T	T	T	
Monarda	T		T	T	S	
Oreganum	MS	MS	-	-	-	
*Papaver**	T*	MS	T	MS	S	S
Penstemon	S	T	MS	T	T	T
Phlox	-		-	MS	S	
Potentilla	T	MS	T	T	S	S
Primula	T	S	S	MS	S	T
Pulmonaria	MS	T	T	T	S	T
Schizostylis	T		-	MS	S	
Stachys	T	T	T	T	S	T
Tradescantia	T		S	T	S	

T = Tolerant
MS = Moderately susceptible
S = Susceptible

* Previous trials have shown these species to be susceptible so these results should be treated with caution.

Herbicide efficacy and safety

- The granular herbicide Helmsman showed excellent general weed control with better liverwort control than Ronstar 2G. Slightly poorer control of groundsel was noted in one trial. It was safe on all but one woody species tested in containers but caused damage (white blotching) to Clematis and several herbaceous subjects, and killed *Delphinium* and *Papaver.* Helmsman currently has label approval for open ground amenity use, but these results show promise for use on container grown woody subjects.
- The standard Ronstar 2G / Flexidor 125 or Ronstar 2G programme on shrubs was overall about as effective as Helmsman. The Ronstar 2G application gave better control of groundsel than Helmsman at the first summer application, but Helmsman gave better control of mouse-ear chickweed on the final application.
- None of the other herbicide treatments tested in year 1 were overall as effective as those above. Stomp 400SC, Monitor and Debut gave generally disappointing control.
- Titus showed some suppression of chickweed, bittercress and groundsel and proved safe on most of the herbaceous perennials except *Papaver* in year 1. In year 2 it was much more effective as a herbicide but also damaged the majority of herbaceous subjects this time. It could however have potential as a herbicide on selected herbaceous subjects *Hemerocallis*, *Host*, *Iris*, *Miscanthus*, *Digitalis* and *Tradescantia.* Titus was the only herbicide tested to give full control of New Zealand bittercress on herbaceous crops.
- Katamaran gave moderate weed control, not as good as Helmsman, Ronstar 2G, Butisan S and Flexidor 125. However it showed some post-weed emergence activity against groundsel and willowherb from the first summer application. Initially it appeared safe on herbaceous plants (except *Primula*), but subsequently in year 2 more herbaceous subjects were damaged. Katamaran does not appear to offer any advantages in effectiveness or crop safety over Butisan S.
- Lexone performed best as a summer spray treatment, where it gave good control of all weeds except groundsel. Some germination had occurred from chickweed, groundsel and willowherb at this time, and Lexone proved to have good contact activity. Its residual activity was less good except against bittercress. It proved too phytotoxic for use on herbaceous subjects. It was also the only herbicide in the trial to cause damage to the shrub species grown. *Euonymus* suffered leaf drop, *Buddleia* leaf scorch, and *Philadelphus* interveinal yellowing but only following the summer spray. Lexone was trialled as a potential winter contact treatment for deciduous shrubs and conifers, but was more damaging and less effective than Ronstar liquid or Butisan S / Flexidor 125.
- Ronstar liquid performed well as a winter contact/residual treatment on both deciduous and evergreen shrubs. Most species were unaffected, *Choisya*, *Ceanothus* and *Lavatera* suffered slight scorching, but the latter two recovered. *Choisya* remained affected. Ronstar liquid could be used as an alternative to Butisan S + Flexidor 125 where willowherb and sowthistle were particular problems.

- The "standard" Butisan S + Flexidor 125 treatment still performed well compared with other winter treatments. For chickweed and liverwort, this combination would be better than other treatments
- Further herbaceous crops have been found to be tolerant to Flexidor 125, these include *Tradescantia*, *Monarda*, *Miscanthus* and *Schizostylis*. *Pulmonaria* was moderately susceptible and *Anemone* was susceptible.

Mulches

- Of the three new mulch materials examined, all gave some weed suppression, but were not as effective as the best herbicide treatments. Enviroguard gave slightly better weed suppression, but this product and particularly Terrastar swelled up excessively after application and watering, and overflowed the pot. While these two mulches may be better suited for open ground use, only Biotop appears practically viable for commercial scale use in containers. The germination of *Miscanthus* grass seedlings was a particular problem with the Biotop mulch.

Anticipated practical and financial benefits

The development of Helmsman as an alternative granule treatment should give shrub growers the potential for better control of chickweeds (resistant to Ronstar 2G), whilst retaining good control of groundsel and willowherb (largely resistant to Axit granules). However, as only a limited number of species have been tested over 2 seasons, further small scale trialling by growers would be beneficial.

Whilst Ronstar liquid has been used to a small extent on deciduous shrubs overwinter, the potential for use on certain evergreen subjects as well offers improved contact weed control for larger seedling weeds, where the use of other contact herbicides such as parquat, glufosinate-ammonium would be too damaging.

Further information on herbaceous crop tolerance to Venzar and Flexidor 125 increases the range of crops on which herbicide can be used, reducing dependence on hand weeding. This information can be included in updates of the HDC Weed Control handbook.

Titus proved damaging to a number of herbaceous crops but has potential for use as a contact/residual herbicide on a particular range of crops. *Hemerocallis*, *Hosta, Iris*, *Miscanthus, Tradescantia* and *Digitalis* for which contact herbicides are not available. *Digitalis* appears to be tolerant whereas this species is normally susceptible to herbicides necessitating hand weeding.

Action points for growers

- The positive results from Helmsman make it worth growers undertaking their own small scale trials on container crops of woody subjects.
- Ronstar liquid has potential for use as a winter contact/residual herbicide on a range of delicious and evergreen woody shrubs.
- Willowherb, groundsel and bittercress control are the main benefits. This treatment would not be effective on chickweeds, for this the "standard" Butisan S / Flexidor 125 would be preferable.
- *Tradescantia*, *Monarda*, *Micscanthus* and *Schizostylis* can now be listed as tolerant to Flexidor 125.
- *Anemone* should now be listed as susceptible to Flexidor 125.
- Titus could be further trialled as a potential contact/residual herbicide in *Digitalis*, *Hemerocallis*, *Hosta*, *Iris*, *Miscanthus* and *Tradescantia*.

Herbaceous perennial and woody species experiments in May 2002

It is essential to follow the instructions on the approved label before handling, storing or using any crop protection product. Approved off-label uses are made entirely at the risk of the user.

It is advisable to apply new products to a small area of crop to assess crop safety under the conditions found on each site.

SCIENCE SECTION

INTRODUCTION

Good weed control continues to be important for maintaining plant quality and achieving accreditation standards. Herbicides remain the most cost-effective weed control method where they can be applied safely. Deficiencies in weed control programmes have to be resolved by expensive and inefficient hand weeding. Since the last set of HDC pre-emergence herbicide screening experiments were undertaken 4 - 6 years ago (HNS 35f), a number of new products have become available on the amenity and agricultural market. There are also some promising non-chemical alternatives that require evaluation. It is important to continue to assess new products to help combat weed species and extend the range of subjects screened for which off-label approval can be used.

This project aims to evaluate several new herbicides for efficacy and safety for use on a wide range of container-grown woody and herbaceous subjects. Emphasis is placed on their use through the growing season to give an extended period of control. In the first part of the project, carried out at HRI Efford, the new herbicides were tested against a range of problem weeds: American willowherb, mouse-eared chickweed, annual meadow grass, groundsel and hairy bittercress. In addition, some non-chemical weed control products were tested to see if they are a cost-effective alternative to herbicides.

In Part 2, the most promising of the herbicide and non-chemical treatments were taken on and tested across a wider range of subjects on a larger scale at two nurseries under commercial conditions. The main objective at this stage was to test for crop safety, but observations were also taken of efficacy of the herbicides. In addition to extending the species range, testing the herbicides on the indicator species in a different location and season should give further confidence about crop safety results. As one treatment (Lexone) appeared from year one results, to have potential as a winter treatment rather than a growing season treatment, it was decided to extend the shrub trial to include 3 winter herbicide treatments, primarily for contact weed control.

Ultimately the project will contribute towards extending herbicide recommendations (albeit at the grower's risk) for both woody subjects and herbaceous perennials. These will be made available in due course as updates to the Grower's handbook - 'Practical weed control for nursery stock'.

OBJECTIVES

1. To establish weed control efficiency and safety of use of selected new herbicides, with summer, autumn and winter applications on a range of both woody and herbaceous perennial subjects, particularly against 5 ‘problem’ weed species.

2. To establish weed control efficiency and practicality of use of selected non-chemical mulch treatments.

MATERIALS AND METHODS

YEAR 1

The first part of the project at Efford was split into two sub-trials:

a. Hardy nursery stock (woody) species.

b. Herbaceous perennial species

Although herbicides were applied at approximately the same time to both the woody and herbaceous species the plants had to be laid out and grown on separate beds because of the differences in pot size and irrigation requirements and the need to slightly vary some of the herbicide treatments used.

The woody species sub-trial looked at the efficacy and safety of selected herbicides, whilst the herbaceous perennials were screened for phytotoxicity alone.

A. WOODY SPECIES

This section of the trial looked at both the efficacy and phytotoxicity of 8 herbicide treatments against a non-treated control, with a further 3 non-chemical mulch treatments being screened for efficacy alone alongside these.

Weed seeds were sown into ‘blank’ pots at 3 separate intervals across the growing season and emergence and survival records taken. At the same time 5 species of shrubs were monitored for phytotoxicity symptoms throughout the trial.

HNS Woody Species:

	Supplier
Buddleia davidii 'Harlequin'	New Place Nurseries
Chamaecyparis lawsoniana 'Elwoodii'	Seiont Nurseries
Euonymus fortunei 'Sunshine'	New Place Nurseries
Philadelphus 'Virginal'	The Northern Liner Company
Viburnum tinus	New Place Nurseries

Two of shrub species were pruned back on 5th January 2002 prior to the second year's growth. *Buddleia* were cut back to a height of about 20 cm and *Philadelphus* to around 30 cm.

Supplier Details:

New Place Nurseries, London Road, Pulborough, W. Sussex, RH20 1AT
The Northern Liner Company, Lancaster Road, Out Rawcliffe, Preston, PR3 6SR
Seiont Nurseries, Cae'r Glyddyn, Pontrug, Caernarfon, LL55 2BB

Plants were bought in 9 cm pots during March and April 2001 and potted on into 3 litre pots before the start of the trial.

Potting Mix

100 % Premium grade med/coarse peat
5.0 kg/m^3 Osmocote Plus Spring 12-14 month*
1.8 kg/m^3 Magnesian limestone
0.75 kg/m^3 SuSCon Green
0.5 kg/m^3 Aquamix G (granular wetting agent)

***except** for *Chamaecyparis* which had a rate of 4.0 kg/m^3

The same potting mix was used for the 'blank' 3 litre pots into which the weed seeds were sown, except no SuSCon Green was added.

Experimental Design and Statistical Analysis

See Appendix 1 for plan details

Split plot design:
9 Herbicides (includes 1 control) x 3 replicates = 27 main plots for herbicide treatments
5 HNS shrub species sub-plots x 3 plants +
5 Weed species ('blank') sub-plots

Total 270 sub-plots

3 Non-chemical (mulches) x 3 replicates = 9 main plots for non-chemical treatments
5 Weed ('blank') species sub-plots x 3 pots

Total 45 sub-plots

The shrub pots and weed pots were placed on large Efford sand beds on 24 May 2001 (Photographs Appx.4, P1-2). Overhead irrigation was used throughout.

Results were examined by analysis of variance, after transformation of data where necessary to satisfy the conditions for ANOVAR.

Herbicide Treatments

Code	Trade name	Active ingredient	Rate of product used	
			per hectare	Per m^2
U	Untreated	water		
D	Debut	trisulfuron methyl	30 g/ha	0.003 g
H	Helmsman (granular)	oxadiazon + diflufenican + carbetamide	150 kg/ha	15 g
K	Katamaran	metazachlor + quinmerac	2.0 l/ha	0.2 ml
L	Lexone 70DF	metribuzin	0.75 kg/ha	0.075 g
M	Monitor	sulfosulfuron	25 g/ha	0.0025 g
R	Ronstar 2G (granular)*	oxadiazon	200 kg/ha	20 g
S	Stomp 400SC	pendimethalin	3.3 l/ha	0.33 ml
T	Titus	rimsulfuron	50 g/ha	0.005 g

* Trt R (Industry standard treatment) middle application (September 2001) used Flexidor 125 (isoxaben) at a rate of 0.1 mls/m^2, returning to Ronstar 2G for the third application in February 2002.

Herbicide Applications

Liquid herbicide treatments were applied using an Oxford Precision Sprayer in a high water volume equivalent to 2500 l/ha i.e. 250 mls/m^2 (Appx 4, P3). Granular treatments were applied using a 'pepperpot' sprinkler to ensure even coverage.

Herbicides were applied on 3 occasions:

Timings

1. Early summer -14 June 2001
2. Autumn - 28 September 2001
3. Winter - 15 February 2002

Non-Chemical Mulch Treatments

Code	Mulch	Contains	Source/Supplier
B	Biotop	Starch + plant fibres	Dutch product via East Riding Horticulture Ltd, York
E	Enviroguard	Recycled paper	Tascon Inc., Houston, Texas, USA
TE	Terrastar	Wheat straw + iron sulphate + lignosulphate	Strawproducts c.v., Tienen, Belgium

The non-chemical mulch treatments were applied to pots on the 7 June 2001 (Appx 4, P4).

Application Rates

Manufacturers guidelines were followed to give a depth of 5 mm for Biotop and 20 mm for both Enviroguard and Terrastar.

The Enviroguard and, particularly, the Terrastar pellets, swelled substantially when wetted up, causing some overflowing from the pots. It was necessary to scrape the surface to the level of the container after pots had been initially watered.

Where the thinner Biotop mulch layer had been disturbed by the removal of large weeds between sowings, any bare patches were 'patched up' in late January 2002, prior to Sowing 3.

Weed Species tested for herbicide efficacy

Common name	Latin name
American willowherb (paraquat resistant clone)	*Epilobium ciliatum*
Hairy bittercress*	*Cardamine hirsuta*
Groundsel (simazine resistant)	*Senecio vulgaris*
Mouse-ear chickweed	*Cerastium fontanum*
Annual meadow grass	*Poa annua*

* The original proposal was to include New Zealand bittercress (*Cardamine flexuosa)*, but a seed source for this could not be located, hence hairy bittercress was used as a substitute for the duration of the project.

The weed seeds were bought from Herbiseed, (The Nurseries, Billingbear Park, Wokingham, Berkshire, RG40 5RY).

Weed Seed Sowings

A calibrated scoop was used to apply a measured volume of seed, which was mixed with sand to aid measurement and distribution.

The five weed species were sown separately onto the 'blank' pots on three occasions as follows:

Sowing 1 - early summer - 7th to 9th June 2001 - 6 days prior to herbicide application
0.25 ml of seed was applied to each 3 litre 'blank' pot

Sowing 2 - autumn - 3rd to 5th October 2001 - 6 days after herbicide application
Due to the excessive number of seeds germinating after Sowing 1 a reduced volume of 0.05 ml of seed was sown per pot

Sowing 3 - winter - 14th February 2002 - 1 day prior to herbicide application
For American willowherb, hairy bittercress and mouse-ear chickweed a volume of 0.05 ml of seed was sown per pot. Due to low germination of annual meadow grass and groundsel in Sowing 2 it was decided to increase the volume of seed applied for these two species to 0.25 ml.

For the mulch treatments, weed seed was sown on top of the mulches. This was to simulate the nursery situation where most weed infestation occurs from seed being spread into pots after potting and standing out, rather than as a contamination of growing media.

Assessments

Weed Control

Weed emergence and survival records were taken as follows on the 'blank' weed pots:

July 2001 - % pot cover
November 2001 - weed counts
January 2002 - weed counts
April 2002 - weed counts
May 2002 - weed counts

Seed Sowing 1 produced an excessive amount of germinating seed and individual weed counts were not possible, hence a % cover score was used.

Weeds were removed by hand at the time of recording, except after the July 2001 % pot cover score where the amount of weed present and rapid growth made removal and counting of individual weeds impossible. Instead, all weed pots were taken into an empty glasshouse and sprayed with a contact herbicide, Challenge (glufosinate-aluminium), at a rate of 12.5 mls per litre to kill weeds with minimum disruption to the herbicide layer. The weeds were allowed to dry back and subsequently removed so that pots were clean before the second sowing and herbicide application in autumn 2001.

In addition to the main weed count records on the 'blank' pots an extra observational record was made on the weeds present in the shrub pots in the trial on 11th January 2002 (before the 3rd sowing and herbicide application).

Phytotoxicity

Written observations on phytotoxic symptoms and possible growth effects were made as and when they occurred.

Growth records were taken on the *Chamaecyparis* shrubs in mid November 2001 and mid May 2002.

Photographic records were taken as appropriate throughout the trial; they are listed as P1-P7 in the text and can be found in the Appendix 4.

B. HERBACEOUS SPECIES

In this section of the trial 16 herbaceous perennial subjects were screened for phytotoxity alone against 8 chemical herbicide treatments (including 1 untreated control).

Herbaceous Perennial Species:

	Supplier
Anenome 'Prince Harry'	Proculture Plants
Aster 'Wartburgstern'	Barretts Bridge Nurseries
Astilbe chinensis pumila	Barretts Bridge Nurseries
Delphinium 'Guinevere'	Barretts Bridge Nurseries
Geranium 'Patricia'	Proculture Plants
Hosta krossa 'Regal'	Proculture Plants
Leucanthemum 'Esther Read'	Proculture Plants
Lupinus 'Chandelier'	Barretts Bridge Nurseries
Origanum vulgare 'Aureum'	Proculture Plants
Papaver 'Matador'	Barretts Bridge Nurseries
Penstemon 'Blackbird'	Proculture Plants
Potentilla 'Ron McBeath'	Barretts Bridge Nurseries
Primula Double 'Big Red Giant'	Proculture Plants
Pulmonaria 'Roy Davidson'	Proculture Plants
Stachys lanata	Barretts Bridge Nurseries
Verbascum 'Helen Johnson'	Proculture Plants

Supplier Details:

Barretts Bridge Nurseries, Leverington Common, Wisbech, Cambs. PE13 5JR
Proculture Plants Ltd, Knowle Hill, Badsey, Evesham, Worcs. WR11 5EN

Plug plants were bought in and potted on into 9 cm pots in mid April 2001. They were placed in Empot carrier trays and held in a polythene tunnel before being placed out onto trial beds in early June.

Potting Mix

100 % Premium grade med/coarse peat
3.0 kg/m^3 Osmocote Plus Spring 12-14 month
2.4 kg/m^3 Magnesian limestone
0.75 kg/m^3 SuSCon Green
0.5 kg/m^3 Aquamix G (granular wetting agent)

Experimental Design

Split-plot design.
8 Herbicides (includes 1 control) x 3 replicates = 24 main plots for herbicide treatments.
16 Herbaceous species sub-plots x 10 replicate plants* in half of Empot tray.

Total 384 sub-plots

* except *Stachys* only 6 or 7 plants per plot

See Photo 3 and Appendix II for detail.

Plants were placed on small Efford sand beds in the first week June 2001 (Appx 3, P21).
Overhead irrigation was used.

Herbicide Treatments

Code	Trade name	Active ingredient	Rate of product used	
			Per hectare	Per m^2
U	Untreated	water		
F	Flexidor 125	isoxaben	1.0 l	0.1 mls
H	Helmsman (granular)	oxadiazon + diflufenican + carbetamide	150 kg	15 g
K	Katamaran	metazachlor + quinmerac	2.0 l	0.2 mls
L	Lexone 70DF	metribuzin	0.75 kg	0.075 g
R	Ronstar 2G (granular)	oxadiazon	200 kg	20 g
T	Titus	rimsulfuron	50 g	0.005 g
V	Venzar Flowable	lenacil	3.0 l	0.3 mls

Herbicide Applications

Liquid herbicide treatments were applied using an Oxford Precision Sprayer in a high water volume equivalent to 2500 l/ha i.e. 250 mls/m^2.

Timings:
1. Early summer - 19th June 2001
2. Autumn - 2nd October 2001
3. Winter - 28th February 2002

Assessments

July 2001 - initial damage record 2 weeks post herbicide application

An assessment of herbicide damage following the second herbicide application in October was not possible because of the amount of natural dieback as well as carry over effects from the June application. However, in November 2001 the size of *Papaver*, plus number of dead plants were recorded

In early February 2002, prior to the final herbicide application, pots were cleaned of old dead leaves, any weed and moss was removed, and *Penstemon* was pruned back.

Late April/early May 2002 - final size/quality assessments with number of dead plants noted.

Written observations were taken throughout the trial, along with photographs.

YEAR 2

The 2nd part of the project was carried by ADAS with two trials carried out at two commercial nurseries:

a. Hardy nursery stock (woody) species – Darby Nursery Stock Ltd, Methwold

b. Herbaceous perennial species – R A Meredith & Son (Blooms) Ltd, Bressingham

The main focus for both trials was to screen for phytotoxicity, however some observations were made on efficacy of weed control.

A. WOODY SPECIES

This trial looked at both the efficacy and phytotoxicity of 7 herbicide treatments against a non-treated control, with a non-chemical mulch treatment being screened for efficacy alone alongside these.

20 species of shrubs were monitored for phytotoxity symptoms throughout the trial.

HNS Woody Species

Potentilla 'Red Ace'
Lavender 'Hidcote'
Choisya ternata
Lavatera 'Olbia Rosea'
Ceanothus 'Blue Mound'
Deutzia 'Mont Rose'
Vibernum tinus 'Eve Price'
Weigela 'Purpureus'
Escallonia 'Gold Ellen'
Buddleia davidii 'Pink Delight'
Euonymous 'Emerald Gaiety'
Forsythia spectabilis 'Lynwood'
Hebe 'Red Edge'
Spiraea 'Gresham'
Vinca minor 'Atropurpurea'
Clematis montana 'Rubens'
Prunus rotundifolia
Chamaecyparis 'Elwoodii'
Erica darleyensis

Supplier Details:

All plants were from Darby Nursery Stocks own production except,
Chamaecyparis lawsoniana 'Elwoodii'. – Greenleaf Nursery, Tregarth, Newgatestreet Road, Goffs Oak, Herts, EN7 5RP
Erica darleyensis – Kingfisher Nurseries, Gedney Hill, Spalding, Lincolnshire, PE12 0RU

Plants were supplied as 9cm liner pots, potted on into 3 litre pots before the start of the trial, except for *Erica darleyensis* which was supplied as 3 litre pot grown plants.

Potting Mix

60% Premium grade med/coarse peat. 30% Bark, 10% Grit
6 kg/m³ Osmocote Exact Standard 12-14 month
1.8 kg/m³ Magnesian limestone
300 gm/m³ Ammonium Nitrate

Experimental Design

See Appendix 1 for plan details

Split plot design:
9 Herbicides (includes 1 control and 1 bio mulch) x 3 replicates = 27 main plots for herbicide treatments
20 HNS shrub species sub-plots x 3 plants

Total 540 sub-plots

The shrub pots were placed on large sub irrigated sand beds on 17 May 2002 supplimentary overhead irrigation was used as required.

Herbicide Treatments

Code	Trade name	Active ingredient	Rate of product used	
			Per hectare	Per m^2
1	Untreated			
2	Helmsman (granular)	oxadiazon + diflufenican + carbetamide	150 kg/ha	15 g
3	Katamaran	metazachlor + quinmerac	2.01 l/ha	0.2 ml
4	Ronstar 2G (granular)	oxadiazon	200 kg/ha	20 g
5	Butisan S	metazachlor	2.5 l/ha	0.25 ml
6	Biotop mulch		5 mm depth	
7	Flexidor 125 + Butisan S	isoxaben + metazachlor	2.0 l/ha 2.5 l/ha	0.2 ml 0.25 ml
8	Ronstar liquid	oxadiazon	4.0 l/ha	0.4 ml
9	Lexone 70DF	metribuzin	0.75 kg/ha	0.075 g

Herbicide Applications

Liquid herbicide treatments were applied using an Oxford Precision Sprayer in a high water volume equivalent to 2500 l/ha i.e. 250 mls/m^2. Granular treatments were applied using a 'pepperpot' sprinkler to ensure even coverage. The Biotop mulch was applied to give a depth of 5 mm.

Herbicides were applied on 3 occasions:

Timings:
1. Early summer – 31 May 2002. Treatments 1-6
2. Autumn – 10th September 2002. Treatments 1-5
3. Winter – 17th December 2002. Treatments 7-9

Assessments

Weed Control

Seedling weed emergence and survival records were taken as follows from all crop species pots:

10 December 2002 – weed counts
28 January 2003 – weed counts
% liverwort was recorded on the *Prunus rotundifolia* pots as these had the most consistent infestation. Records were taken on 10 December 2002 and 28 January 2003.

Phytotoxicity

Written observations on phytotoxic symptoms and possible growth effects were made as and when they occurred. The final observations were made on 24 March 2003. The stage of growth for each species was noted on 10 December 2002 (Appendix 3 Table 1) prior to application of contact herbicide treatments 7-9 on 17 December 2002.

Photographic records were taken as appropriate throughout the trial.

B. HERBACEOUS SPECIES

In this section of the trial 25 herbaceous perennial subjects were screened for phytotoxicity against 5 chemical herbicide treatments (including 1 untreated control).

Herbaceous Perennial Species:

Lupinus 'Russell Hybrids'
Tradescantia 'Pauline'
Monarda 'Garden View Scarlet'
Crocasmia 'Irish Flame'
Hosta 'Wide Brim'
Hemerocallis 'Frans Hals'
Astilbe 'Sprite'
Pulmonaria 'Roy Davidson'
Geum boris
Aster 'Purple Dome'
Digitalis grandiflora 'Ambigua'
Geranium Bressingham Delight
Anemone 'Montrose'
Campanula 'Blue Waterfall'
Potentilla 'Yellow Queen'
Oreganum 'Pilgrim'
Achillea 'Terracotta'
Delphinium 'Blue Jay'
Papaver orientalis 'Allegro'
Miscanthus sinensis 'Sirene'
Euphorbia amygdaldides 'Rubra'
Phlox 'May Breeze'
Schizostylis 'Maidens Blush'
Iris foetidissima
Aconitum 'Sparks Variety'

Supplier Details:

All plants were supplied by R A Meredith & Son (Blooms) Ltd.
Plug plants were potted on into 9 cm pots at end May 2002. They were placed in Empot carrier trays then placed out into trial beds in early June

Potting Mix

85% Premium grade coarse peat, Levington
15% Composted bark
3.0 kg/m³ Osmocote Exact, Standard 8-9 month
2.4 kg/m³ Magnesian limestone
0.28 kg/m³ Intercept 5GR
Wetting agent

Experimental Design

Split-plot design.
5 Herbicides (includes 1 control) x 3 replicates = 15 main plots for herbicide treatments.
25 Herbaceous species sub-plots x 5 replicate plants in Empot trays.

Total 375 sub-plots

See Photo Appendix 4 and Appendix 2 for detail.

Plants were placed on gravel standing beds in the first week June 2002. Overhead irrigation was used.

Herbicide Treatments

Code	Trade name	Active ingredient	Rate of product used	
			Per hectare	Per m^2
1	Untreated	water		
2	Katamaran	metazachlor + quinmerac	2.0 l	0.2 mls
3	Ronstar 2G (granular)	oxadiazon	200 kg	20 g
4	Titus	rimsulfuron	50 g	0.005 g
5	Flexidor 125	isoxaben	1.0 l	0.1 mls

Herbicide Applications

Liquid herbicide treatments were applied using an Oxford Precision Sprayer in a high water volume equivalent to 2500 l/ha i.e. 250 mls/m^2

Timings:
1. Early summer – 7th June 2002
2. Autumn – 11th September 2002

Assessments

Phytotoxicity

12 July 2002 – Initial damage record after first herbicide application - visual assessment
17 July 2002 – Crop vigour/phytotoxcity score
24 September 2002 – Damage record after second herbicide application – visual assessment and crop vigour/phytotoxicity score
14 April 2003 – Final crop vigour/phytotoxicity score on spring growth weed control
24 September 2003 - % weed cover, weed species present.

RESULTS

Year 1 HRI Efford Weed Control Studies

1. Weed seed germination

The hairy bittercress (*Cardamine hirsuta*), mouse-ear chickweed (*Cerastium fontanum*) and American willowherb (*Epilobium ciliatum*) germinated well at all 3 sowings. The chickweed did show less emergence at Sowing 2, but this is more likely a result of cold temperatures inhibiting germination. Despite excellent germination at Sowing 1, groundsel (*Senecio vulgaris*) showed very poor emergence on the subsequent two sowings, even on the untreated pots. Annual meadow grass (*Poa annua*) germinated very poorly on all three occasions. Following poor germination of *Poa* and *Senecio* after the second sowing, seed counts were made from five replicate seed doses of each species used. This averaged 36 *Poa* and 71 *Senecio* per pot from the 0.05 ml / pot rate used.

Germination tests were done under glass in January 2002. The annual meadow grass showed reasonable viability with an average of 50% of sown seed germinating. However, the triazine resistant groundsel showed much lower viability, with only 10% germination.
Despite increasing the sowing rate by a factor of 5 back to 0.25 ml seed/pot for the final sowing in February, and allowing for a 'field factor', emergence of groundsel and annual meadow grass in the control plots was still lower than expected for these weeds. Seed was kept in dry sealed

bags and refrigerated through the trial; the seed suppliers could not offer any explanation for the apparent loss of viability with this batch of simazine resistant groundsel.

2. Weed Control

Figs 1 to 4 summarise the weed assessments. See Appendix 2 for data from all weed assessments and Photos in Appx. 4, (P6-9).

Herbicides

Seed Sowing 1 was six days before the first herbicide application. By the time herbicides were applied, willowherb, mouse-ear chickweed and to a lesser extent groundsel were beginning to emerge (Appx 4, P5). Sowing 1 thus provided a test of post-emergence activity of herbicides against these species.

The new compounds **Debut**, **Monitor** and **Titus** gave rather disappointing results throughout the trial. Although there was some evidence of weed suppression after Sowing 1 (eg **Debut** for bittercress and groundsel and **Monitor** and **Titus** for chickweed, bittercress and groundsel), very little control was observed in the later sowings and these herbicides were generally outperformed by others (Appx 3, P8).

Of all the treatments **Helmsman** was one of the best all round performers, giving nearly 100% control on all the weed species after Sowings 2 and 3. It showed less good control following Sowing 1, particularly on groundsel, but this was partly a result of poor contact activity against germinating or emerged weeds at that time (Appx 4, P6). This residual herbicide relies on pre-emergence action.

After Sowing 1, **Lexone** gave very good results on all the weed species, except groundsel, and gave 100% control against bittercress, chickweed and willowherb. For the later sowings it was less effective, apart from giving some suppression of bittercress. Results indicate that although **Lexone** worked well as a post-emergence weed control (except on groundsel) its residual effectiveness may be less good in containers.

Katamaran gave moderately good control of all species in Sowing 1, particularly groundsel and willowherb where some contact action was apparent (Appx 4, P7). However, it performed less well in the later sowings. While it did give some suppression of chickweed, and to a lesser extent groundsel and willowherb, several other herbicides gave better results.

Stomp 400SC did not prove to be particularly effective against any of the weed species. It did appear to have some post-emergence effect on bittercress and chickweed at Sowing 1, but the results from Sowings 2 and 3 were generally poorer, although some further control was noted against chickweed. Generally, it was outperformed by other treatments.

The **Ronstar 2G/Flexidor 125** combination gave very good results on all species, except chickweed. Along with Helmsman this was a very successful treatment, with **Ronstar 2G** giving better control on the germinating groundsel in Sowing 1.

The containers of shrubs generally had low numbers of naturally occurring weeds during the trial, and these were occasionally removed by hand. However significant amounts of mainly bittercress developed overwinter in the shrub pots, and these were recorded in early January 2002 (Fig 4 below & Appx 4, P14-17)). The results of this assessment backed up the findings from the weed sowing records with **Helmsman** and the **Ronstar 2G / Flexidor 125 programme** clearly giving the best control.

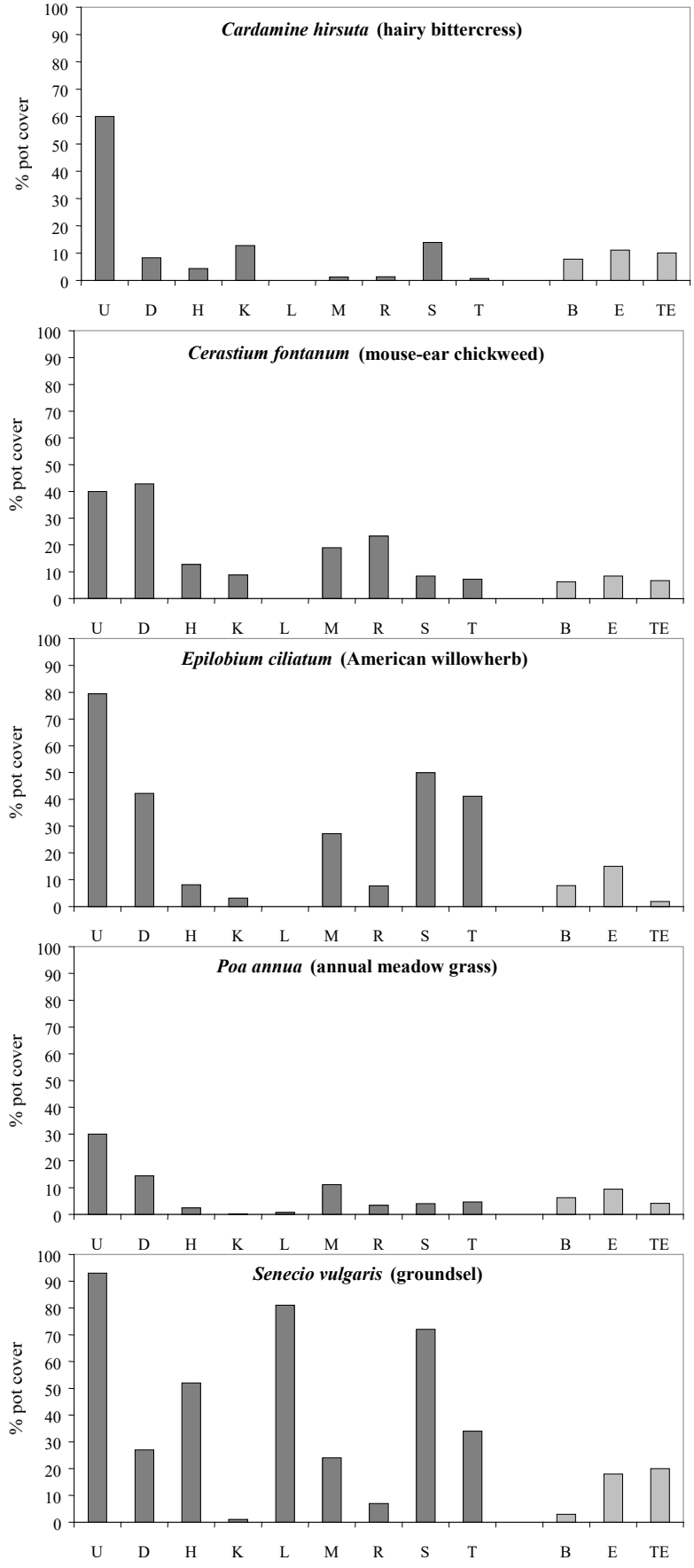
Mulches

Generally the **Biotop**, **Enviroguard** and **Terrastar** mulches did give some control over the development of all weed species (Appx 4, P9). Sowing 1 results were the most positive with all treatments performing fairly well, although not as good as the best of the chemical treatments. At the later sowings **Biotop** performed less well than the other mulches and **Enviroguard** gave slightly better control than the **Terrastar**.

The **Enviroguard** pellets retained their form throughout the trial, whereas **Terrastar** pellets rapidly crumbled after wetting. This layer did settle after a while. **Biotop** formed a good 'mat', however the layer was damaged relatively easily during removal of larger weed seedlings (Appx 4, P18-20). Holes in the **Biotop** layer were 'patched up' once in late January, a month before the second weed sowing.

Biotop contains starch and *Miscanthus* fibres, and some *Miscanthu*s seedlings emerged in the **Biotop** pots sown with all weed species. These may have been confused with some annual meadow grass seedlings in the *Poa* treatment. The **Enviroguard** pots developed some fungi and saprophytic slime mould growth over the autumn and winter, but these did not appear to adversely affect the shrub plants.

Fig 1 % Pot Cover early July 2001
Mean of 3 replicates with 3 pots per plot.

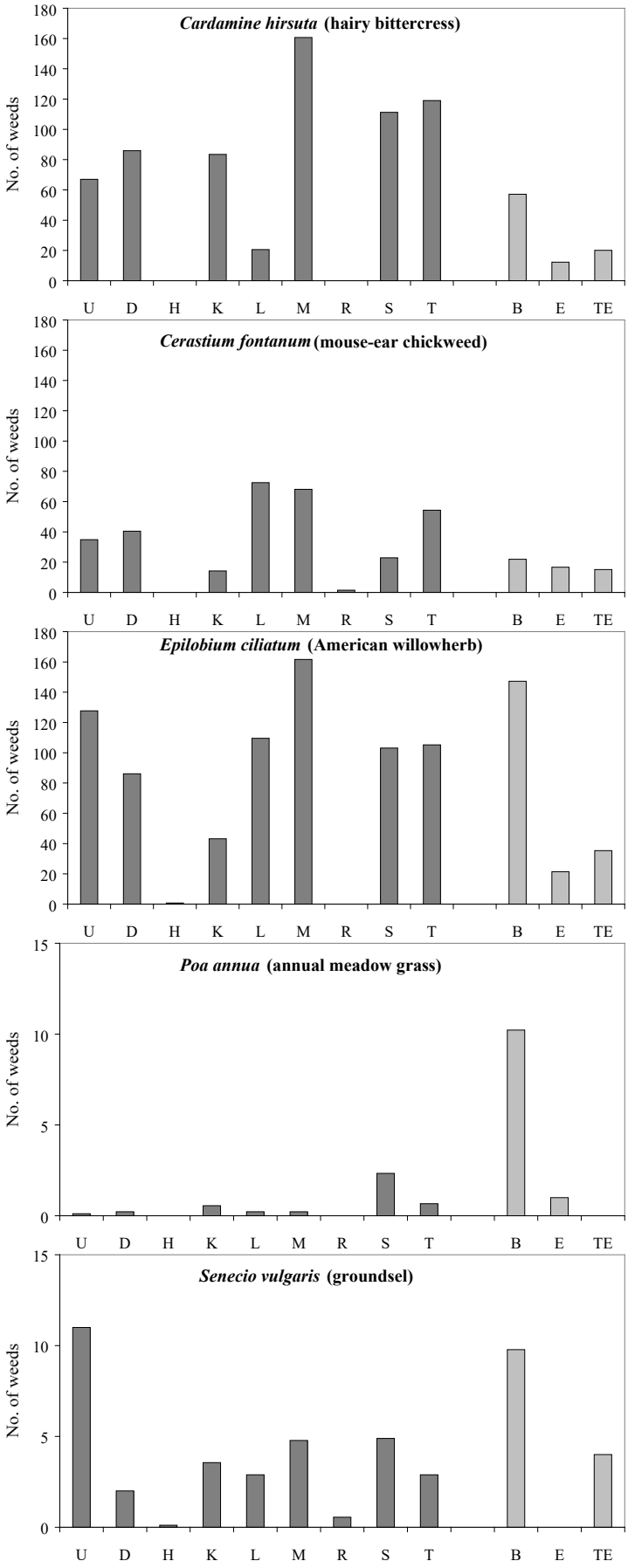


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar
S - Stomp 400SC
T - Titus

B - Biotop
E - Enviroguard
TE - Terrastar

Fig 2 Number of weeds per pot present early November 2001
Mean of 3 replicates with 3 pots per plot.

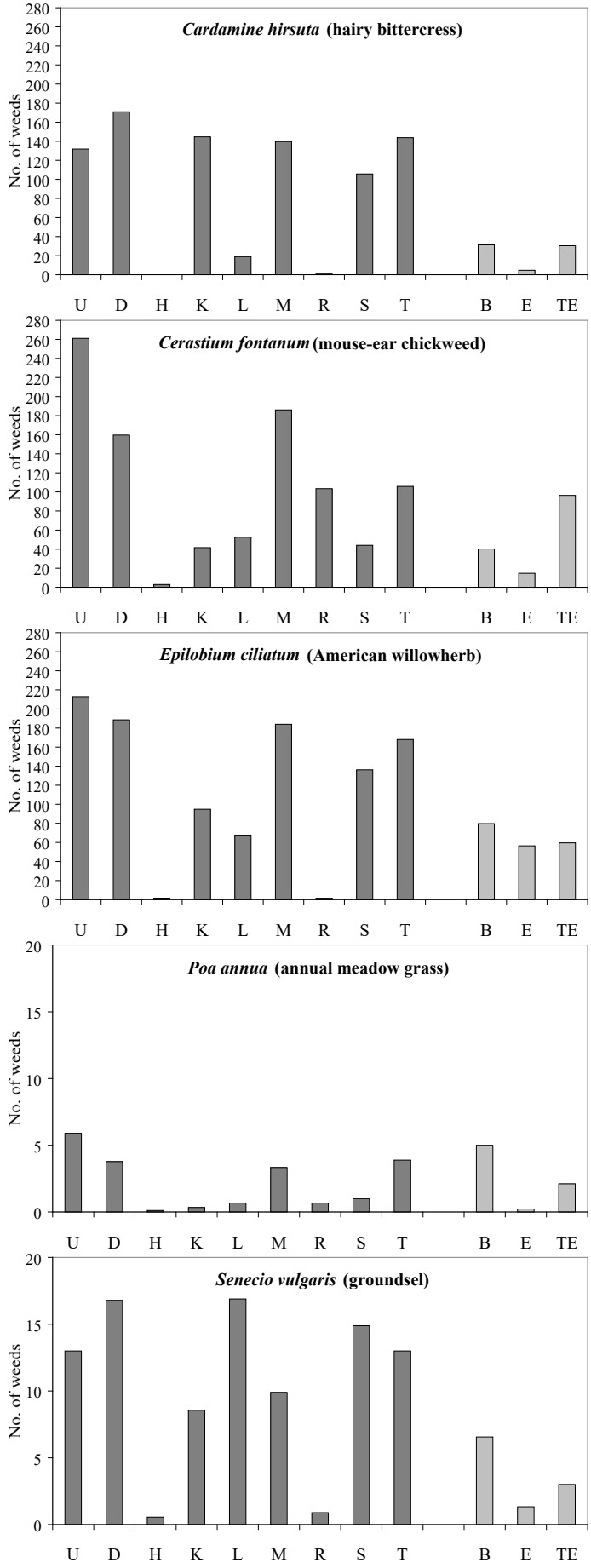


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar (Flexidor 125)
S - Stomp 400SC
T - Titus

B - Biotop
E - Enviroguard
TE - Terrastar

Fig 3 Number of weeds per pot present mid April 2002
Mean of 3 replicates with 3 pots per plot.

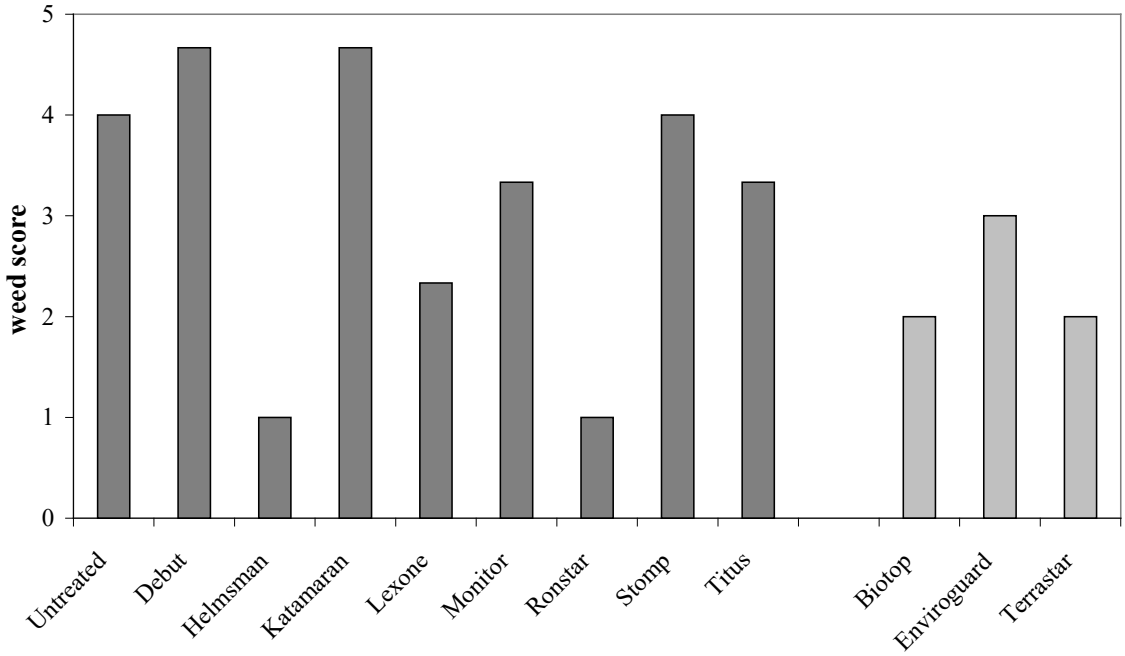


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar
S - Stomp 400SC
T - Titus

B - Biotop
E - Enviroguard
TE - Terrastar

Fig 4 Levels of *Cardamine hirsuta* (hairy bittercress) present in shrub pots 11 January 2002 Score 1 = no weed, 5 = severe weed



Year 2 Experiments on Growers Nurseries

Darby Nursery Stock Ltd, Methwold

1. Weed Population

The pots were not seeded with weeds, so all assessments were made on the naturally occurring weed population at the site.

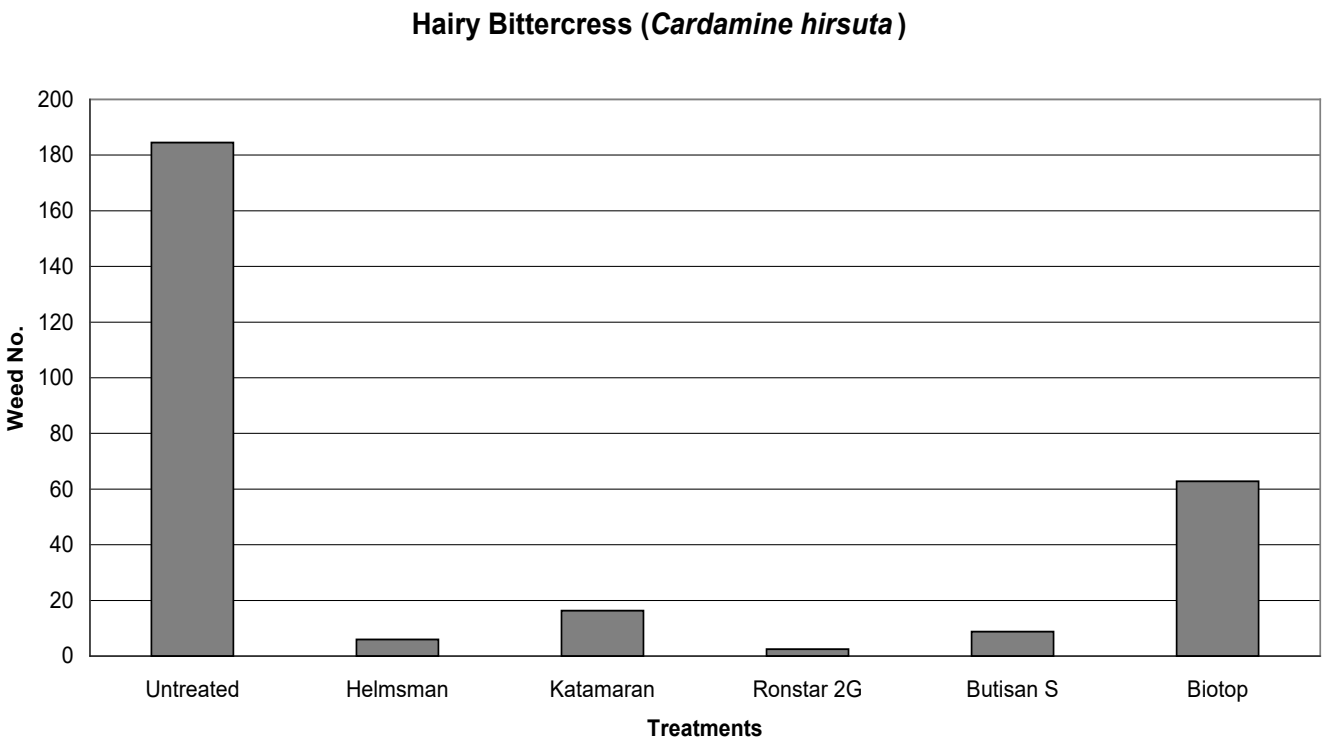
Very little weed germinated from potting (May) until October. During wetter autumn conditions from October more weed germinated so that by December the weed population was predominantly hairy bittercress (*Cardamine hirsula*) and groundsel (*Senecia vulgaris*). Smaller amounts of willowherb (*Epilobium ciliatum*), pearlwort (*Sagina procumbens*), mouse-ear chickweed (*Cerastium fontanum*), annual meadow grass (*Poa annua*), sowthistle (*Sonchus oleraceus*) and canadian fleabane (*Conyza canadensis*) were noted. Liverwort (*Marchantia polymorpha*) developed on the surface of the Prunus pots, so these were used for recording % liverwort cover.

2. Weed Control

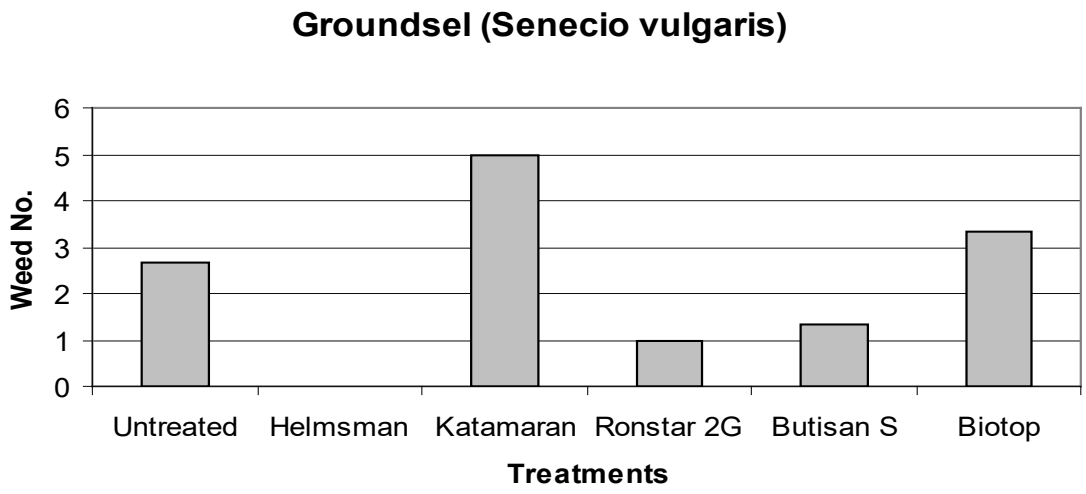
Figs 5 to 6 below summarise the weed assessments. See Appendix 2 for data from all weed assessments.
Post potting herbicide treatments.

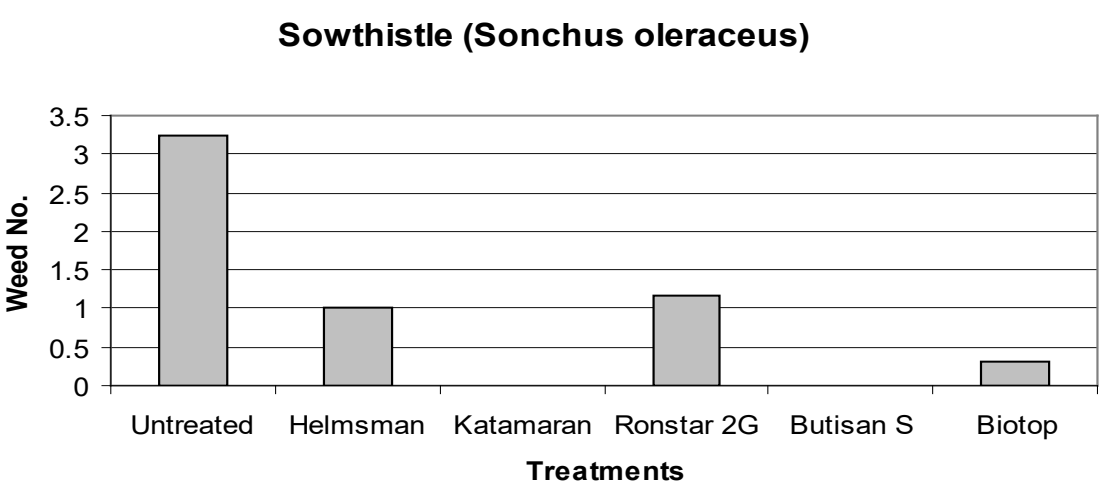
Darby Nursery Stock

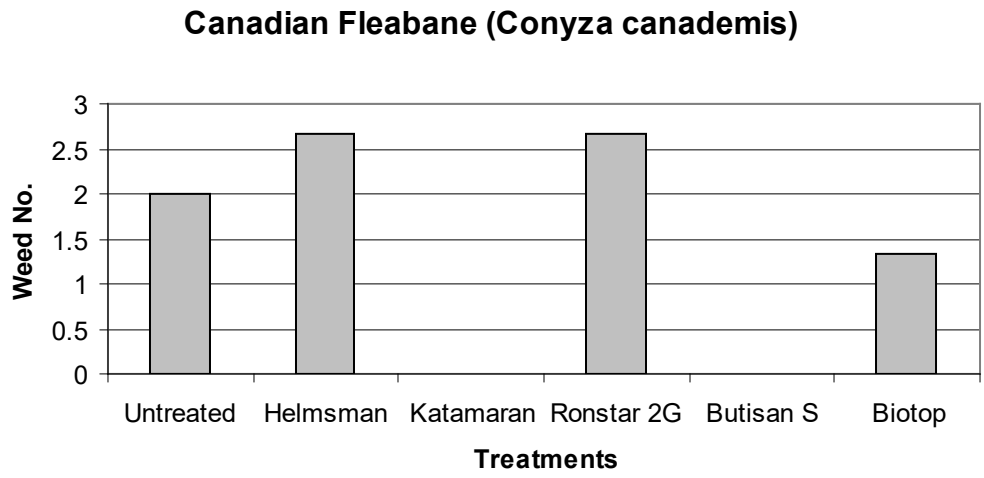
Fig 5 Weed Numbers 10 December 2002

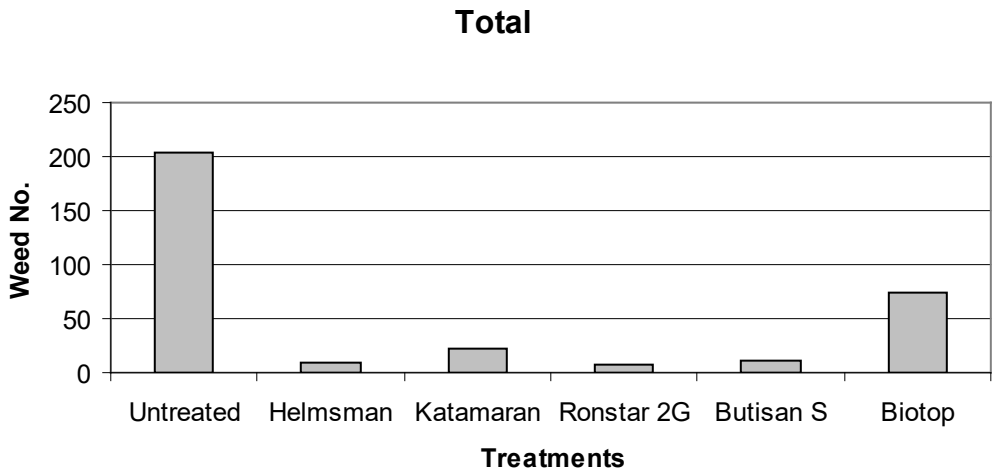


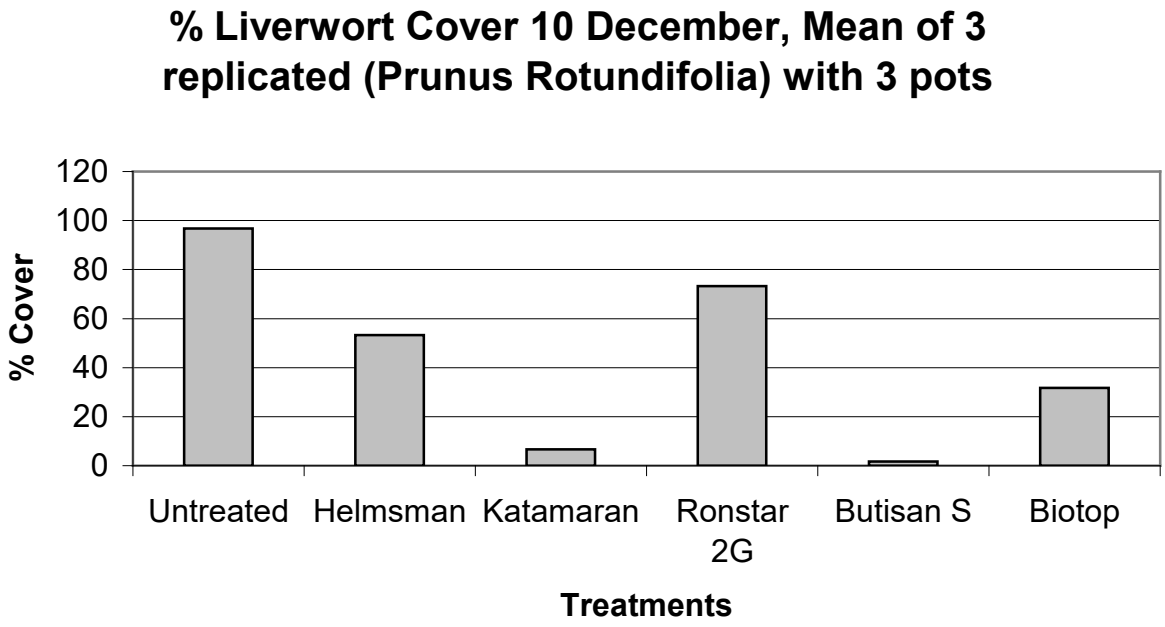
Mean of 3 replicates with 60 pots





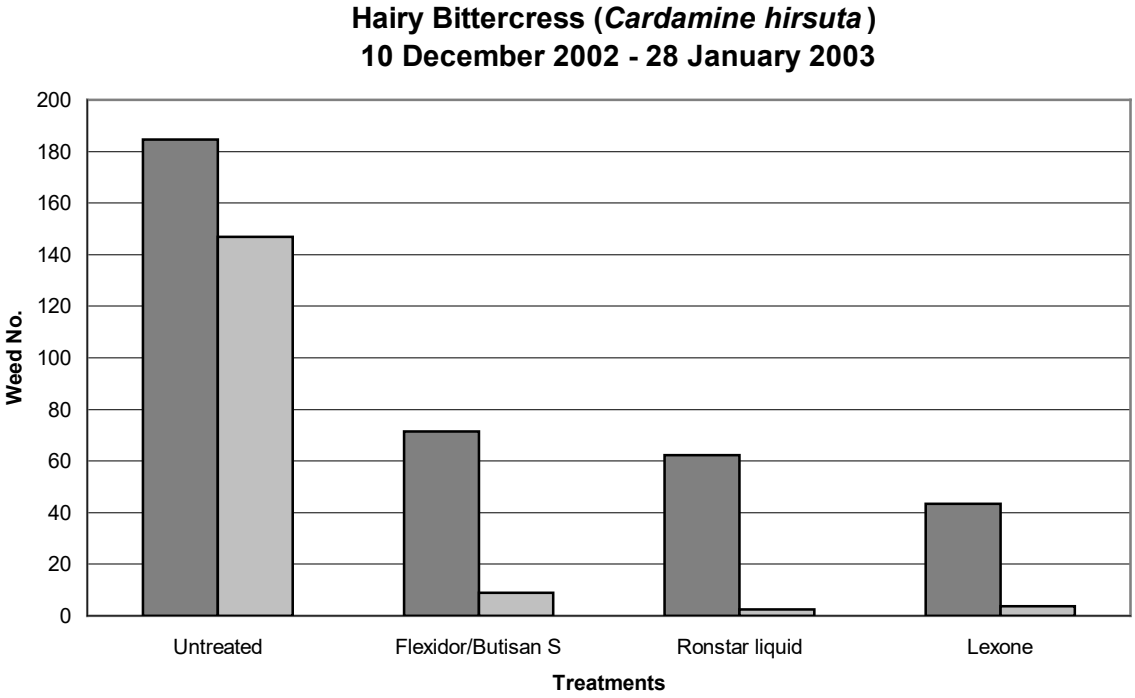






Post emergence winter herbicide treatment – Darby Nursery Stock
Fig 6 Weed Numbers 10 December – 28 January 2003

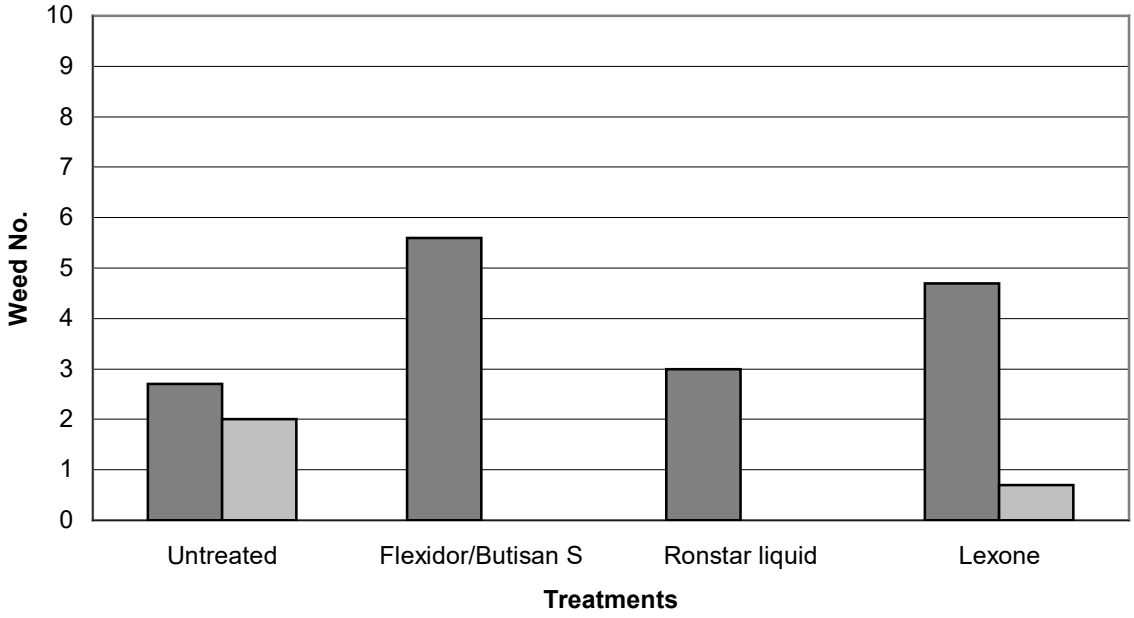
Mean of 3 replicates with 60 pots



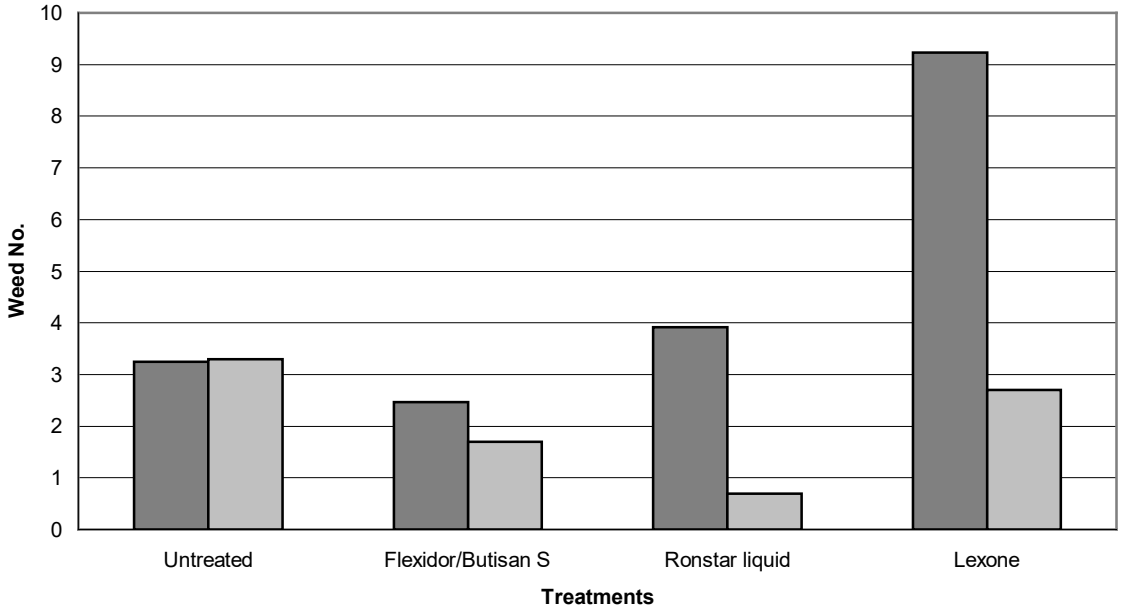
Key

10th December first column
28th Jan second column

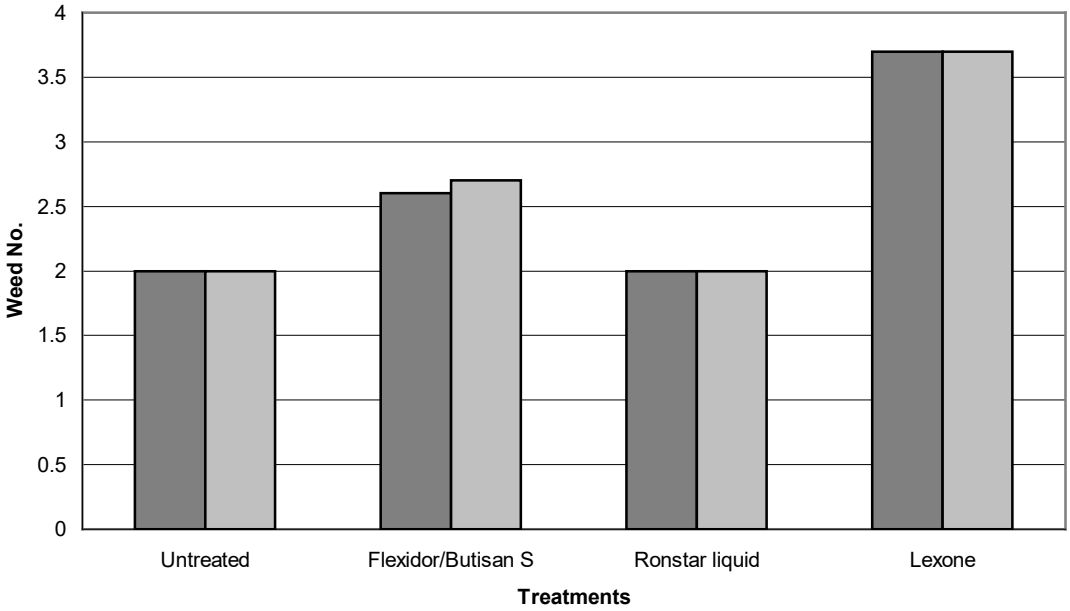
Groundsel (*Senecio vulgaris*)



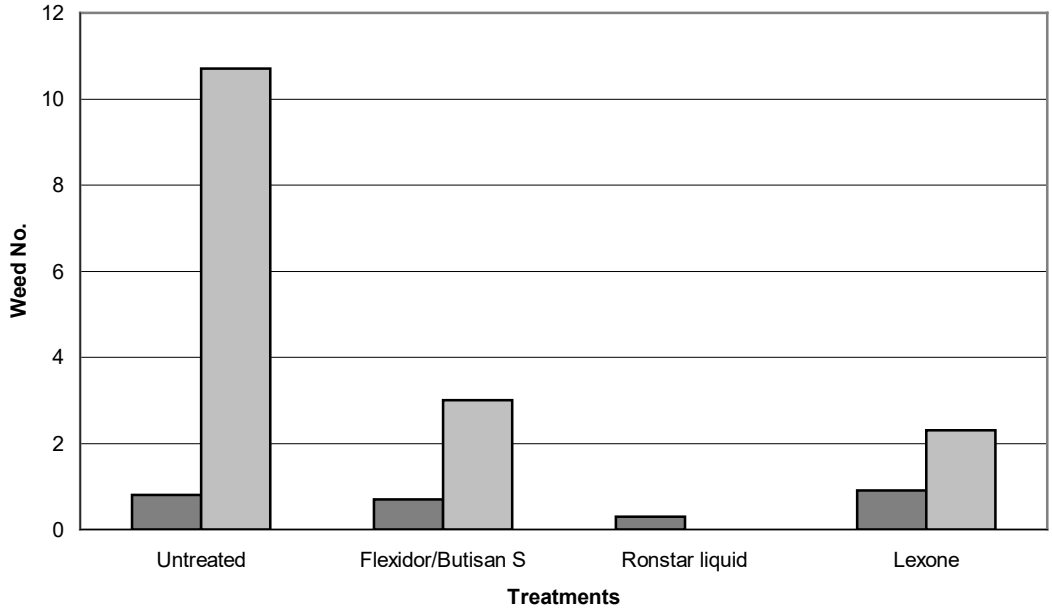
Sowthistle (*Sonchus oleraceus*)

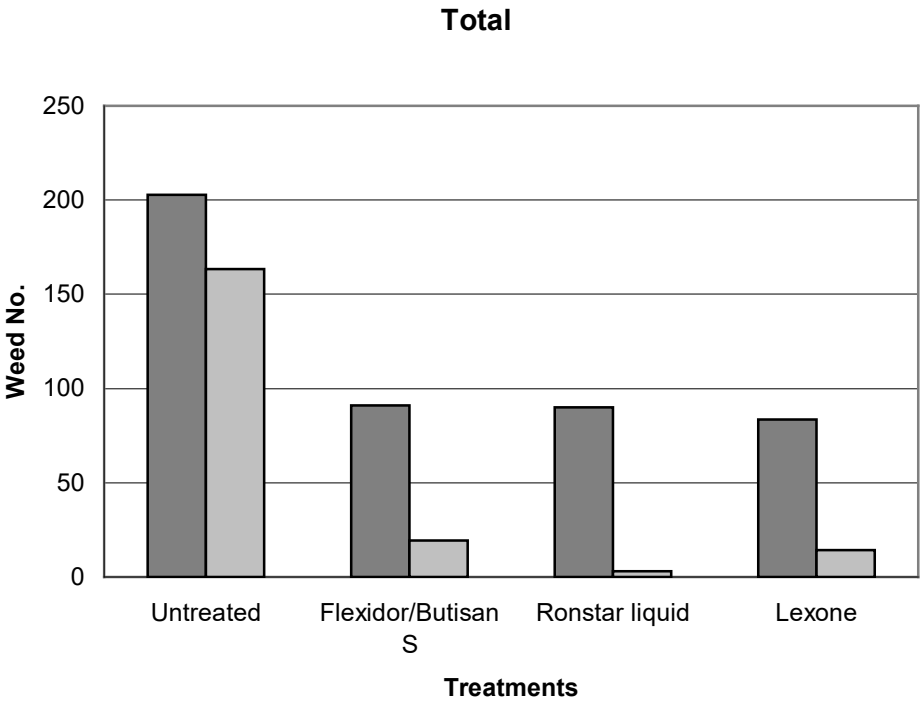


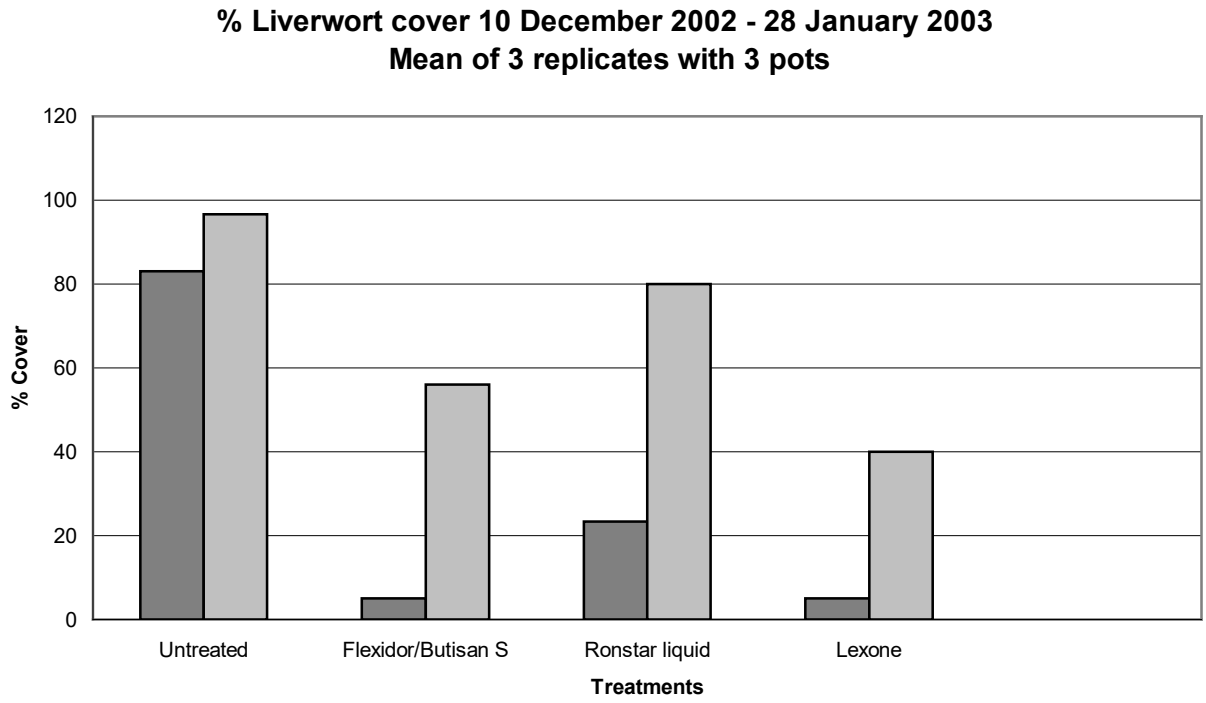
Canadian Fleabane (*Conyza canadenis*)



Willowherb (*Epilobium ciliatum*)







All 4 herbicide treatments applied after potting and in September gave good overall weed control, significantly better than the control. Differences between the 4 treatments were not significant, but Ronstar 2G appeared to give the best control of bittercress and good control of groundsel, the two predominant weeds. Helmsman performed similarly to Ronstar 2G, but gave less good control of bittercress and better control of groundsel.

The two metazachlor products Katamaran and Butisan S were slightly less effective in the control of bittercress and groundsel, but gave the best control of sowthistle and Canadian fleabane. Katamaran was less effective than Butisan S for groundsel control.

The mulch product Biotip reduced weed infestation by almost 50% but a significant number of Miscanthus grass seedlings emerged from the mulch (See Appx 4 fig 55)

The 3 post emergence winter herbicide treatments were applied to an existing seedling weed stand of predominantly bittercress and groundsel, together with willowherb, mouse-ear hickweed, annual meadow grass, sowthistle and Canadian fleabane. All treatments significantly reduced the overall weed numbers, by giving good control of bittercress and groundsel. There was no control of canadian fleabane from any of the treatments. The distribution of pearlwort and mouse-ear chickweed was too patchy for conclusions to be drawn. The Flexidor 125 + Butisan S treatment was most effective in controlling annual meadow grass and the Ronstar liquid treatment was particularly effective in controlling sowthistle. Willowherb continued to germinate between December and January. Ronstar liquid gave the best control with pre and post emergence action. Willowherb numbers increased on the Flexidor 125 / Butisan S and Lexone treatments, less than in the control plots, but these results could not be compared statistically due to a non-transformable skew in the data.

Of the post potting and September treatments, Butisan S gave the best control of liverwort, Katamaran performed almost as well, but was significantly different from Butisan S. Ronstar 2G gave a small but not significant reduction. Helmsman was slightly more effective, but significantly less effective than Butisan S.

For the winter treatments, the Flexidor 125 / Butisan S mix gave the best % reduction of liverwort followed by Lexone then Ronstar liquid.

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1. Weed Population

The pots were not seeded with weeds, so all assessments were made on the naturally occurring weed population at the site.

A limited range of weed species germinated following potting in early June, so that an assessment of overall weed cover could be made in September. Much of the weed recorded was present at the time of the second herbicide application on 11 September. The predominant weeds present were willowherb (*Epilobium ciliatum*), hairy bittercress (*Cardamine hirsuta*), groundsel (*Senecio vulagaris*) and New Zealand bittercress (*Cardamine flexuosa*).

2. Weed Control

Fig 7 below summarises the weed assessments. See Appx 2 for data from all weed assessments.

Titus gave very good weed control, the only weeds present at assessment were stunted willowherb and almost dead groundsel. Katamaran gave good control of willowherb, but allowed some bittercress and groundsel to develop, although some plots remained relatively clean (Appx 4 fig 69). Ronstar 2G maintained reasonable control of willowherb, but allowed some groundsel and bittercress of both species to develop.

The Flexidor plots contained a high level of willowherb, some groundsel, but no hairy bittercress, although some new zealand bittercress developed. Only Titus gave complete control of New Zealand bittercress

Phytotoxity Studies

Year 1 HRI Efford

A. Woody Species

No phytotoxity symptoms were observed on the shrubs with the mulch treatments.

None of the herbicides, apart from Lexone**,** showed any damage to the shrubs during the trial. The damage from Lexone was apparent following the initial herbicide treatments in summer 2001, where it caused significant scorch and some leaf drop on the *Buddleia*, scorch and interveinal chlorosis on the *Philadelphus* and yellowing and leaf drop on the *Euonymous* (Appx 4, P10-13). The *Vibernum* also showed signs of damage with the development of yellowing leaves. However, over autumn and winter *Vibernum* plants in all treatments began to develop brown patches on leaves, and generally looked sickly. Initially this was thought to be due to frosts and exposure overwinter, but plants were slow to grow away in spring. By early summer, at the end of the trial, *Viburnum* was diagnosed with the notifiable disease *Phytophthora ramorum* ('Sudden Oak Death' or 'Viburnum Wilt') and were destroyed.

Following the second and third herbicide applications, no further damage from Lexone was seen, and new shrub growth appeared normal. However, some *Euonymus* and *Buddleia* that had been severely affected the previous summer were of poorer final quality.

Height records on the *Chamaecyparis* were taken in November 2001 and May 2002, but showed no differences (data not shown).

Year 2 Experiments on Growers Nurseries – Darby Nursery Stock Ltd – Methwold

No phytotoxicity symptoms were noted on the shrubs with the mulch treatments.

Following application of the post potting herbicides (treatments 2-5) an observation for phytotoxicity was made in July 2002, 6 weeks after treatment. No damage was apparent from the Ronstar 2G treatment. Helmsman caused a small white blotching on Clematis, 2-3 leaves per plant affected, and a slight reduction in vigour. The two metazachlor containing products Katamaran and Butisan S caused leaf edge scorch to *Buddleia*, *Lavatera* and *Viburnum tinus* (Appx 4 fig 56). In addition Butisan S appeared to cause a small reduction in growth on *Erica darleyensi*.

The September application of herbicides did not cause any additional damage, and by this time the damage noted in July was no longer apparent, no further damage was noted by Spring 2003 from the post potting and September herbicide treatments.

Following application of winter (contact) herbicides, treatments 7-9 in December, observations for phytotoxicity were made in January and end of March.

The Flexidor 125 + Butisan S treatment only caused damage to *Buddleia* (Appx 4 fig 57), where tip yellowing was noted, this damage persisted into March.

Ronstar liquid caused a scorch to *Lavatera*, *Ceanothus* and *Choisya* (Appx 4 figs 58,59), all were in leaf at the time of spraying. *Lavatera* and *Ceanothus* suffered slight tip scorch, but grew away by end of March. Tip scorch to *Choiysa* was more persistent, plants remaining affected at end of March.

Lexone caused the most severe damage (Appx 4 figs 60-62), as with Ronstar liquid, only certain species in leaf at spraying were affected. *Lavandula*, *Escallonia*, *Vibernum* and *Ceanothus* were severely scorched and did not grow away. *Buddleia* suffered reduced leaf size.

No other growth differences were noted that were not associated with foliar scorch.

Across the trial the *Chamaecyparis* were affected by tip scorch and hardening. Contact treatments were equally affected, with no obvious treatment effect.

B. HERBACEOUS PERENNIALS

Year 1 HRI Efford

General growth

The constraints of the experimental design for this trial, meant that growing conditions (i.e. exposure and irrigation) were necessarily a compromise for all the species grouped together in herbicide treatment plots (Appx 4, P21). Some, such as *Hosta*, and *Primula* would have preferred some shade, and *Delphinium* more shelter from wind, for example. The hairy leaved *Stachys* were susceptible to wet conditions, and a number of plants were lost between potting and setting out on the trial bed, and plant numbers were reduced to 6 or 7 per plot for this subject. Further losses occurred overwinter in the trial. All others started with a full complement. By the final assessment in May 2002, the subjects with significant losses (in the Untreated plots) were *Verbascum* (43% dead), *Stachys* (40%), *Delphinium* (33%) and *Papaver* (13%). The *Lupinus* developed some serious *Colletotrichum* leaf spot disease in late summer 2001, and were removed from the trial.

Nevertheless, despite less than ideal growing conditions for some species, growth was generally good, and sufficiently healthy for growth and phytotoxicity effects of herbicide treatments to be assessed. Apart from the overall caveat about reporting results from a single year, results from *Verbascum*, *Stachys* and *Delphinium* below need cautious interpretation because of the poorer growth and survival of these subjects.

The objective of the herbaceous perennial part of the project was to assess phytotoxicity of herbicides, and not weed growth. Observations on control of any naturally occurring weed would have been made, but levels were low during the trial, and what little weed occurred was carefully removed by hand.

At the time of the final herbicide application in late February 2002, most subjects were beginning to show some new growth, either from previous overwintered shoots or rosettes, or with *Astilbe* as new shoots emerging from below compost level. *Hosta* was an exception with bare growing media at this stage. *Stachys Delphinium* and *Pulmonaria* also had little new growth. The main coverage of herbicide was still to the surface of growing media, however, in contrast to the first application where full foliage canopies were exposed to spray or granules. What shoot growth was present in February was also likely to have been less soft and less susceptible to any contact action damage from the chemical.

Phytotoxicity of herbicides

These results are summarised with symptoms, by herbicide, below. Figures 8 - 10 below summarise damage following the July 2001 assessment, size and proportion of dead plants record for *Papaver* in November and the final quality and dead plant record in May 2002. See also Appx 4 for examples of symptoms (P25-42) and final quality grades (P49-52).

Where relevant, reference is made to entries in the HDC handbook 'Practical Weed Control for Nursery Stock'.

Untreated
At the final assessment in May 2002, untreated plants of *Anemone* were showing white blotching on the leaves, and *Aster* and *Leucanthemum* were showing some leaf yellowing which caused some downgrading. Unless this was more severe on the herbicide treatments at this time these symptoms have not been commented on below. However, both foliage discolouration and size would have contributed to the final quality score on the same basis for all treatments. Thus a low final quality score for these subjects compared to the Untreated would have meant generally smaller plants.

Flexidor 125
This was one of the safest herbicide treatments tested. *Delphinium,* and *Anemone* showed yellowing or interveinal chlorosis, and *Verbascum* scorch following the summer herbicide spray. The final assessment in May 2002 reflected the earlier damage on *Anemone* with smaller plants, and *Verbascum* damage with 90% dead plants. However, for *Delphinium* final scores of surviving plants were no worse than the Untreated control.

There were some differences in our results for *Oreganum* and *Papaver* with the HDC handbook, where they are listed as susceptible. *Delphinium* is listed as moderately susceptible to Flexidor 125. *Anemone* is not listed as susceptible to Flexidor 125.

Helmsman
The typical symptoms seen on some weeds of white blotching of foliage was evident on *Verbascum, Anemone, Origanum, Delphinium* and *Potentilla* (leaf tips) following the first application of this granular herbicide. *Primula* was dull green with some necrosis on young leaves, and *Papaver* appeared slightly smaller and duller blue leaves. On some subjects, subsequent new growth was unaffected.

By the final assessment, *Delphinium* and *Papaver* both had 80% dead plants. *Anemone* were slightly smaller and *Primula* were smaller with 17% dead. Some white speckling was evident on *Astilbe* foliage. However *Geranium, Hosta, Oreganum, Penstemon, Potentilla, Pulmonaria,* and *Stachys* appeared relatively unaffected at this time.

Katamaran
There was little evidence of damage following the summer 2001 spray, apart from some slight leaf yellowing on *Aster* and *Penstemon*.

At the final assessment, there was some slight yellowing on *Penstemon* and *Asters* were also smaller on average although this was not statistically significant. *Astilbe* and *Delphinium* had some leaf scorch. The clearest evidence of phytotoxicity was with *Primula* where 43% were dead and the remaining plants stunted. *Verbascum* deaths (83%) were also higher than the control, although this was not statistically significant.

Katamaran on *Papaver* appeared to show a growth enhancement effect, with larger plants in November 2001, and May 2002, and few deaths overall. Interestingly the product label recommends this product for control of poppy weeds.

Lexone
As reflected with the shrubs, this was clearly the most damaging herbicide tested on the herbaceous perennials.

After the first summer spray, most subjects suffered either severe leaf scorch or significant yellowing. Exceptions at this time were *Origanum* and *Papaver*.

By the final assessment, all or nearly all *Astilbe, Delphinium, Pulmonaria* and *Stachys* were dead, with significant losses also in *Aster* (50%), *Primula* (30%), and *Verbascum* (87%). *Geranium, Origanum*, and *Papaver* had good final quality scores and were the only subjects with apparent tolerance.

Papaver showed an even more dramatic growth enhancement effect with Lexone than with Katamaran both in November and at the final assessment (Appx 4, P45-46). A curious phenomenon was also observed with *Hosta.* Following total foliage dieback overwinter, new foliage growth developed very much earlier in March than all the other treatments (Appx 4, P43-44). However, final plant size by May was smaller, with a lower quality score.

Ronstar 2G
Little phytotoxicity was seen in the month following the first granule application in June 2001 apart from some stunting and yellowing on *Aster* and some leaf marking on *Delphinium*.

By the final assessment, however, 83% of the *Papaver* and 27% of *Primula* had died, with the remaining *Primula* plants being smaller. *Delphinium* also had higher losses (60%) than the control.

Our results differed from the HDC handbook which states that *Papaver* and *Primula* are tolerant. There was agreement with *Delphinium* which it lists as susceptible. *Hosta* is stated as moderately susceptible, and *Oreganum* as susceptible, but no damage was observed in this trial.

Titus
This herbicide also appeared safe over most subjects tested.

No damage was evident following the first application. However 33% of *Papaver* had died by November 2001, and 73% by the final assessment. There was some indication of smaller size plants of *Oreganum, Potentilla* and *Primula,* but this was not statistically significant. *Primula* flower colour in March, however, was dramatically affected. The normal colour of c.v. 'Big Red Giant' is a deep pink / crimson, but these were a pale blue / mauve colour on Titus plots (Appx 4, P47-48).

Venzar
The summer 2001 application caused marked intervienal yellowing on *Leucanthemum, Potentilla* and *Astilbe*, and some leaf scorch on the latter two subjects. *Papaver* was most severely damaged though, with leaves scorched and dead plants evident within the first few weeks following treatment. Nearly all *Papaver* were dead by the November assessment.

At the final assessment, in addition to the total loss of *Papaver, Delphinium Astilbe* and *Leucanthemum* had deaths of 60% 30% and 7% respectively. The 10% losses of *Primula* were not statistically significant.

There was little evidence of interveinal yellowing on plants at this time. Although final quality scores for some subjects such as *Origanum*, *Potentilla*, and surviving *Astilbe* indicated smaller plants, they were not significant.

The results confirm tolerance of *Anemone, Aster, Geranium, Hosta,* and *Primula,* to Venzar as given in the HDC handbook, and in addition, *Penstemon, Pulmonaria, Stachys* and *Verbascum* appear to show tolerance. *Potentilla* and *Chrysanthemum* (related to *Leucanthumum*) are listed as moderately susceptible but normally grow away. Our results also supported *Delphinium* stated as susceptible. The handbook lists *Papaver* as 'tolerant but some cultivars have shown susceptibility', and clearly our c.v. 'Matador' was one of the latter.

Fig 8 Herbicide damage assessment July 2001
Score 1 = no damage, 2 = some damage, 3 = severe damage
Means across 3 replicates (10 plants per replicate)

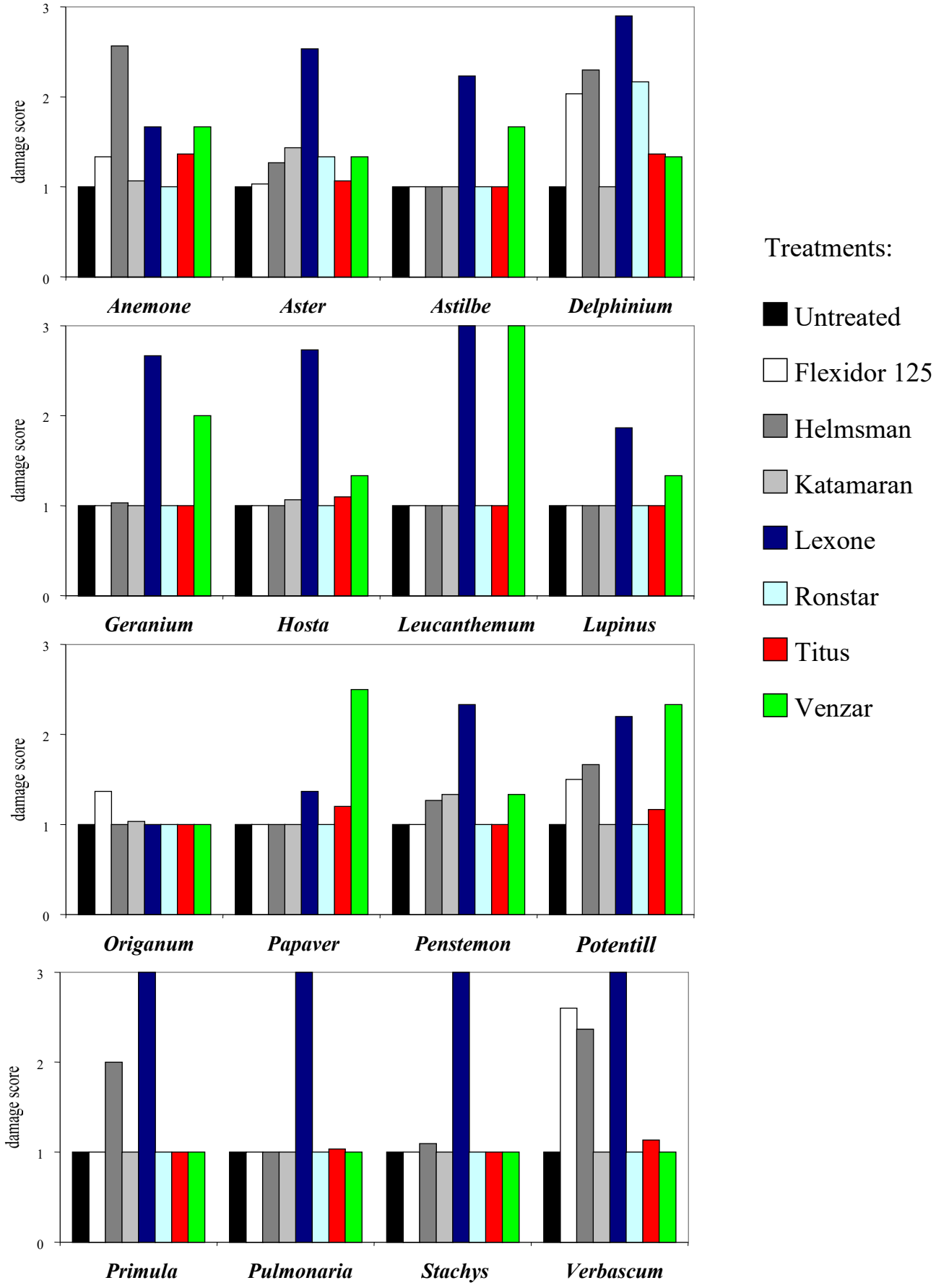


Fig 9 *Papaver* plant size and % dead plant assessment November 2001

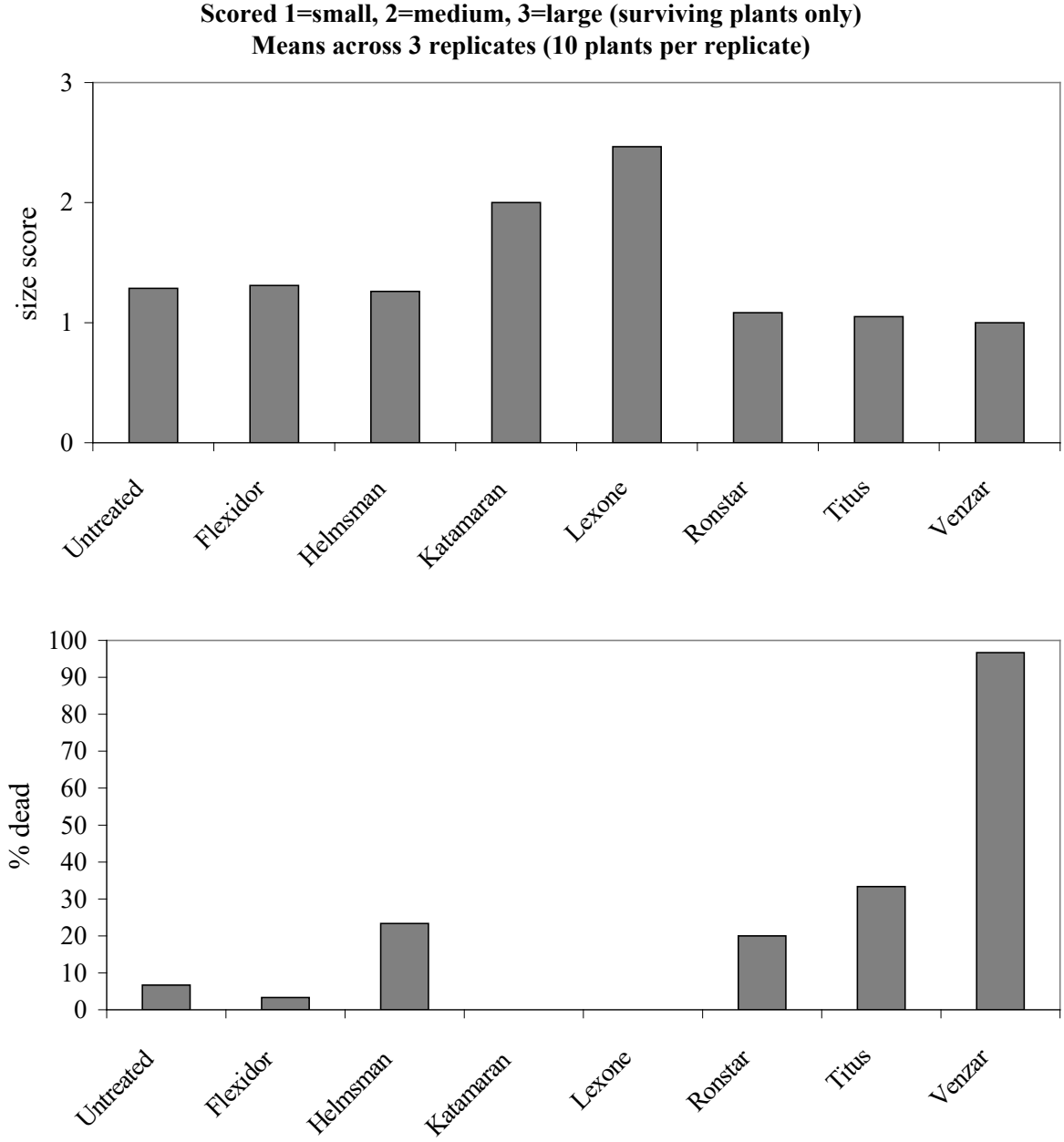


Fig 10 Size / quality of surviving plants and proportion dead at final assessment May 2002. Score 1 = poor, 5 = best except *Geranium, Hosta, Papaver & Penstemon* (score 1 - 3).

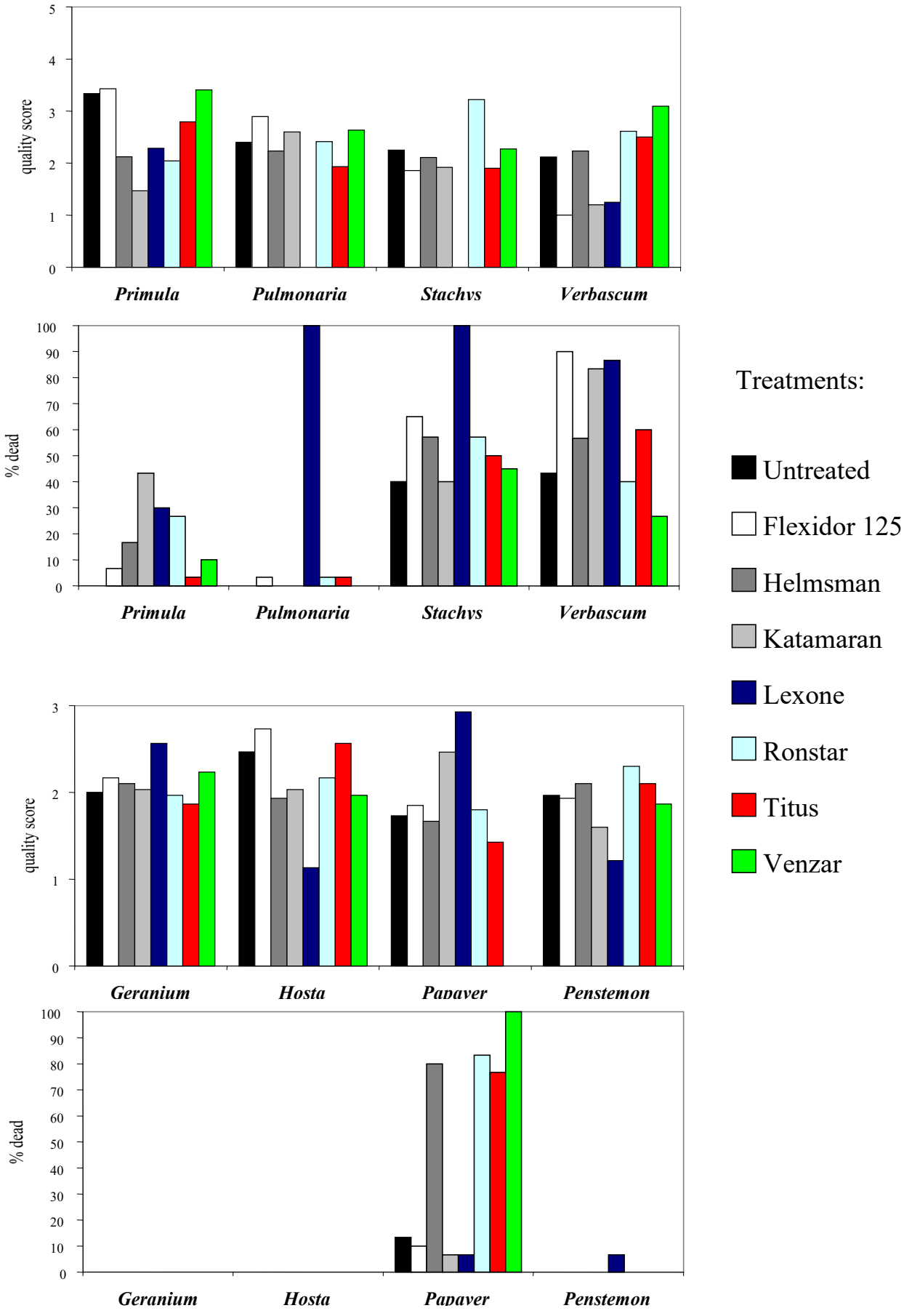
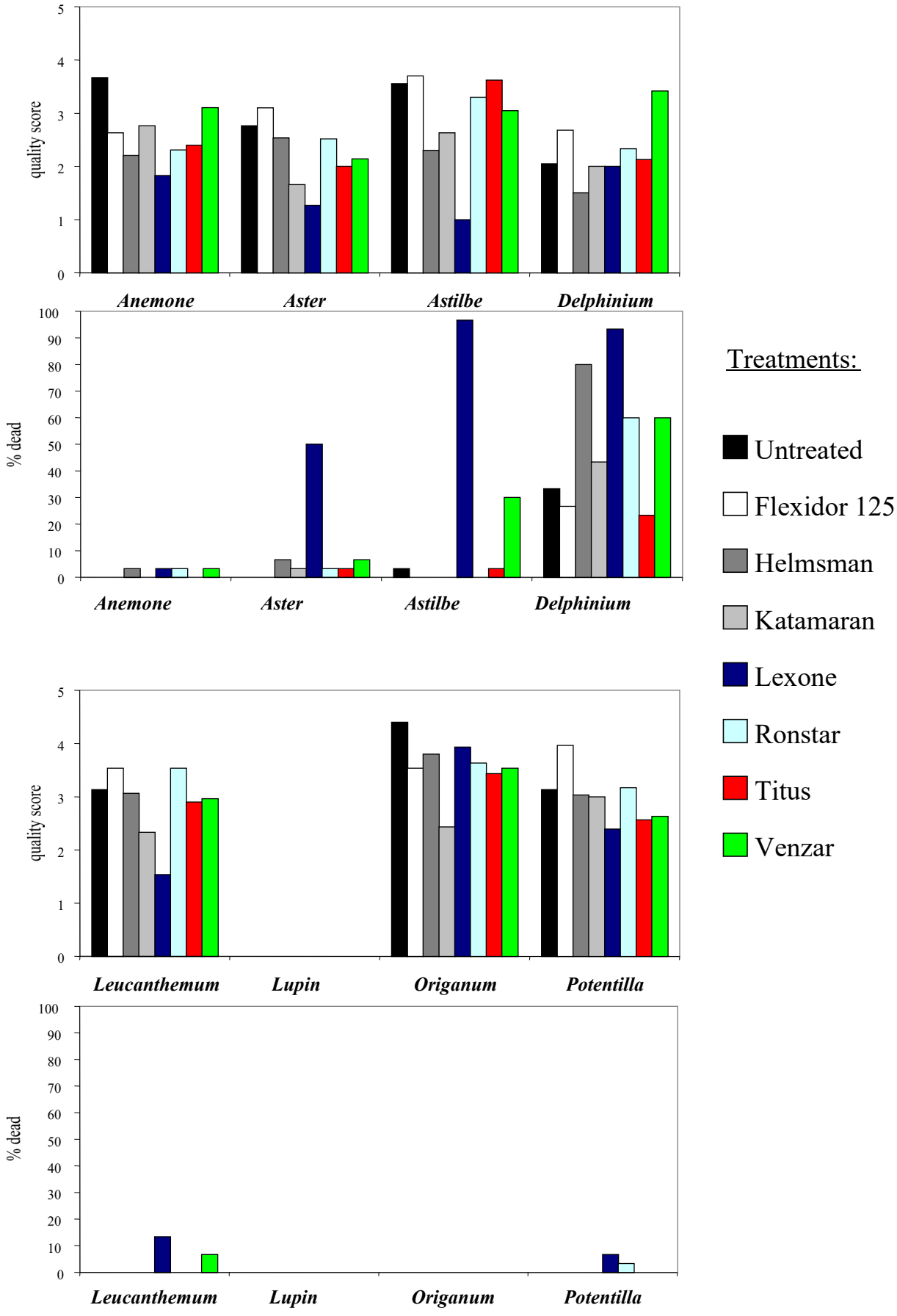


Fig 10 (continued)



Year 2 Experiments on Growers Nurseries

R A Meredith & Son (Blooms) Ltd

General Growth

Following establishment of the trial in June, some rabbit and slug damage was experienced on *Lupinus*, *Tradescantia*, *Monarda*, *Hosta*, *Hemerocallis* and *Pulmonaria*. However following netting and treatment with slug pellets growth on these subjects recovered in time for the vigour assessment in September.

A number of species failed to establish for other reasons. *Oreganum*, *Delphinium*, *Euphorbia*, *Phlox*, *Schizostyus* and *Aconitum* suffered plant losses and poor growth across the trial including the untreated control making treatment comparisons difficult on these subjects. For *Euphorbia* plants losses were attributed to *Phytophthora* root rot.

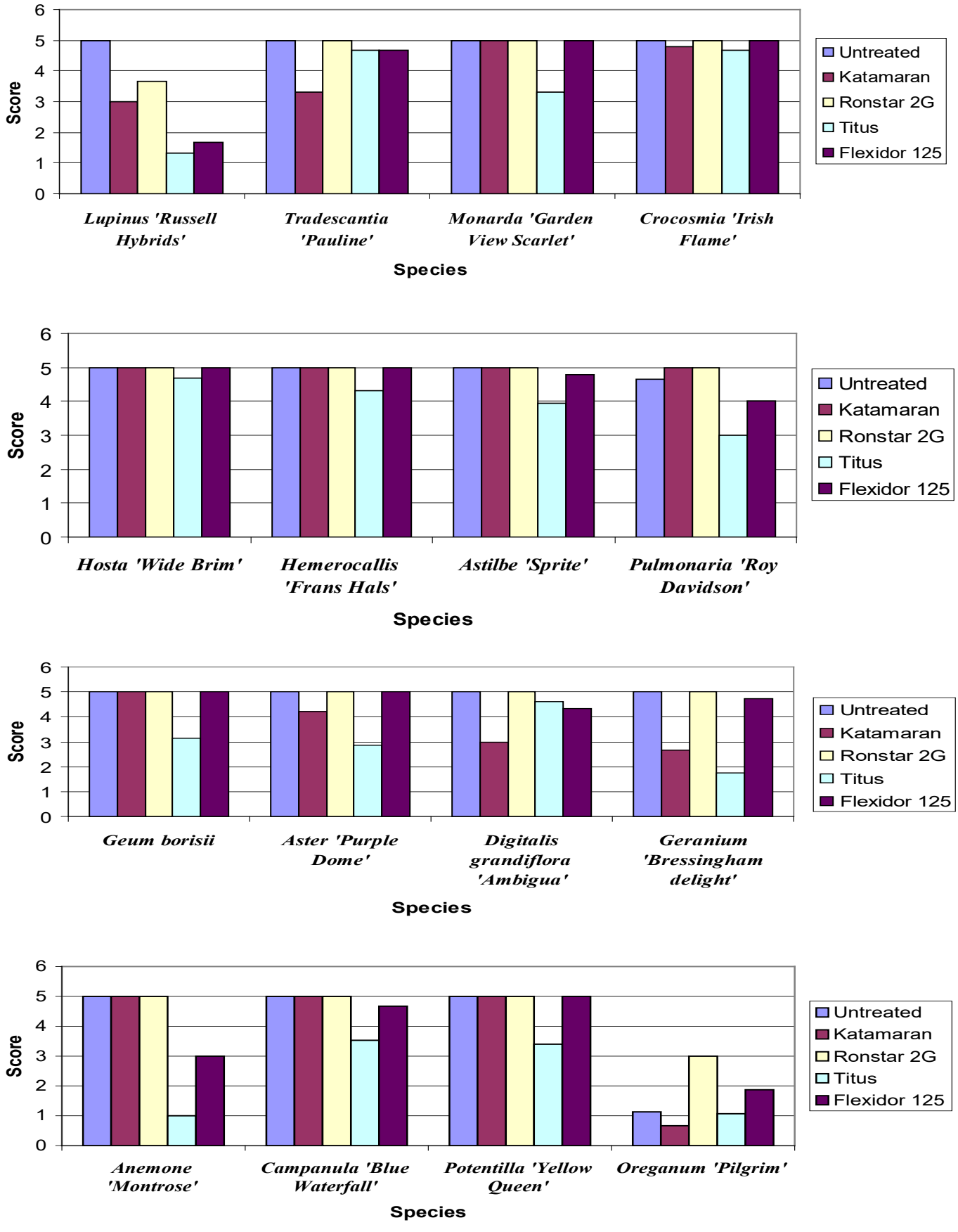
Other subjects established and grew normally on untreated control plots.

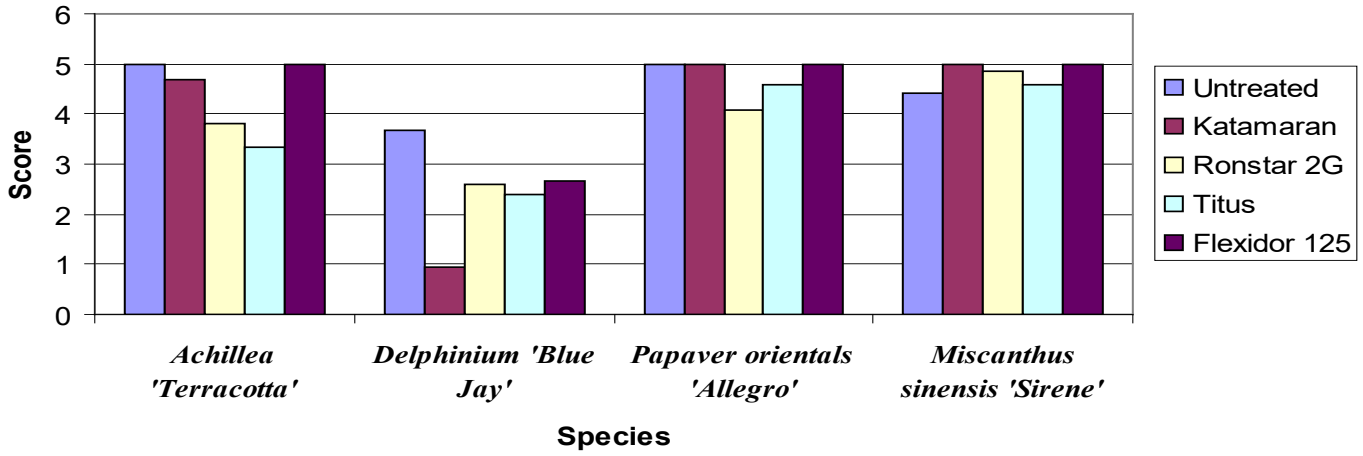
At the time of the first herbicide treatment in June, subjects had been just potted and were starting to grow away. By the time of the September herbicide treatment, all subjects were still in full leaf, but growth was slowing down and foliage was quite hard. A final assessment was made in April 2003 when most species were growing away following winter dormancy.

Phytotoxicity of Herbicides

These results are summarised with symptoms, by herbicide below. Figures 11 – 12 below summarise the phytotoxicity/quality scores following the September 2002 and April 2003 assessments.

Fig 11 size/quality/vigour assessments
R A Meredith & Son (Blooms) Ltd, 24th September 200





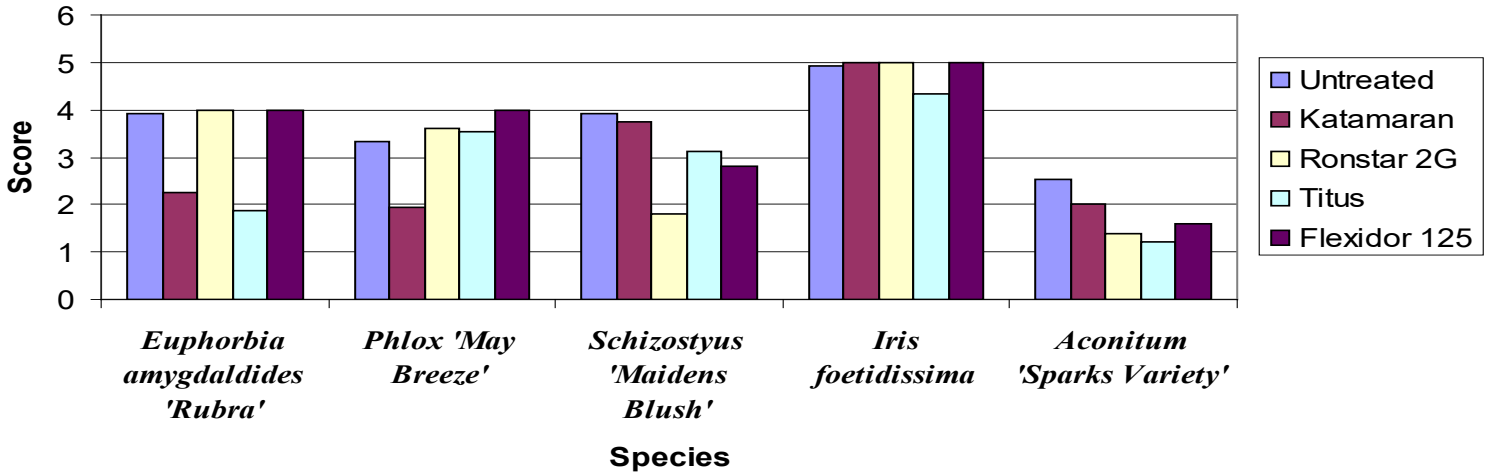
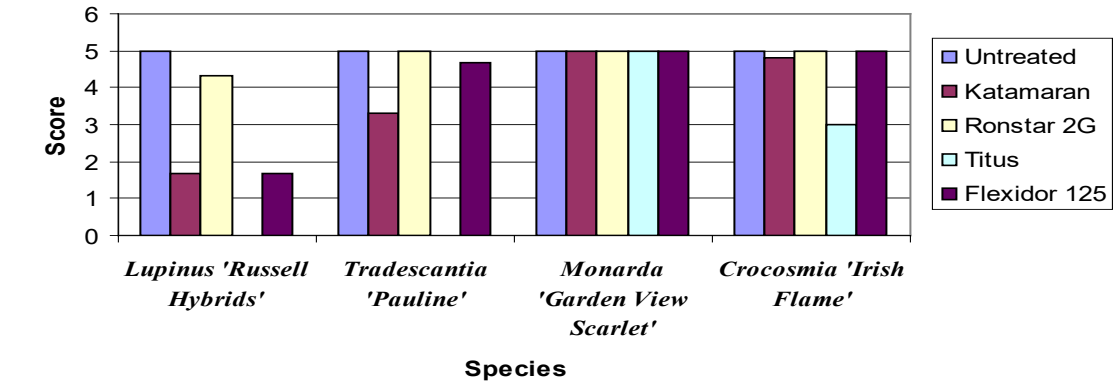
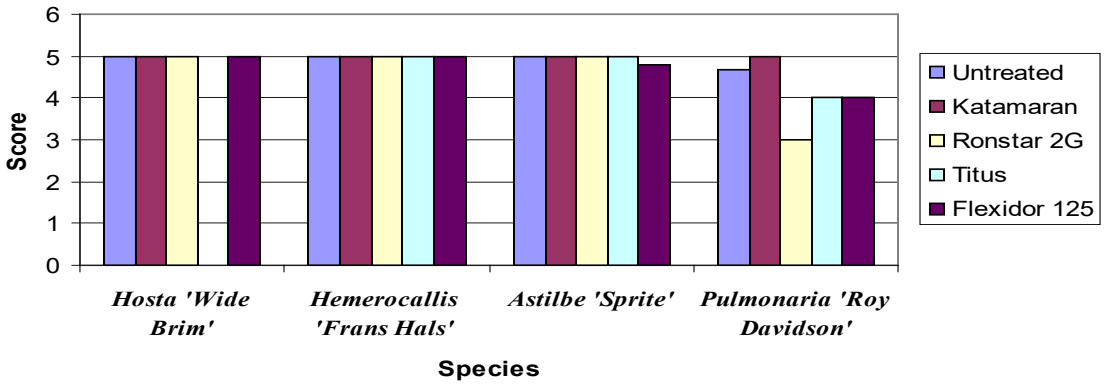
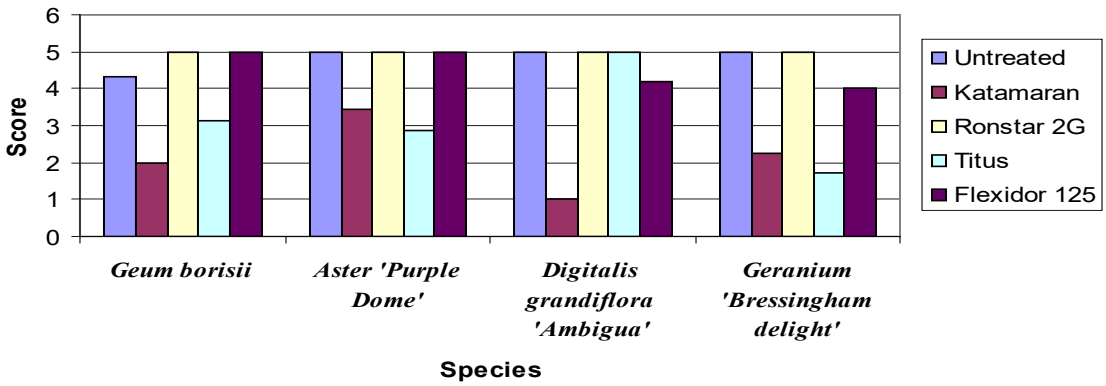
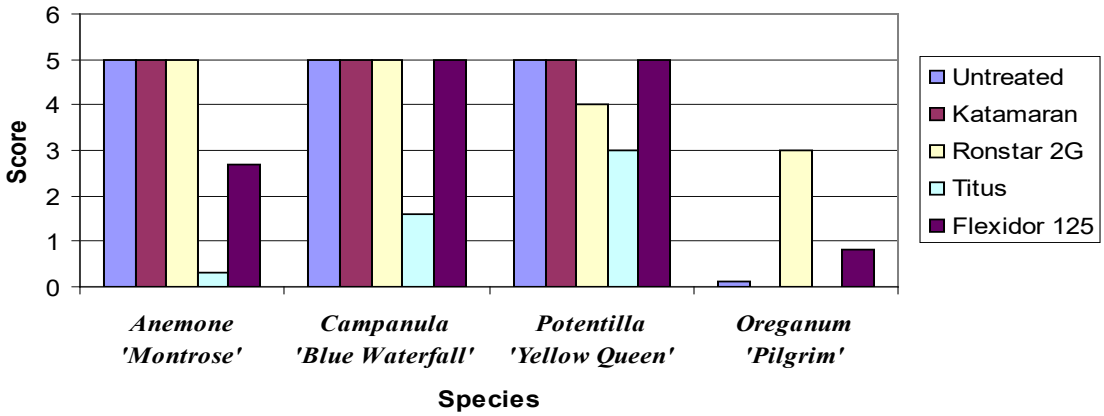


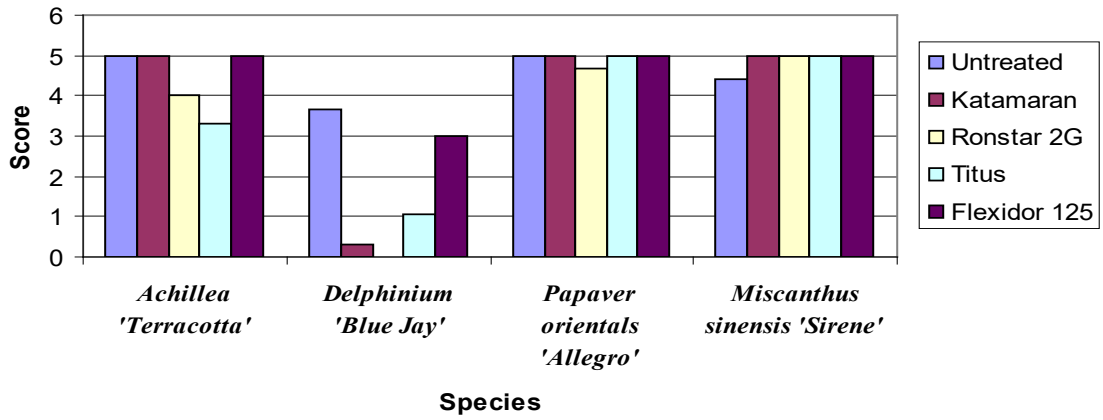
Fig 12 size/quality/vigour assessments
- R A Meredith & Son (Blooms) Ltd, 14th April 2003

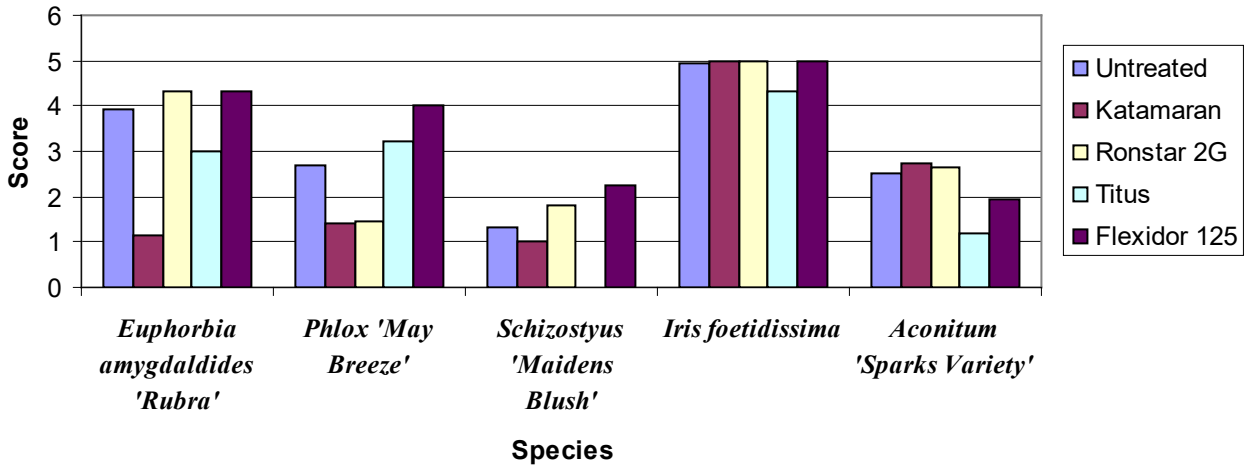












Katamaran

Following the summer 2002 post potting spray, *Delphineum* and *Hemerocallis* suffered leaf scorch and *Campanula* and *Oreganum* were reduced in size. Leaf scorch on *Delphineum* was also recorded in the 2001 trial. By September 2002 and following the second spray treatment, more scorch damage was apparent in *Delphineum* and in addition *Digitalis* and *Geranium* suffered tip distortion and reduced growth. *Hemerocallis* were unaffected by the second treatment. At the final assessment significant reduction in growth were noted in *Lupinus*, *Tradescantia*, *Geum*, *Aster*, *Digitalis*, *Geranium* and *Delphinium*. Results on *Oreganum*, *Euphorbia*, *Phlox*, *Schizostyus* and *Aconitum* were inconclusive due to the poor over-wintered growth of the untreated control plants. In general Katamaran proved slightly more damaging in this trial than in the HRI Efford 2001 trial. Papaver were unaffected by treatment as noted previously and may even have had growth enhanced

Ronstar 2G

Following treatment in summer 2002, very little conclusive damage was seen. *Phlox* plants were smaller however. By September the *Phlox* had recovered in size. *Delphinium* were yellowed and reduced in growth. There was a suggestion that *Schizostyus* and *Aconitum* suffered more plant losses compared with the control although this was not significant and by the April 2003 assessment general losses amongst these subjects made comparisons difficult. Overall, Ronstar 2G was one of the safest treatments. The successful use of Ronstar 2G on *Lupinus*, *Crocosmia*, *Astilbe*, *Geranium*, *Potentilla*, *Achillea*, *Euphorbia* and *Iris* confirms the information in the HDC Weed Control handbook. The successful use of Ronstar 2G on *Tradescantia*, *Monarda*, *Hemerocallis*, *Pulmonaria* and *Miscanthus* is new information that could warrant new entries in the handbook. As with the Year 1 HRI Efford data no damage occurred on *Hosta* whereas the HDC handbook states moderately susceptible.

The damage experienced on *Delphinium* confirms the "susceptible" rating given in the handbook. Successful results on *Geum* and *Digitalis* are at a variance with the "susceptible" rating given. Successful results on *Campanula* and *Hosta* possibly confirm the varietal nature of susceptibility. The lack of damage to *Papaver* confirms the handbook rating, but contrasts with damage experienced in the HRI Efford 2001 trial.

Titus

Titus proved to be quite damaging to the majority of subjects. *Lupinus*, *Tradescantia*, *Monarda*, *Achillea*, *Pulmonaria*, *Geum*, *Anemone*, *Campanula*, *Potentilla*, *Achillea*, *Delphinium*, *Papaver*, *Euphorbia*, *Phlox* and *Aconitum* all suffered substantial tip yellowing (Appx 4 figs 65-68). *Geraniums* were reduced in growth with plant losses. By the following spring (2003) *Monarda*, *Pulmonaria* and *Papaver* had recovered but all other previously affected species remained poor. The only species relatively unaffected by Titus were *Hemerocallis*, *Digitalis*, *Miscanthus*, *Hosta* and *Iris*. This is a contrast to the 2002 HRI Efford trial where Titus had been relatively safe to the herbaceous species tested including *Anemone*, *Aster*, *Astilbe*, *Delphinium*, *Geranium*, *Lupinus*, *Oreganum*, *Papaver* and *Pulmonaria* that were common to both trials.

Flexidor 125

As with the HRI Efford 2001 trial, Flexidor 125 proved a relatively safe treatment. Virtually no damage was noted following the post potting summer treatment. The *Digitalis* however, were slightly smaller at this stage. By September, and following the second treatment, more effects were noted.

Astilbe, *Pulmonaria*, *Geranium* and *Campanula* had slight yellowing in the tips. *Anemone* was much more yellowed with stunting (Appx 4 fig 71). *Digitalis* remained smaller and there were more plant deaths in the Flexidor 125 treated *Delphinium* plants. Results on *Lupinus*, *Oreganum*, *Phlox*, *Schizostyus* and *Aconitum* were inconclusive because of slug damage and other general plant losses.

By the spring (2003) *Astilbe*, *Pulmonaria*, *Geranium* and *Campanula* had recovered from the earlier yellowing. *Anemone* continued to be stunted and *Digitalis* were only marginally smaller than the control. Growth on all plants of *Lupinus*, *Oreganum*, *Phlox* and *Aconitum* was too variable to draw conclusive results. Surviving plants on the *Delphinium* and *Schizostyrus* appeared no worse than the control plants. Results on *Delphinium* are broadly similar to the HRI Efford 2001 trial where following some initial damage, plants recovered. *Delphinium* is listed as moderately susceptible in the HDC handbook, these results confirm this entry. *Anemone* is not listed as susceptible but both this trial and the earlier HRI Efford trial indicate susceptibility. Both this trial and the HRI Efford trial failed to indicate any adverse effect from Flexidor 125 on the *Papaver* variety tested. In other respects the 2002/03 results confirm the HDC handbook references for *Crocosmia*, *Hosta*, *Hemerocallis*, *Astilbe* (moderately susceptible), *Digitalis* (susceptible), *Geranium*, *Campanula* (varietal response), *Potentilla*, *Achillea*, *Euphorbia*, *Phlox* and *Iris* and new records for tolerance to Flexidor 125 are possible for *Tradescantia*, *Monarda*, *Pulmonaria* (moderately susceptible), *Miscanthus* and *Schizostyus*.

DISCUSSION

Herbicide efficacy and safety

The emergence of willowherb, mouse-eared chickweed and some groundsel in the HRI Efford 2002 trial prior to the first herbicide application, gave a good test of post-emergence activity of the herbicides for these weeds. Although no cotyledons or leaves of hairy bittercress were visible at this time, all herbicides, including the 'weak' products **Debut**, **Monitor** and **Titus**, gave significantly better control compared to the untreated. Also the better activity in June 2001 compared to the later dates for **Stomp 400SC** and **Katamaran**, suggests that bittercress was at a particularly sensitive stage of germination at the first application.

The year 2 grower site trials were not seeded for weed control efficacy, but useful natural population of hairy bittercress, groundsel, willowherb and other weeds developed at both sites. All post potting herbicide treatments gave significantly better weed control than the control. The winter contact treatments used at Darby Nursery Stock Ltd – **Lexone**, **Ronstar liquid** and **Flexidor 125**/**Butisan S** all significantly reduced the over wintered seedling weed population ad gave useful control of liverwort.

While **Katamaran** was not the most effective herbicide in the HRI Efford Year 1 Trial, it showed some post-emergence activity particularly against groundsel and willowherb, and some suppression of weed except bittercress following autumn / winter applications. Year 2 results showed good control of groundsel, although control of bittercress was not as good as **Butisan S** which was in turn less effective that industry standards **Ronstar 2G** and **Flexidor 125**.

From the results of the Year 2 it would not be possible to conclude that **Katamaran** was any safer to use than **Butisan S** (which also contains metazachlor albeit at a higher rate). Phytoxicity to shrubs in the Darby Nursery Stock Ltd trial was broadly similar to **Butisan S** and a number of herbaceous subjects were damaged at the R A Meredith & Sons (Blooms) Ltd herbaceous trial site.

Helmsman is a mix of three active ingredients, including oxadiazon the a.i of **Ronstar 2G**. It is important therefore to compare it with **Ronstar 2G** to see if the additional a.i.'s, carbetamide or diflufencican in **Helmsman** confer any advantage in weed control or additional phytotoxicity risks. In the Year 1 HRI Efford trial it gave excellent all-round performance on four of the five weed species. Its activity against already germinating groundsel was poor compared with **Ronstar 2G**. Product literature states that groundsel is only moderately susceptible (in open ground soils). However, groundsel was well controlled from the Sowings 2 and 3 in the HRI Efford trial, performing slightly better than **Ronstar 2G**, even allowing for the relatively low germination in the untreated controls It is not uncommon to find enhanced initial activity from herbicides when used in container grown crops compared with soil grown. The higher water content of the media may lead to enhanced activity, a result that has been noted previously with lenacil. **Helmsman** gave better control of mouse-ear chickweed and annual meadow grass than **Ronstar 2G** in the Year 1 HRI Efford trial, but the absence of these weeds in quantity at the Year 2 Darby Nursery Stock Ltd site meant that overall results for Year 2 were generally similar to **Ronstar 2G**. **Helmsman** was rather more effective for liverwort control than **Ronstar 2G**, but not as good as **Butison S**. **Helmsman** is currently only recommended for shrubs grown in the soil in amenity situations, but the lack of phytotoxicity on the range of woody species tested in this experiment, means it has potential for container grown shrubs. It has less potential with herbaceous subjects, particularly as a summer application resulted in the distinctive white blotching of foliage on a range of subjects in the Year 1 HRI Efford trial. Any use on container grown plants will currently be at grower's risk, but because of its good weed control it may be worth further trialling. Use on herbaceous crops is likely to be ruled out because of the risk of damage.

Stomp 400SC, Titus, Monitor and **Debut** generally gave disappointing weed control as a treatment for container-grown stock., but because **Titus** showed good safety with the herbaceous subjects tested in year 1, and because it showed some suppression of chickweed, bittercress and groundsel from the first application, it was decided it was worth re-trialling **Titus** in the Part 2 herbaceous nursery trial.

In the Year 2 R A Meredith & Son (Blooms) Ltd trial **Titus** was much more effective, giving excellent weed control, but unfortunately unacceptable levels of crop damage to many species. Only *Hemerocallis*, *Digitalis*, *Miscanthus*, *Hosta* and *Iris* were tolerant. As *Hemerocallis* , *Hosta* and *Iris* were important lines, the use of **Titus** on these crops could be a useful development, particularly as New Zealand bittercress was well controlled alongside all the other prevalent weeds at the site. The successful result on *Digitalis* is interesting as this crop is normally sensitive to herbicides, restricting the choice available to growers.

Titus had good post emergence activity on weeds so the availability of such a product could be useful but only on a limited range of crops. The very low product use rate could be problematical for growers applying the product to small areas.

Lexone was clearly too phytotoxic for consideration as a herbicide for herbaceous subjects, and also its damage to *Euonymus,* and *Buddleia* in particular makes it unsafe as a summer treatment for shrubs. Its weed control activity as a residual from autumn and winter applications was not as good as from the summer spray, and it was generally not effective against groundsel. However it gave good control of hairy bittercress and it was felt worth including it in the Year 2 nursery shrub trial as a dormant season treatment for deciduous subjects and conifers.

The performance as a winter treatment was disappointing however, contact weed control was not as good as the other treatments and more (evergreen) subjects were damaged.

Ronstar liquid performed well as a winter treatment in the Year 2 nursery shrub trial. Contact weed control was good , except for Canadian fleabane. Even though some of the deciduous subjects had some leaf on, and there were a number of evergreen subjects in the trial, the only subject scorched was *Lavatera*, *Ceanothus* and *Choisya* and only the *Choisya* remained significantly damaged by end of March. **Ronstar liquid** has good potential as an overall winter contact herbicide even on selected evergreen subjects.

The "standard" winter contact/residual treatment **Butisan S** / **Flexidor 125** also performed well, but the post emergence control of bittercress, sowthistle and willowherb was slightly better on the **Rontstar liquid** plots. Conversely **Butisan S** / **Flexidor 125** gave the best control on liverwort.

The standard **Ronstar 2G** / **Flexidor 125** combination was shown to remain a very effective and safe weed control treatment for shrubs. Both these products also have good safety on many perennials, but this trial did show some different phytotoxicity results to those stated in the HDC handbook for *Anemone, Papaver, Origanum, Primula* and *Hosta*. Cultivar differences could account for some of these discrepancies, but the tolerance rating for *Anemone* should be re-considered. Year 1 trial also gave useful confirmation of handbook entries and potential additional information for **Venzar.**

Mulches

Although not as effective as the best of the chemical treatments, where organic or pesticide free production methods are demanded, or with the withdrawal of many products in the long-term, mulches are an option that deserve further research and development. Of those tested here, while **Enviroguard** gave slightly better weed suppression than the others, currently **Biotop** is the only valid option commercially for containers because of its ease of handling.
The excessive swelling of **Terrastar** and to a lesser extent **Enviroguard** after watering, makes it difficult in practice to apply the correct depth of dry pellets to containers whether machine or hand potting. **Biotop** is also more readily available at present in the UK. **Terrastar** and **Enviroguard** would have much more potential as a mulch for landscaped areas.

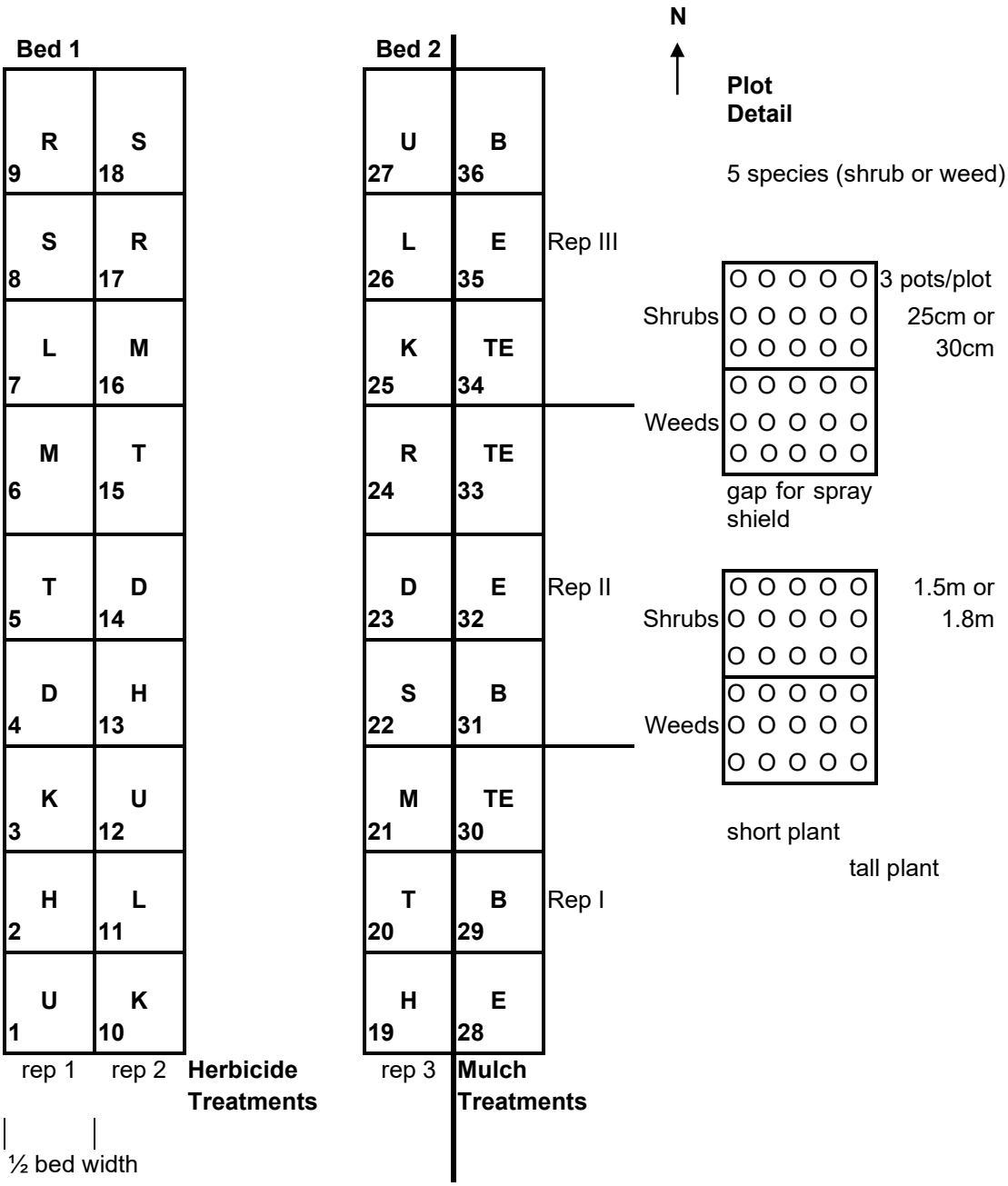
There have been reports of contamination with *Miscanthus* seedlings in **Biotop** from other trials. Clearly this is a quality control problem that needs to be addressed by the manufacturers.

The mulches were probably most effective in the first summer, because together with not having settled as much, the media surface would have been drier and therefore less favourable for seed germination, even following regular overhead irrigation applications. Later on, mulches would also have been less open after settling, particularly the **Terrastar**.

Mulches also have some potential for conserving water in the container during summer. This is being examined in the HDC project HNS 107a along with the effects of wetting agents for improving water management within growing media. Preliminary results have shown that **Cocoshell** and **Cambark 100** are more effective at conserving moisture within growing media than **Enviroguard** and **Biotop**. These latter materials are more water absorbent, and can more easily maintain a capillary link with the growing media and therefore not reduce surface evaporative losses as well. **Cocoshell** and bark have been examined in previous non-chemical weed control trials, and found to give some weed suppression, but not be effective enough to replace herbicides for most commercial situations.

Appendices

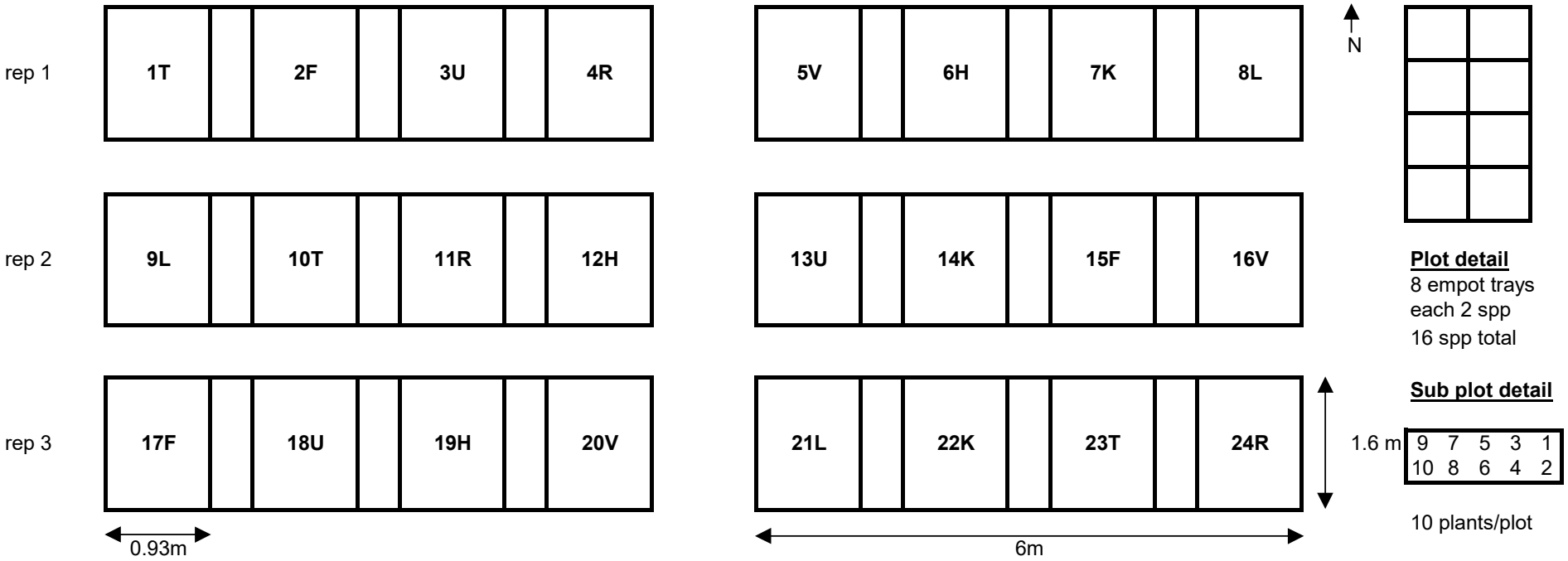
APPENDIX 1a - HNS Woody Species Trial Layout – HRI Efford Year 1



Treatment Key :

U - Untreated	D - Debut	M - Monitor	B - Biotop
	H - Helmsman	R - Ronstar 2G	E - Enviroguard
	K - Katamaran	S - Stomp 400SC	TE - Terrastar
	L - Lexone	T - Titus	

APPENDIX 1b - Herbaceous Perennials Trial Layout – HRI Efford Year 1



Plot detail
8 empot trays
each 2 spp
16 spp total

Sub plot detail

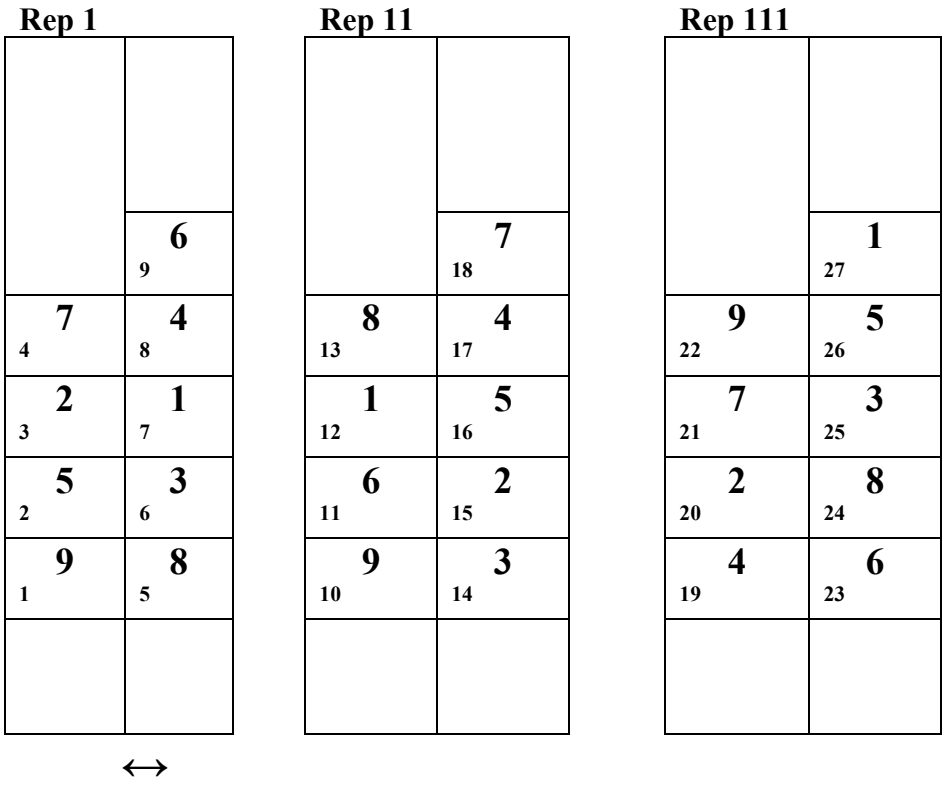
10 plants/plot

Herbicide Treatments

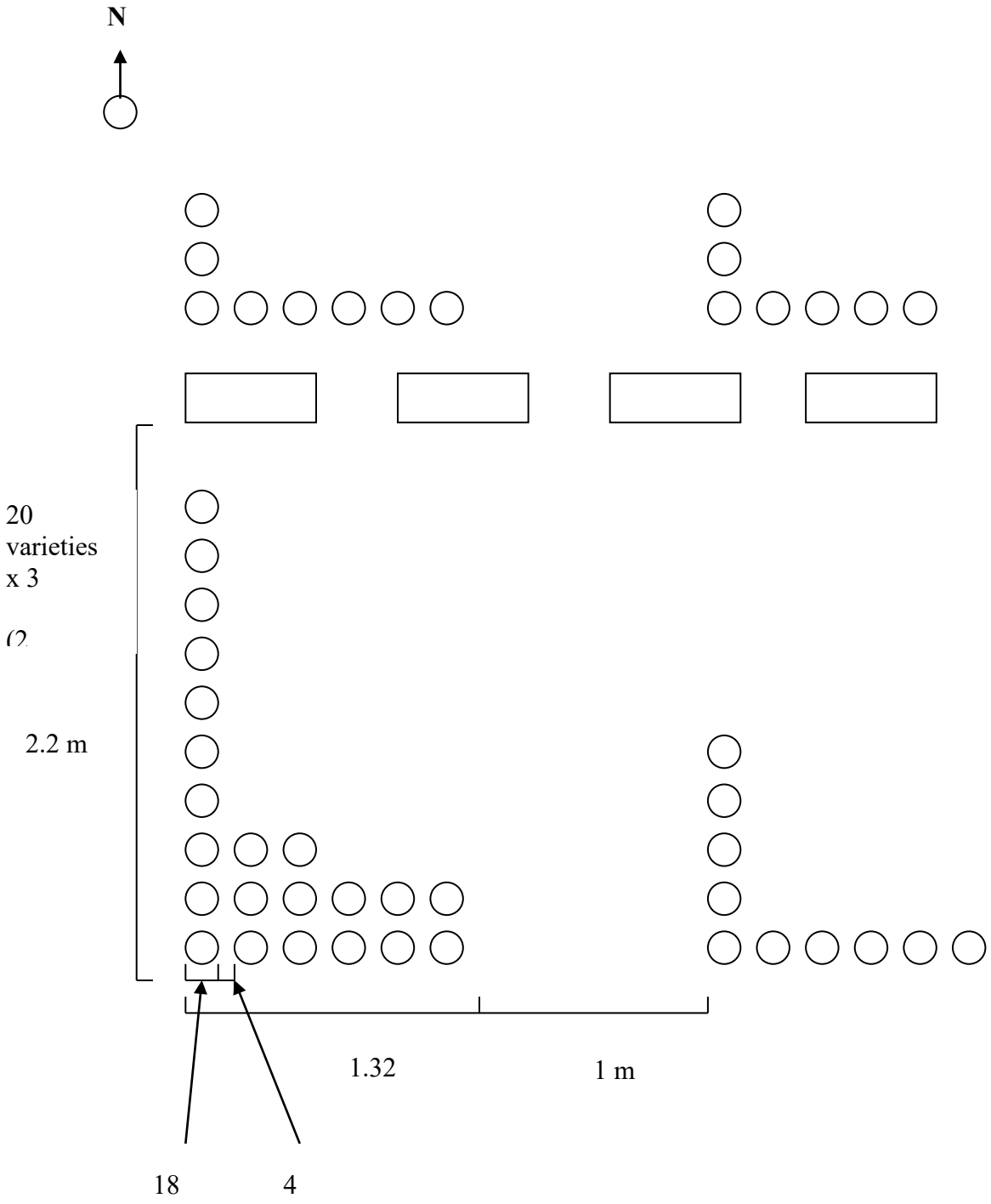
U = UNTREATED	K = KATAMARAN
R = RONSTAR 2G	H = HELMSMAN
F = FLEXIDOR 125	T = TITUS
V = VENZAR	L = LEXONE

APPENDIX 1c – HNS Woody Species Trial Layout – Darby Nursery Stock Ltd (Year 2)

N ←O



Plant Layout Darby Nursery Stock (year 2)



Appendix 1d – Herbaceous Species Trial Layout – R A Meredith & Sons (Blooms) Ltd – (Year 2)

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N

12m

Block 1

5	**1**	**3**	**2**	**4**
5	4	3	2	1

Block 3

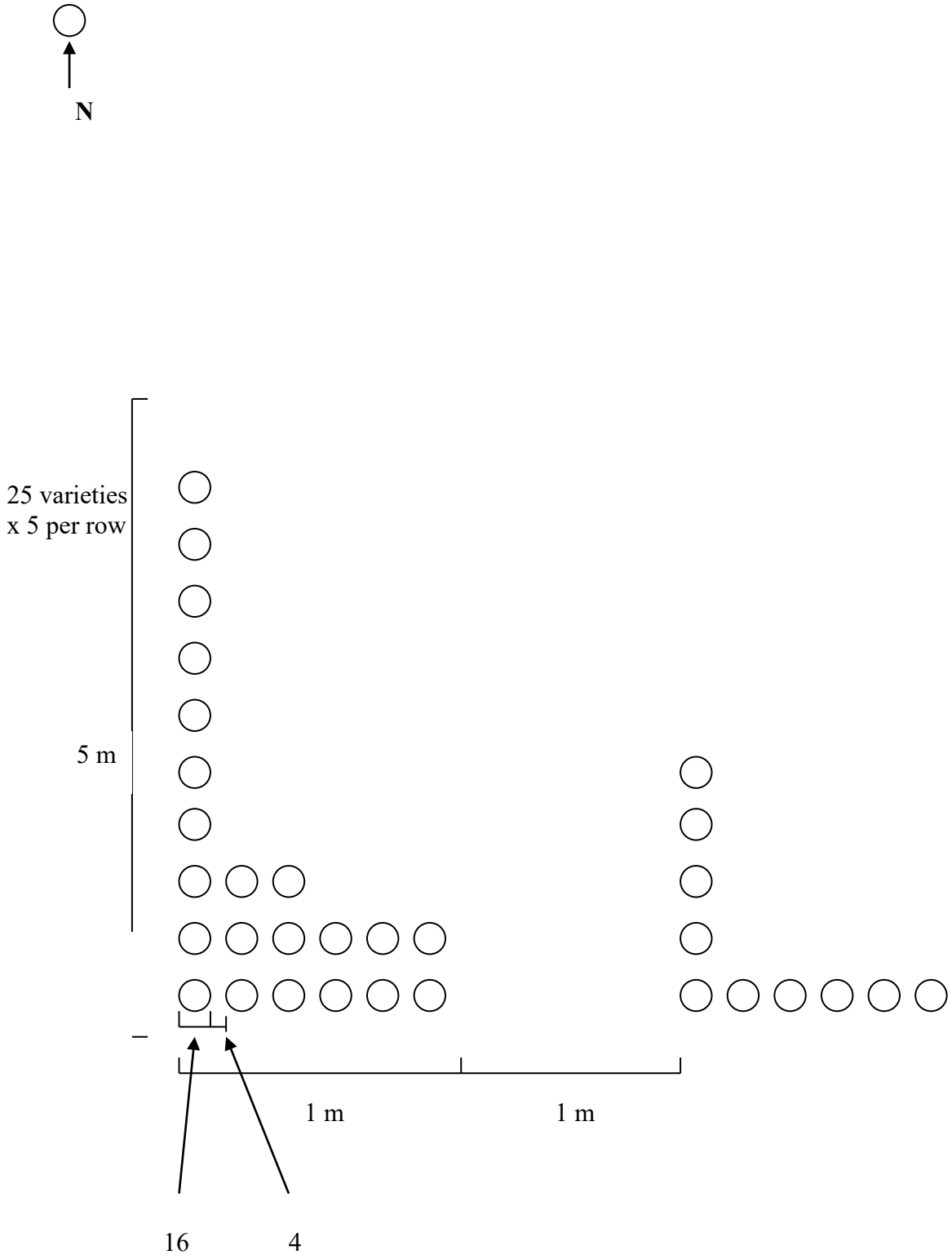
3	**1**	**2**	**4**	**5**
15	14	13	12	11

Block 2

1	**3**	**4**	**5**	**2**
10	9	8	7	6

Main Pathway

Plant Layout R A Meredith & Sons (Blooms) Ltd (year 2)



APPENDIX 2

Table 1 **Weed assessments - *Cardamine hirsuta* (hairy bittercress) (HRI Efford Year 1)**

Figures are a mean across 3 replicates (3 pots per replicate)

Weeds removed at each record

		Weed sowing 1 1st herbicide application 14th Jun 01		Weed sowing 2 2nd herbicide application 28th Sept 01				Weed sowing 3 3rd herbicide application 15th Feb 02			
Code	**Treatment**	**% pot cover early July 01**	***Transformed data (angular transformation)***	**No. of weeds early Nov 01**	***Transformed data (square roots)***	**No. of weeds mid Jan 02**	***Transformed data (square roots)***	**No. of weeds mid April 02**	***Transformed data (square roots)***	**No. of weeds mid May 02**	***Transformed data (square roots)***
U	Untreated	**60.0**	*50.90*	**67.0**	*14.30*	**8.4**	*4.95*	**131.8**	*19.79*	**12.9**	*6.21*
D	Debut	**8.3**	*16.60*	**85.9**	*16.00*	**14.0**	*6.40*	**170.9**	*22.56*	**14.9**	*6.65*
H	Helmsman	**4.4**	*10.85*	**0.0**	*0.00*	**0.0**	*0.00*	**0.0**	*0.00*	**0.0**	*0.00*
K	Katamaran	**12.8**	*20.56*	**83.4**	*15.56*	**19.7**	*7.19*	**144.7**	*20.73*	**18.1**	*7.34*
L	Lexone	**0.0**	*0.00*	**20.6**	*7.71*	**3.7**	*3.26*	**19.0**	*7.24*	**3.4**	*2.96*
M	Monitor	**1.2**	*4.52*	**160.7**	*21.87*	**21.2**	*7.96*	**139.7**	*20.45*	**9.0**	*5.07*
R	Ronstar 2G*	**1.4**	*6.80*	**0.0**	*0.00*	**0.2**	*0.60*	**0.8**	*1.49*	**0.6**	*1.24*
S	Stomp	**13.9**	*21.69*	**111.2**	*18.24*	**17.7**	*7.15*	**105.7**	*17.25*	**14.3**	*6.38*
T	Titus	**0.7**	*3.83*	**119.0**	*18.81*	**24.4**	*8.56*	**143.8**	*20.76*	**10.7**	*5.56*
B	Biotop	**7.8**	*14.64*	**57.1**	*13.00*	**44.9**	*11.50*	**31.3**	*9.50*	**20.7**	*7.87*
E	Enviroguard	**11.1**	*17.87*	**12.2**	*5.56*	**Missing data**	-	**4.7**	*3.35*	**8.3**	*4.95*
TE	Terrastar	**10.1**	*17.54*	**20.1**	7.57	**53.7**	*12.56*	**30.4**	*9.53*	**18.3**	*7.32*
	SED (16 df)		*2.046*		*1.603*		*1.156*		*2.116*		*0.937*
	LSD (5%) for chemicals		*4.36*		*3.41*		*2.46*		*4.51*		*2.00*
	SED (4 df)		*7.506*		*2.086*		*1.269*		*1.688*		*0.783*
	LSD (5%) for mulches		*20.87*		*5.80*		*3.53*		*4.69*		*2.18*

* Flexidor 125 applied in Sept.01

APPENDIX 2

Table 2 **Weed assessments - *Cerastium fontanum* (mouse-ear chickweed) (HRI Efford Year 1)**

Figures are a mean across 3 replicates (3 pots per replicate)

Weeds removed at each record

Code	Treatment	Weed sowing 1 1st herbicide application 14th Jun 01		Weed sowing 2 2nd herbicide application 28th Sept 01				Weed sowing 3 3rd herbicide application 15th Feb 02			
		% pot cover early July 01	Transformed data *(angular transformation)*	**No. of weeds early Nov 01**	***Transformed data (square roots)***	**No. of weeds mid Jan 02**	***Transformed data (square roots)***	**No. of weeds mid April 02**	Transformed data (square roots)	**No. of weeds mid May 02**	***Transformed data (square roots)***
U	Untreated	**40.0**	*39.07*	**34.9**	*9.67*	**4.3**	*3.33*	**261.1**	*27.12*	**12.2**	*5.20*
D	Debut	**42.8**	*40.80*	**40.4**	*10.92*	**2.4**	*2.70*	**159.7**	*21.64*	**5.3**	*3.87*
H	Helmsman	**12.8**	*20.30*	**0.0**	*0.00*	**0.1**	*0.33*	**2.9**	*2.79*	**0.4**	*0.67*
K	Katamaran	**8.8**	*16.50*	**14.2**	*5.33*	**2.2**	*2.04*	**41.7**	*10.01*	**4.2**	*3.44*
L	Lexone	**0.0**	*0.00*	**72.6**	*13.07*	**18.1**	*6.93*	**52.6**	*9.10*	**3.1**	*1.76*
M	Monitor	**18.9**	*25.59*	**68.1**	*13.94*	**7.7**	*4.75*	**186.1**	*21.54*	**4.2**	*3.37*
R	Ronstar 2G*	**23.3**	*28.77*	**1.4**	*1.20*	**0.8**	*1.47*	**103.4**	*16.69*	**8.9**	*5.12*
S	Stomp	**8.3**	*16.60*	**22.9**	*7.73*	**0.8**	*1.22*	**44.1**	*11.36*	**0.7**	*1.14*
T	Titus	**7.2**	*15.24*	**54.3**	*12.07*	**13.1**	*6.04*	**105.8**	*16.72*	**2.1**	*2.28*
B	Biotop	**6.2**	*13.83*	**21.9**	*7.99*	**15.6**	*6.22*	**40.2**	*10.60*	**5.4**	*3.84*
E	Enviroguard	**8.3**	*15.70*	**16.7**	*6.97*	**Missing data**	-	**14.7**	*6.10*	**6.1**	*3.90*
TE	Terrastar	**6.7**	*14.76*	**15.1**	6.17	**11.2**	*5.64*	**96.3**	*16.00*	**7.2**	*4.64*
	SED (16 df)		*2.303*		*3.507*		*1.281*		*4.182*		*1.413*
	LSD (5%) for chemicals		*4.91*		*7.47*		*2.73*		*8.91*		*3.01*
	SED (4 df)		*4.534*		*2.058*		*1.444*		*3.59*		*1.079*
	LSD (5%) for mulches		*12.60*		*5.72*		*4.01*		*9.98*		*3.00*

* Flexidor 125 applied in Sept.01

APPENDIX 2

Table 3 **Weed assessments - *Epilobium ciliatum* (American willowherb) (HRI Efford Year 1)**

Figures are a mean across 3 replicates (3 pots per replicate)

Weeds removed at each record

		Weed sowing 1 1st herbicide application 14th Jun 01		Weed sowing 2 2nd herbicide application 28th Sept 01				Weed sowing 3 3rd herbicide application 15th Feb 02			
Code	**Treatment**	**% pot cover early July 01**	***Transformed data (angular transformation)***	**No. of weeds early Nov 01**	***Transformed data (square roots)***	**No. of weeds mid Jan 02**	***Transformed data (square roots)***	**No. of weeds mid April 02**	**Transformed data (square roots)**	**No. of weeds mid May 02**	***Transformed data (square roots)***
U	Untreated	**79.4**	*64.24*	**127.7**	*18.79*	**38.0**	*9.72*	**212.9**	*24.82*	**30.1**	*9.32*
D	Debut	**42.2**	*40.15*	**86.1**	*15.71*	**30.4**	*9.53*	**188.7**	*23.75*	**43.3**	*11.22*
H	Helmsman	**8.1**	*15.75*	**0.8**	*0.88*	**0.3**	*0.58*	**1.6**	*1.68*	**2.7**	*2.67*
K	Katamaran	**3.1**	*9.93*	**43.2**	*11.31*	**31.6**	*9.69*	**94.8**	*16.81*	**31.8**	*9.70*
L	Lexone	**0.0**	*0.00*	**109.6**	*17.83*	**34.6**	*10.08*	**67.7**	*14.09*	**21.3**	*7.77*
M	Monitor	**27.2**	*30.71*	**161.7**	*22.01*	**30.7**	*9.58*	**184.0**	*23.38*	**34.6**	*10.11*
R	Ronstar 2G*	**7.7**	*15.27*	**0.0**	*0.00*	**8.6**	*5.03*	**1.4**	*1.49*	**4.9**	*3.77*
S	Stomp	**50.0**	*44.87*	**103.1**	*17.48*	**35.8**	*10.13*	**136.2**	*20.19*	**30.1**	*9.50*
T	Titus	**41.1**	*39.49*	**105.2**	*17.69*	**25.1**	*8.58*	**168.0**	*22.29*	**34.9**	*10.15*
B	Biotop	**7.8**	*15.98*	**147.2**	*21.00*	**130.6**	*19.46*	**79.7**	*15.21*	**44.6**	*11.48*
E	Enviroguard	**15.0**	*22.34*	**21.4**	*7.96*	**Missing data**	-	**56.4**	*12.70*	**44.7**	*11.15*
TE	Terrastar	**1.9**	*6.53*	**35.3**	*10.01*	**42.3**	*11.26*	**59.6**	*13.31*	**37.1**	*10.48*
	SED (16 df)		*5.277*		*2.346*		*1.680*		*2.385*		*1.197*
	LSD (5%) for chemicals		*11.24*		*5.00*		*3.58*		*5.08*		*2.55*
	SED (4 df)		*1.991*		*1.842*		*1.999*		*2.320*		*1.227*
	LSD (5%) for mulches		*5.53*		*5.12*		*5.56*		*6.45*		*3.41*

* Flexidor 125 applied in Sept.01

APPENDIX 2

Table 4 **Weed assessments - *Poa annua* (annual meadow grass) (HRI Efford Year 1)**

Figures are a mean across 3 replicates (3 pots per replicate)

Weeds removed at each record

		Weed sowing 1 1st herbicide application 14th Jun 01		**Weed sowing 2 2nd herbicide application 28th Sept 01**				**Weed sowing 3 3rd herbicide application 15th Feb 02**			
Code	**Treatment**	**% pot cover early July 01**	***Transformed data (angular transformation)***	**No. of weeds early Nov 01**	***Transformed data (square roots)***	**No. of weeds mid Jan 02**	***Transformed data (square roots)***	**No. of weeds mid April 02**	**Transformed data (square roots)**	**No. of weeds Mid May 02**	***Transformed data (square roots)***
U	Untreated	**30.0**	*33.02*	**0.1**	*0.33*	**0.2**	*0.471*	**5.9**	*4.16*	**0.6**	*1.28*
D	Debut	**14.4**	*21.98*	**0.2**	*0.67*	**0.0**	*0.000*	**3.8**	*3.24*	**1.2**	*1.47*
H	Helmsman	**2.4**	*8.03*	**0.0**	*0.00*	**0.0**	*0.000*	**0.1**	*0.33*	**0.1**	*0.33*
K	Katamaran	**0.2**	*1.28*	**0.6**	*0.75*	**0.0**	*0.000*	**0.3**	*0.80*	**0.0**	*0.00*
L	Lexone	**0.7**	*3.45*	**0.2**	*0.67*	**0.0**	*0.000*	**0.7**	*1.08*	**0.0**	*0.00*
M	Monitor	**11.1**	*19.02*	**0.2**	*0.67*	**0.1**	*0.333*	**3.3**	*3.15*	**1.2**	*1.56*
R	Ronstar 2G*	**3.3**	*10.26*	**0.0**	*0.00*	**0.0**	*0.000*	**0.7**	*1.33*	**0.1**	*0.33*
S	Stomp	**4.0**	*11.32*	**2.3**	*1.92*	**0.0**	*0.000*	**1.0**	*1.73*	**0.2**	*0.67*
T	Titus	**4.7**	*12.39*	**0.7**	*1.15*	**0.6**	*1.276*	**3.9**	*3.33*	**0.1**	*0.33*
B	Biotop	**6.2**	*16.34*	**10.2**	*5.37*	**9.4**	*5.28*	**5.0**	*3.82*	**0.4**	*1.14*
E	Enviroguard	**9.4**	*17.82*	**1.0**	*1.73*	**4.9**	*3.80*	**0.2**	*0.67*	**0.0**	*0.00*
TE	Terrastar	**4.1**	*11.61*	**0.0**	0.00	**1.0**	*1.66*	**2.1**	*2.50*	**0.1**	*0.33*
	SED (16 df)		*2.572*		*0.843*		*0.2579*		*0.587*		*0.619*
	LSD (5%) for chemicals		*5.48*		*1.80*		*0.55*		*1.25*		*1.32*
	SED (4 df)		*1.900*		*0.785*		*0.472*		*0.427*		*0.320*
	LSD (5%) for mulches		*5.28*		*2.18*		*1.312*		*1.19*		*0.89*

* Flexidor 125 applied in Sept.01

APPENDIX 2

Table 5 **Weed assessments - *Senecio vulgaris* (groundsel) (HRI Efford Year 1)**

Figures are a mean across 3 replicates (3 pots per replicate)

Weeds removed at each record

Code	Treatment	Weed sowing 1 1st herbicide application 14th Jun 01		Weed sowing 2 2nd herbicide application 28th Sept 01				Weed sowing 3 3rd herbicide application 15th Feb 02			
		% pot cover early July 01	*Transformed data (angular transformation)*	No. of weeds early Nov 01	*Transformed data (square roots)*	No. of weeds mid Jan 02	*Transformed data (square roots)*	No. of weeds mid April 02	Transformed data (square roots)	No. of weeds mid May 02	*Transformed data (square roots)*
U	Untreated	**93.0**	*77.9*	**11.0**	*5.05*	**0.7**	*1.15*	**13.0**	*6.18*	**1.8**	*1.89*
D	Debut	**27.0**	*31.0*	**2.0**	*2.35*	**0.0**	*0.00*	**16.8**	*7.04*	**1.7**	*2.20*
H	Helmsman	**52.0**	*47.8*	**0.1**	*0.33*	**0.1**	*0.33*	**0.6**	*0.75*	**0.3**	*0.80*
K	Katamaran	**1.0**	*5.60*	**3.6**	*2.65*	**5.3**	*3.44*	**8.6**	*5.04*	**1.4**	*2.08*
L	Lexone	**81.0**	*64.7*	**2.9**	*2.88*	**0.3**	*0.58*	**16.9**	*7.11*	**1.2**	*1.79*
M	Monitor	**24.0**	*29.0*	**4.8**	*3.09*	**0.6**	*1.24*	**9.9**	*5.44*	**1.8**	*2.28*
R	Ronstar 2G*	**7.0**	*15.4*	**0.6**	*0.75*	**0.3**	*0.58*	**0.9**	*1.63*	**0.6**	*1.24*
S	Stomp	**72.0**	*58.6*	**4.9**	*3.83*	**0.1**	*0.33*	**14.9**	*6.61*	**1.3**	*1.90*
T	Titus	**34.0**	*35.9*	**2.9**	*2.92*	**0.7**	*1.38*	**13.0**	*6.20*	**1.6**	*2.10*
B	Biotop	**3.0**	*10.42*	**9.8**	*5.23*	**1.7**	*2.10*	**6.6**	*4.30*	**1.1**	*1.73*
E	Enviroguard	**18.0**	*24.30*	**0.0**	*0.00*	**8.9**	*4.99*	**1.3**	*1.85*	**0.2**	*0.67*
TE	Terrastar	**20.0**	*26.45*	**4.0**	3.22	**2.1**	*2.41*	**3.0**	*2.14*	**1.2**	*1.90*
	SED (16 df)		*6.04*		*1.336*		*0.919*		*0.758*		*0.660*
	LSD (5%) for chemicals		*12.86*		*2.85*		*1.96*		*1.61*		*1.41*
	SED (4 df)		*2.261*		*1.034*		*1.037*		*1.483*		*0.535*
	LSD (5%) for mulches		*6.29*		*2.87*		*2.88*		*4.12*		*1.49*

*Flexidor 125 applied in Sept.01

APPENDIX 2

Table 6 **Weed assessments – Darby Nursery Stock Ltd 10th December 2002**
Figures are a mean across 3 replicates (60 pots per replicate)

Herbicide	Weed numbers								
	Bittercress*	Groundsel	Willowherb**	Pearlwort***	MouseEar***	A.Mead.Grass***	Sowthistle*	Fleabane	Total*
Untreated	13.62 (184.50)	2.67	-0.56 (0.80)	0.33	0.00	0.00	2.06 (3.25)	2.00	14.28 (202.92)
Helmsman	2.64 (5.97)	0.00	-1.00 (0.00)	0.00	0.00	0.00	1.41 (1.00)	2.67	3.19 (9.18)
Katamaran	4.16 (16.31)	5.00	-1.00 (0.00)	0.00	0.00	0.33	1.00 (0.00)	0.00	4.82 (22.23)
Ronstar 2G	1.87 (2.50)	1.00	-1.00 (0.00)	0.00	0.00	0.00	1.47 (1.16)	2.67	3.01 (8.06)
Butisan S	3.13 (8.80)	1.33	-1.00 (0.00)	0.00	0.00	0.00	1.00 (0.00)	0.00	3.46 (10.97)
Biotop	7.99 (62.84)	3.33	-0.74 (4.50)	0.00	0.00	3.33	1.14 (0.30)	1.33	8.69 (74.52)
Butisan S / Flexidor 125	8.50 (71.25)	5.60	-0.58 (0.72)	1.60	0.00	0.00	1.86 (2.46)	2.60	9.60 (91.16)
Ronstar Liq.	7.96 (62.36)	3.00	-0.69 (0.45)	0.00	0.00	4.67	2.22 (3.91)	2.00	9.54 (90.01)
Lexone	6.66 (43.36)	4.67	-0.53 (0.90)	0.00	4.33	4.33	3.20 (9.23)	3.67	9.19 (83.46)
Fpr.	0.083	0.114	0.078	-	-	-	<0.001	0.219	0.030
d.f.	16	16	16	-	-	-	16	16	16
s.e.d.	3.550	1.936	0.1979	-	-	-	0.2810	1.421	3.188

* = data were skewed and transformed using square root.
** = data were skewed and transformed using negative reciprocal.
*** = data were skewed but non-transformable.
Back transformed data in brackets

APPENDIX 2

Table 7 **Weed assessments – Darby Nursery Stock Ltd 28th January 2003**

Figures are a mean across 3 replicates (60 pots per replicate)

Herbicide	Weed numbers								
	Bittercress *	Groundsel	Willowherb ***	Pearlwort ***	MouseEar ***	A.Mead.Grass ***	Sowthistle	Fleabane ***	Total *
Untreated	2.17 (146.91)	2.00	10.7	1.00	0.00	0.00	3.33	0.33	2.216 (163.43)
Helmsman	0.57 (2.72)	0.00	0.0	0.00	0.00	0.00	0.67	1.00	0.731 (4.38)
Katamaran	1.23 (15.98)	5.33	0.0	0.00	0.00	0.00	0.00	0.00	1.372 (22.55)
Ronstar 2G	0.30 (1.00)	1.00	0.3	0.00	0.33	0.00	1.33	0.00	0.719 (4.24)
Butisan S	0.74 (4.50)	1.33	0.0	0.00	0.00	0.00	0.00	0.00	0.977 (8.48)
Biotop	1.79 (60.66)	3.33	1.0	0.00	0.00	3.33	0.33	0.33	1.880 (74.86)
Butisan S / Flexidor 125	1.00 (9.00)	0.00	3.0	0.67	0.00	0.00	1.67	0.0	1.310 (19.41)
Ronstar Liq.	0.55 (2.54)	0.00	0.0	0.00	0.00	0.33	0.67	0.00	0.619 (3.16)
Lexone	0.68 (3.79)	0.67	2.3	1.67	0.00	0.00	2.67	1.33	1.184 (14.28)
Fpr.	0.010	0.004	-	-	-	-	0.003	-	0.002
d.f.	16	16	-	-	-	-	16	-	16
s.e.d.	0.447	1.165	-	-	-	-	0.743	-	0.3262

* = data were skewed and transformed using square root.

*** = data were skewed but non-transformable.

Back transformed data in brackets

APPENDIX 2

Table 8 **Liverwort cover – Darby Nursery Stock Ltd**
Figures are a mean across 3 replicates (3 pots per replicate)

Herbicide	% Liverwort Cover	
	10th December 2002	28th January 2002***
Untreated	96.7	83.3
Helmsman	53.3	13.3
Katamaran	6.7	0.0
Ronstar 2G	73.3	50.0
Butisan S	1.7	0.0
Biotop	31.7	6.7
Flexidor 125 + Butisan S	56.0	5.0
Ronstar Liq.	80.0	23.3
Lexone	40.0	5.0
Fpr.	0.004	-
d.f.	16	-
s.e.d.	20.74	-

*** = data were skewed and non-transformable

APPENDIX 2

Table 9 % Weed Cover – R A Meredith & Son (Blooms) Ltd – 24th September 2002

Herbicide	Mean
Untreated	57.1 c
Katamaran (2.0 l/ha)	13.7 ab
Ronstar 2G (20kg/ha)	35.0 bc
Titus (50g/ha)	8.3 a
Flexidor 125 (1.0 l/ha)	24.2 ab
Fpr	0.007
Df	8
s.e.d.	9.79

Table 9 shows that there were significant differences between the treatments when looking at % weed cover. A Duncan's mean separation test was run (indicated by the letter's after each mean). From this it can be seen that Titus performed significantly better than Ronstar and the untreated. Katamaran and Flexidor performed significantly better than the untreated control.

APPENDIX 3

Table 1 % Leaf – Darby Nursery Stock Ltd, Methwold – 10th December 2002

	% Leaf
Potentilla 'Red Ace'	50
Lavender 'Hidcote'	100
Choisya ternata	100
Lavatera 'Olbia Rosea'	10
Lonicera 'Baggesons Gold'	100
Caenothus 'Blue Mound'	100
Deutzia 'Mont Rose'	5
Vibernum 'Eve Price'	100
Weigela 'Purpureus'	0
Escallonia 'Gold Ellen'	100
Buddleja 'Pink Delight'	10
Euonymus 'Emerald Gaiety'	100
Forsythia 'Lynwood'	50
Hebe 'Red Edge'	100
Spirea 'Gresham'	0
Vinca minor 'Atropurpurea'	100
Clematis montana 'Rubens'	10
Prunus rotundifolia	100
Chamaecyparis 'Ellwoodii'	100
Erica darleyensis	100

APPENDIX 3

Table 2 Vigour Assessment at R A Meredith (Blooms) Ltd – 24th September 2002

Species	Herbicide					
	Untreated	Katamaran (2.0 l/ha)	Ronstar 2G (200 kg/ha)	Titus 50 g/ha)	Flexidor 125 (1.0 l/ha)	Mean
Lupinus 'Russell Hybrids'	5.00	3.00	3.667	1.33	1.667	2.933
Tradescantia 'Pauline'	5.00	3.33	5.00	4.667	4.667	4.533
Monarda 'Garden View Scarlet'	5.00	5.00	5.00	3.33	5.00	4.667
Crocosmia 'Irish Flame'	5.00	4.80	5.00	4.67	5.00	4.893
Hosta 'Wide Brim'	5.00	5.00	5.00	4.67	5.00	4.933
Hemerocallis 'Frans Hals'	5.00	5.00	5.00	4.33	5.00	4.867
Astilbe 'Sprite'	5.00	5.00	5.00	3.93	4.80	4.747
Pulmonaria 'Roy Davidson'	4.667	5.00	5.00	3.00	4.00	4.333
Geum 'Boris'	5.00	5.00	5.00	3.13	5.00	4.627
Aster 'Purple Dome'	5.00	4.20	5.00	2.87	5.00	4.413
Digitalis grandiflora 'Ambigua'	5.00	3.00	5.00	4.60	4.33	4.387
Geranium 'Bressingham delight'	5.00	2.67	5.00	1.73	4.73	3.827
Anemone 'Montrose'	5.00	5.00	5.00	1.00	3.00	3.800
Campanula 'Blue Waterfall'	5.00	5.00	5.00	3.53	4.67	4.640
Potentilla 'Yellow Queen'	5.0	5.00	5.00	3.40	5.00	4.680
Oreganum 'Pilgrim'	1.13	0.67	3.00	1.07	1.87	1.547
Achillea 'Terracotta'	5.00	4.67	3.80	3.33	5.00	4.360
Delphinium 'Blue Jay'	3.67	0.93	2.60	2.40	2.67	2.453

Papaver orientalis 'Allegro'	5.00	5.00	4.07	4.60	5.00	4.733
Miscanthus sinensis 'Sirene'	4.40	5.00	4.87	4.60	5.00	4.773
Euphorbia amygdaldides 'Rubra'	3.93	2.27	4.00	1.87	4.00	3.213
Phlox 'May Breeze'	3.33	1.93	3.60	3.53	4.00	3.280
Schizostyus 'Maidens Blush'	3.93	3.73	1.80	3.13	2.80	3.080
Iris foetidissima	4.93	5.00	5.00	4.33	5.00	4.853
Aconitum 'Sparks Variety'	2.53	2.00	1.40	1.2	1.60	1.747
Mean	4.501	3.888	4.312	3.211	4.152	4.013
	factor 1 (herbicide)	factor 2 (species)	factor 1.factor2			
F.pr.	<0.001	<0.001	<0.001			
s.e.d.	0.1549	0.3463	0.7743			
Resid df.	248					

Unfortunately the data were skewed and non-transformable. It is only possible to comment on the general trend of the data.

Score 0= Dead
1= Severe loss of growth, barely alive (20%)
2= Severe (40%)
3= Significant reduction in growth and/or yellowing (60%)
4= Slight reduction in growth (80%)
5= Completely healthy

APPENDIX 3

Table 3 Vigour Assessment at R A Meredith (Blooms) Ltd – 14th April 2003

Species	Herbicide					
	Untreated	Katamaran (2.0 l/ha)	Ronstar 2G (200 kg/ha)	Titus 50 g/ha)	Flexidor 125 (1.0 l/ha)	Mean
Lupinus 'Russell Hybrids'	5.00	1.67	4.33	0.00	1.67	2.533
Tradescantia 'Pauline'	5.00	3.33	5.00	0.00	4.67	3.600
Monarda 'Garden View Scarlet'	5.00	5.00	5.00	5.00	5.00	5.00
Crocosmia 'Irish Flame'	5.00	4.80	5.00	3.00	5.00	4.560
Hosta 'Wide Brim'	5.00	5.00	5.00	0.00	5.00	4.000
Hemerocallis 'Frans Hals'	5.00	5.00	5.00	5.00	5.00	5.00
Astilbe 'Sprite'	5.00	5.00	5.00	5.00	4.80	4.960
Pulmonaria 'Roy Davidson'	4.67	5.00	3.00	4.00	4.00	4.133
Geum '*Boris*'	4.33	2.00	5.00	3.13	5.00	3.893
Aster 'Purple Dome'	5.00	3.46	5.00	2.86	5.00	4.267
Digitalis grandiflora 'Ambigua'	5.00	1.00	5.00	5.00	4.20	4.040
Geranium 'Bressingham Delight'	5.00	2.27	5.00	1.73	4.00	3.600
Anemone 'Montrose'	5.00	5.00	5.00	0.33	2.67	3.600
Campanual 'Blue Waterfall'	5.00	5.00	5.00	1.60	5.00	4.320
Potentilla 'Yellow Queen'	5.00	5.00	4.00	3.00	5.00	4.400
Oreganum 'Pilgrim'	0.133	0.00	3.00	0.00	0.80	0.787
Achillea 'Terracotta'	5.00	5.00	4.00	3.33	5.00	4.467
Delphinium 'Blue Jay'	3.67	0.33	0.00	1.07	3.00	1.613

Papaver orientalis. 'Allegro'	5.00	5.00	4.67	5.00	5.00	4.933
Miscanthus sinensis 'Sirene'	4.40	5.00	5.00	5.00	5.00	4.880
Euphorbia amygdaldides 'Rubra'	3.93	1.13	4.33	3.00	4.33	3.347
Phlox 'May Breeze'	2.67	1.40	1.47	3.20	4.00	2.547
Schizostyus 'Maidens Blush'	1.33	1.00	1.80	0.00	2.27	1.280
Iris foetidissima	4.93	5.00	5.00	4.33	5.00	4.853
Aconitum 'Sparks Variety'	2.53	2.73	2.66	1.20	1.93	2.213
Mean	4.304	3.405	4.131	2.632	4.093	3.713
	factor 1 (herbicide)	factor 2 (species)	factor 1.factor2			
F.pr.	<0.001	<0.001	<0.001			
s.e.d.	0.1282	0.2868	0.6412			
Resid df.	248					

Data were normally distributed.

APPENDIX 4 - PHOTOGRAPHS

WOODY SPECIES

Fig P1 Woody species trial 31/7/01

Fig P2 By end of trial 1/5/02

Fig P3 Shrubs and weed seeded pots first herbicide application in summer 2001

Fig P4 Biotop, Terrastar and Enviroguard mulches before and after watering

Fig P5 Germination stage of mouse-eared chickweed, groundsel and American willowherb when summer 2001 herbicides applied

Fig P6 Helmsman causing bleaching on mouse-eared chickweed (left) and hairy bittercress (right)

Fig P7 Katamaran causing distortion on groundsel seedlings

Fig P8 Titus causing yellowing on mouse-eared chickweed seedlings

Fig P9 Effect of herbicides and mulches on weed cover by 6/7/01 following first treatment. Weed labels: groundsel (grey), annual meadow grass (brown), American willowherb (blue), hairy bittercress (black), mouse-eared chickweed (orange).

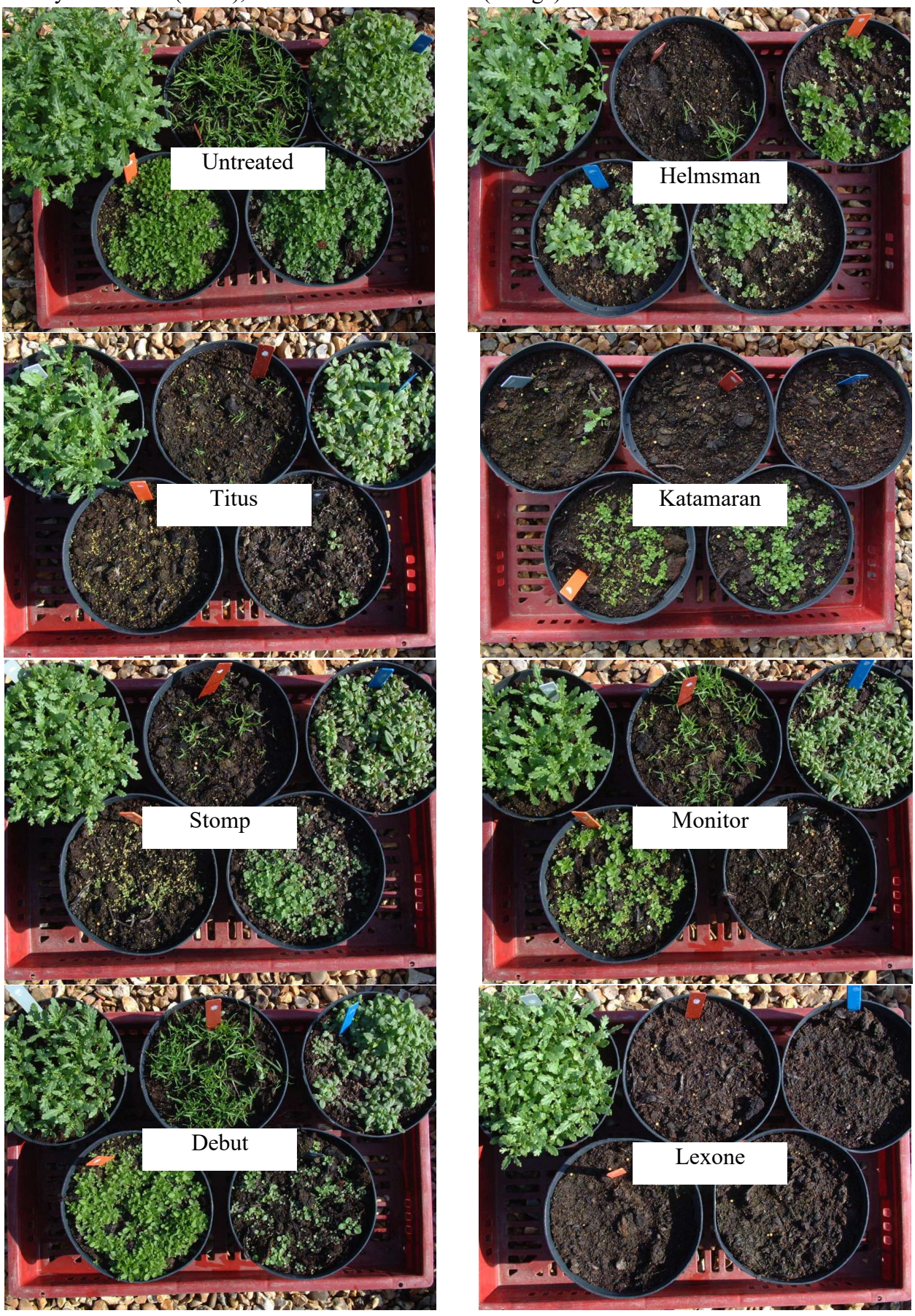


Fig P9 (continued)

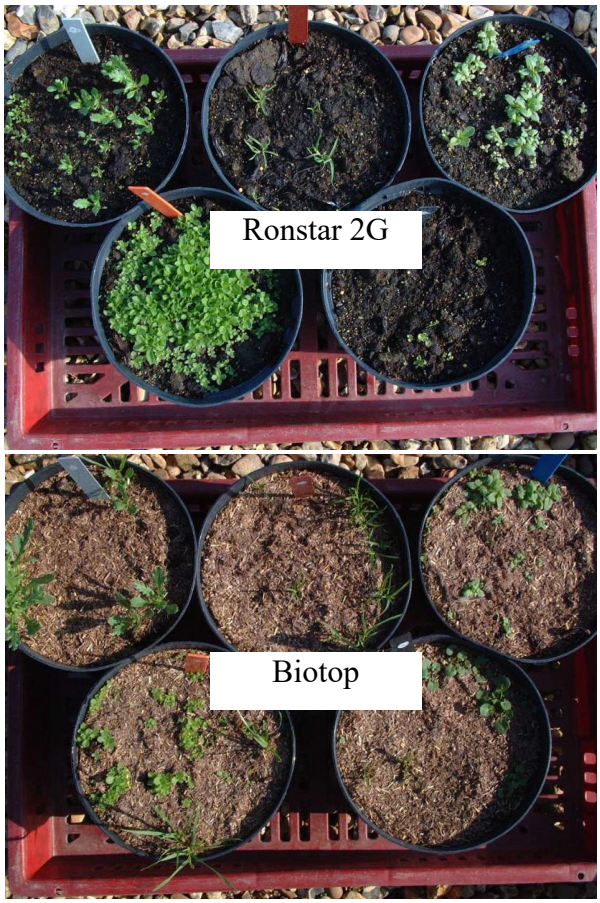


Fig P10 Lexone damage on Euonymus following first herbicide application in summer 2001. 16/07/01.

Fig P11 Lexone damage on Buddleia following first herbicide application in summer 2001. Inset close-up of damage. 16/07/01.

Fig P12 Lexone damage on Philadelphus - interveinal chlorosis - following first herbicide application in summer 2001. 16/07/01.

Fig P13 Lexone damage on Philadelphus - leaf scorching.

Figs P14 to P17 Overwintering weed levels in shrub pots (mainly bittercress) 06/02/02

Fig P14 Debut

Fig P15 Helmsman (clean)

Fig P16 Untreated

Fig P17 Terrastar

Fig P18 Enviroguard 14/9/01 Fairly well settled, pellets still intact

Fig P19 Biotop 14/09/01 Material well settled down

Fig P20 Terrastar 14/09/01 Material has lost pelleted appearance and has settled below rim of pot

HERBACEOUS PERENNIAL SPECIES

Fig P21 General shot of herbaceous perennial trial before first herbicide application 08/06/01

Fig P22 Untreated plot prior to first herbicide application 08/06/01

Fig P23 Overhead sprinkler irrigation in use 19/06/01

Fig P24 Application of first granular herbicides 19/06/01
Inset close-up of Helmsman granules on Papaver

Figs P25 to P42 Damage 13/07/01 following first herbicide application in summer 2001

Fig P25 Lexone - scorch on older leaves of Anemone

Fig P26 Lexone - severe scorch on Astilbe

Fig P27 Lexone - damage to Delphinium - significant number of dead plants

Fig P28 Lexone - leaf yellowing and tip scorch on Leucanthemum

Fig P29 Lexone - no damage on Papaver

Fig P30 Lexone - scorch on older leaves, interveinal chlorosis on younger growth on Potentilla

Fig P31 Lexone - severe scorching on older leaves of Primula

Fig P32 Lexone - severe scorching on older leaves on Pulmonaria

Fig P33 Lexone - severe scorching and death on Verbascum

Fig P34 Flexidor - scorch on Verbascum

Fig P35 Helmsman - white blotching on Anemone

Fig P36 Helmsman - white blotching or bleached leaves on Origanum

Fig P37 Helmsman - interveinal chlorosis and white tipping on Potentilla (variable)

Fig P38 Helmsman - white blotching on Verbascum

Fig P39 Ronstar - some stunting and slight leaf yellowing on Aster

Fig P40 Venzar - some leaf scorch and interveinal yellowing on Astilbe

Fig P41 Venzar - interveinal chlorosis on Leucanthemum

Fig P42 Venzar - interveinal yellowing and scorch on older leaves of Potentilla

Figs x.x to x.x Unusual phenomena due to herbicides - photos 28/03/01

Fig P43 Untreated Hosta

Fig P44 Lexone treated Hostas shooting early

Fig P45 Untreated Papaver

Fig P46 Lexone - growth enhancement on Papaver compared to untreated plants

Fig P47 Untreated Primula

Fig P48 Colour change on Primulas treated with Titus

Figs P49 to P52 Selected size / quality grade photos of plants at final assessment 10/05/02

Fig P49 Hosta 1,2,3

Fig P50 Verbascum 1 to 5

Fig P51 Stachys 1 to 5

Fig P52 Potentilla 1 to 5

Fig P53 Herbaceous perennials at end of trial 29/05/02