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 J Atwood, ADAS (responsible for Year 2 nursery trials)
Report:	Annual Report
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Key workers:	Mr C M Burgess, Project Leader (co- author of report) Miss C Hawes, Project Manager (co-author of report) Mr R Goode, Project Assistant Mr D Joblin, Nursery Staff
Location of Year 1 work:	Horticulture Research International Efford Lymington Hampshire SO41 0LZ Tel: 01590 673341 Fax: 01590 671553
Project co-ordinator:	Dr Paul Sopp Fargro Ltd Toddington Lane Littlehampton West Sussex BN17 7PP
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GROWER SUMMARY

This report covers the first season's results of a two-part project, and data should therefore be applied with caution at this stage. Further information on crop safety in particular will be available following the nursery trials being undertaken during 2002 / 3 where treatments will be tested on a wider range of species. Most of the herbicide treatments are off-label permitted under the Long Term Arrangements for Use and are used entirely at grower's risk .

Headline

- Helmsman (carbetamide + diflufenican + oxadiazon) shows good potential for extending its used from open ground 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 5 woody plant species tested. It is less safe, however, on herbaceous perennials.
- 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 that need assessing. 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 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 will 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	Rate of product used	Woody	Herb.
Untreated	water		□	□
Debut	trisulfuron methyl	0.003 g / m^2	□	
Helmsman	oxadiazon + diflufenican + carbetamide	150 g / m^2	□	□
Katamaran	metazachlor + quinmerac	0.2 ml / m^2	□	□
Lexone 70DF	metribuzin	0.075 g / m^2	□	□
Monitor (experimental)	sulfosulfuron	0.0025 g / m^2	□	
Stomp	pendimethalin	0.33 ml / m^2	□	
Titus	rimsulfuron	0.005 g / m^2	□	□
Ronstar 2G	oxadiazon	25 g / m^2	□	□
Flexidor 125	isoxaben	0.1 ml / m^2	*	□
Venzar Flowable	lenacil	0.3 ml / m^2		□

* Flexidor replaced Ronstar 2G for the second application to the shrub trial in the autumn

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
Buddleja davidii	*Anemone* 'Prince Henry'
Chamaecyparis lawsoniana 'Elwoodii'	*Aster* 'Wartburgstern'
Euonymus fortunei	*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 'Lantana'
	Verbascum 'Helen Johnson'

Herbicide efficacy and safety

- The granular herbicide Helmsman showed excellent weed control but slightly poorer control of groundsel can be expected. It was safe on all woody species tested in containers but caused damage (white blotching) to 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 programme on shrubs was overall about as effective as Helmsman. The Ronstar granule application gave better control of groundsel from the first summer application, but Helmsman gave better control of mouse-ear chickweed on the final application.
- None of the other herbicide treatments tested were overall as effective as those above. Stomp, Titus, Monitor and Debut gave generally disappointing control. However Titus showed some suppression of chickweed, bittercress and groundsel and proved safe on most of the herbaceous perennials except *Papaver*. It may therefore have some application with this group and has been taken on for further trialling.
- Katamaran gave moderate weed control, though not as good as Helmsman, Ronstar and Flexidor. However it showed some post-weed emergence activity against groundsel and willowherb from the first summer application. Because it appeared relatively safe on the herbaceous plants (except *Primula*) it too was taken on for further trialling.
- Lexone performed best from the summer spray, where it gave good control of all weeds except groundsel. Some germination had occurred from chickweed, groundsel, 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 causing damage to the shrubs where *Euonymus* suffered leaf drop, *Buddleia* leaf scorch, and *Philadelphus* interveinal yellowing but only following the summer spray. Lexone is

being further examined as a potential winter contact treatment for deciduous shrubs and conifers.

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.

Financial benefits

Financial benefits from the project will be evaluated and included in the final report.

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 at this stage using a rate of 150 g/m^2.

- Other recommendations will follow the nursery trials being completed in 2003, when further information on the safety of these herbicides for both woody and herbaceous subjects will be available.

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, 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.

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'.

This annual report covers Part 1 of the project carried out at HRI Efford.

In Part 2, the most promising of the herbicide and non-chemical treatments will be taken on and tested across a wider range of subjects on a larger scale on nurseries under commercial conditions. The main objective will be to test for crop safety, but nurseries will be chosen that have a history of the problem weeds identified, so that efficacy of the herbicides can be observed where possible. In addition to extending the species range, testing the herbicides on the indicator species in a different location and season will give further confidence about crop safety results. This second part of the project will also allow some tailoring of treatments based on the first year work.

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

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
'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 9cm 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

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. Overhead irrigation was used throughout.

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 (experimental)	sulfosulfuron	25 g/ha	0.0025 g
R	Ronstar 2G (granular)*	oxadiazon	200 kg/ha	20 g
S	Stomp	pendimethalin	3.3 l/ha	0.33 ml
T	Titus	rimsulfuron	50 g/ha	0.005 g

* Trt R 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. 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.

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 seperately 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 cc 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 cc 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 cc 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 cc.

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

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 9cm 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.
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 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.

RESULTS

A. WOODY SPECIES

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 refridgerated 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 below summarise the weed assessments. See Appendix 2 for data from all weed assessments and Photos in Appendix 3.

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. 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.

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

The containers of shrubs generally had low numbers of naturally occuring 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). The results of this assessment backed up the findings from the weed sowing records with **Helmsman** and **Ronstar** clearly giving the best control.

Mulches

Generally the **Biotop**, **Enviroguard** and **Terrastar** mulches did give some control over the development of all weed species. 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. 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.

3. Phytotoxicity

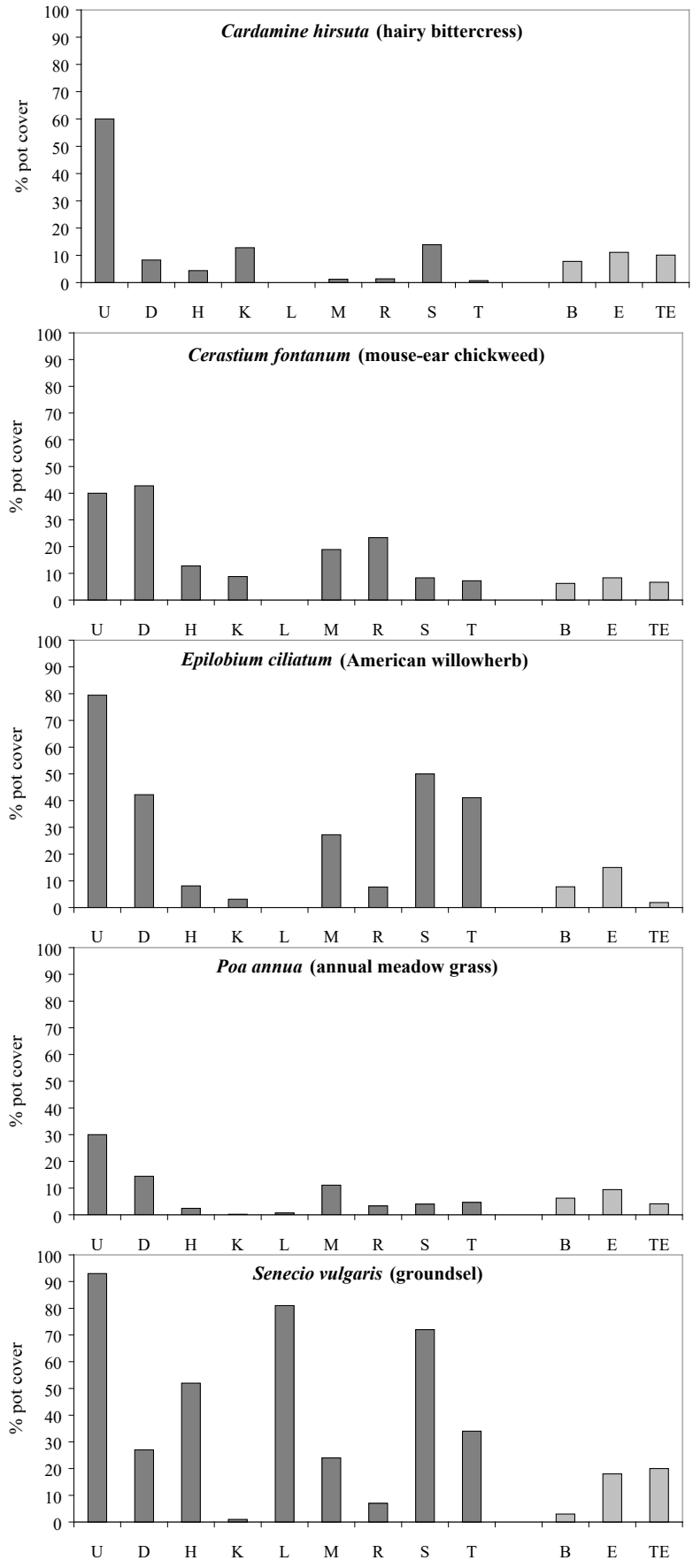
No phytotoxicity symptoms were observed on the shrubs with the mulch treatments.

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 *Euonymus.* The *Viburnum* also showed signs of damage with the development of yellowing leaves. However, over autumn and winter *Viburnum* 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 *Phytopthora 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).

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

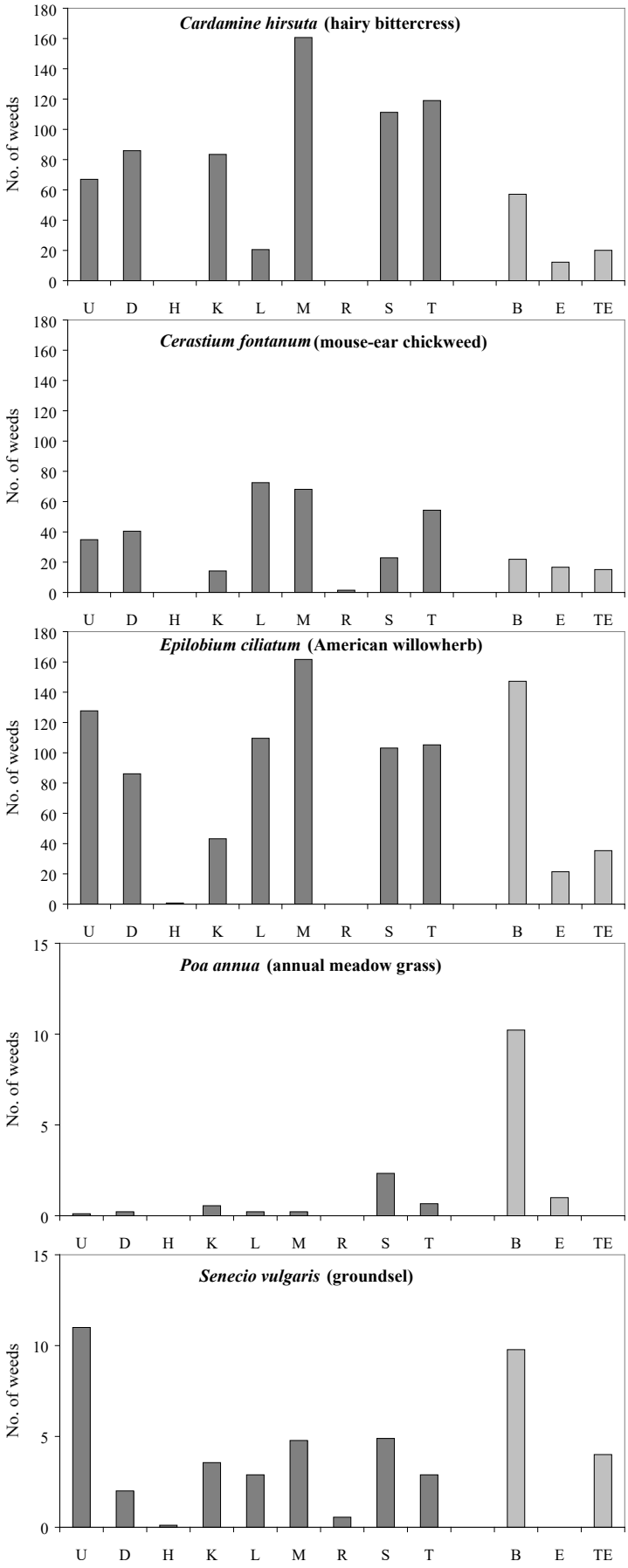


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar
S - Stomp
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.

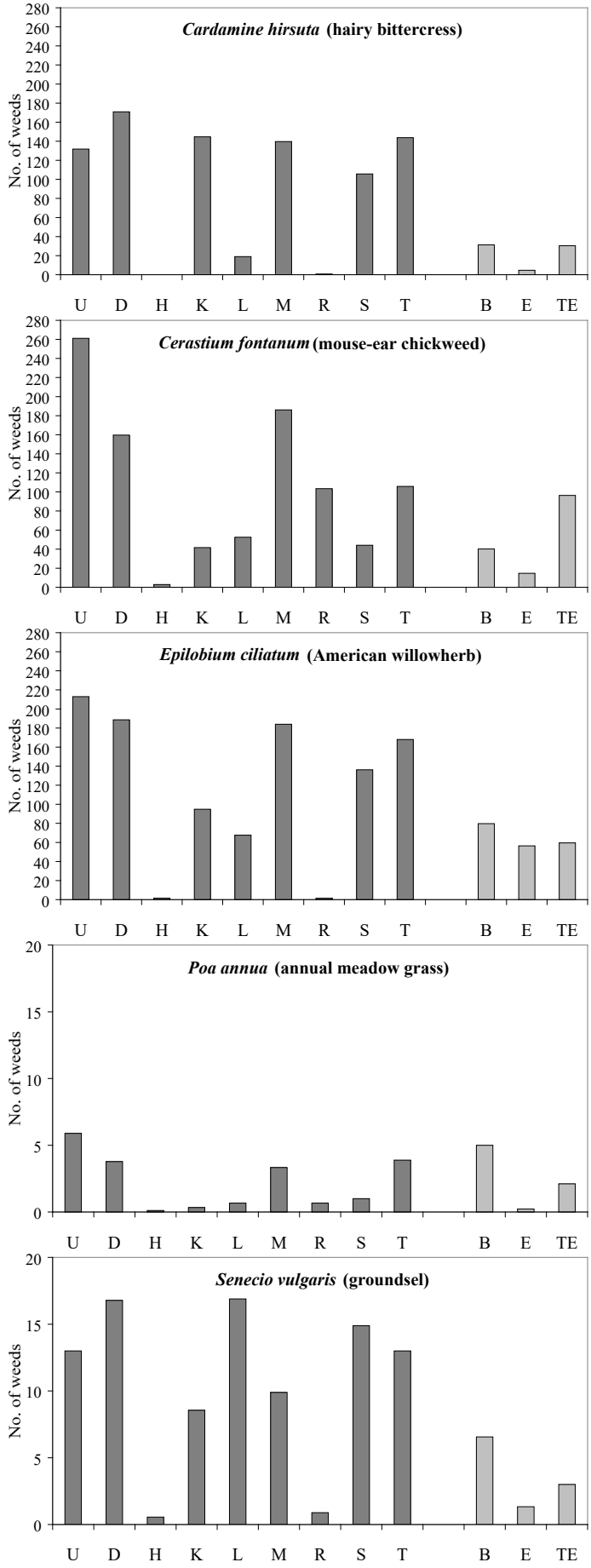


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar (Flexidor)
S - Stomp
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.

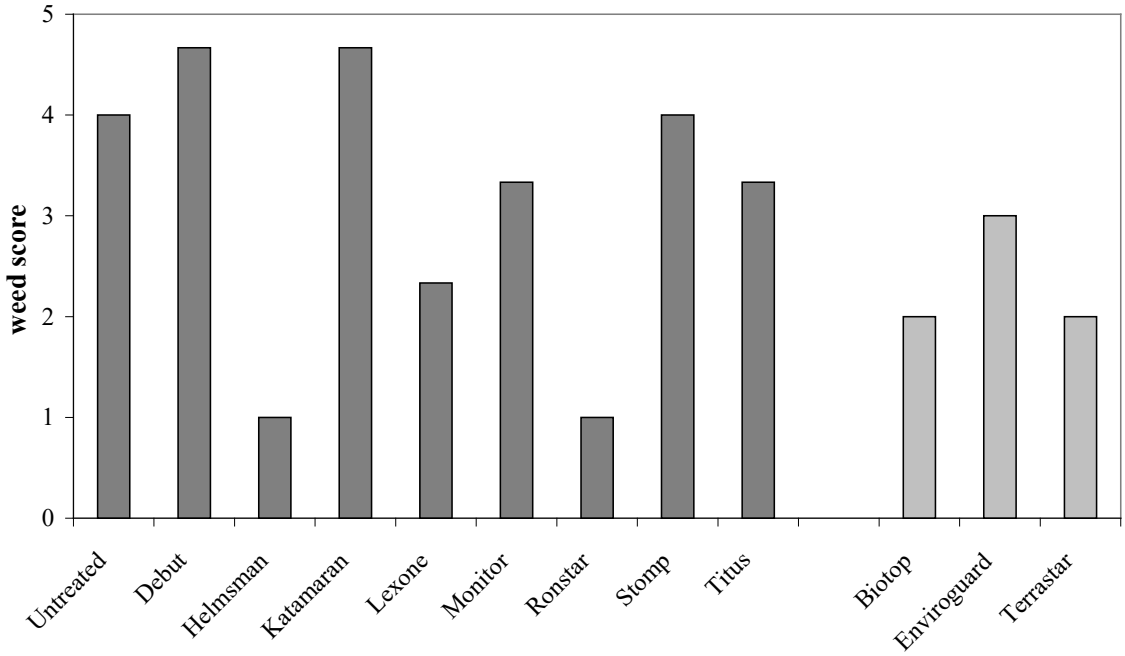


Treatments:

U - Untreated
D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar
S - Stomp
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
Means of 3 replicate plots



B. HERBACEOUS PERENNIALS

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. 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 5 - 7 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 Appendix 3 Photos for examples of symptoms.

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

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.

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. 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. However, final plant size by May was smaller, with a lower quality score.

Ronstar

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.

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

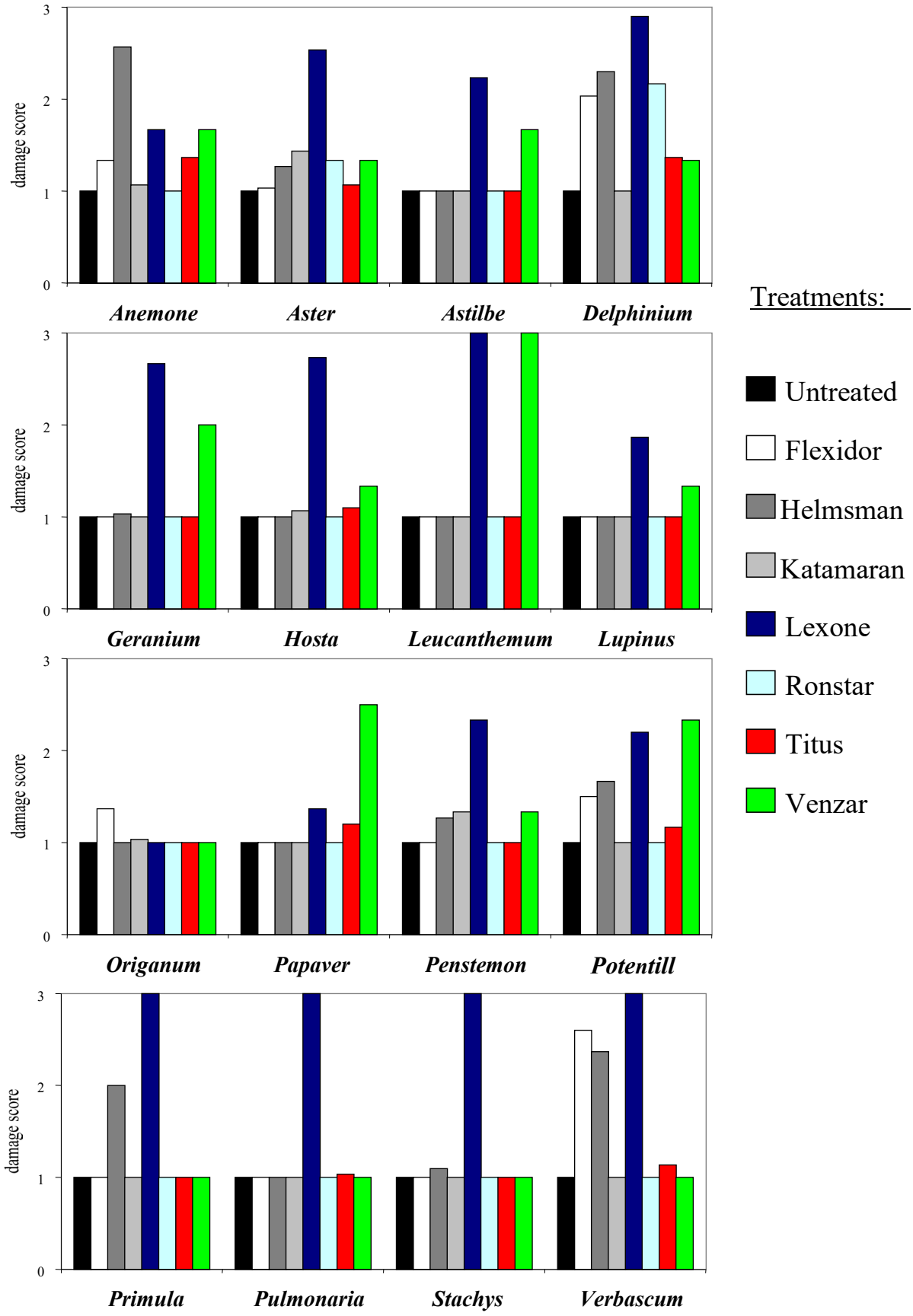


Fig 6 *Papaver* plant size and % dead plant assessment November 2001

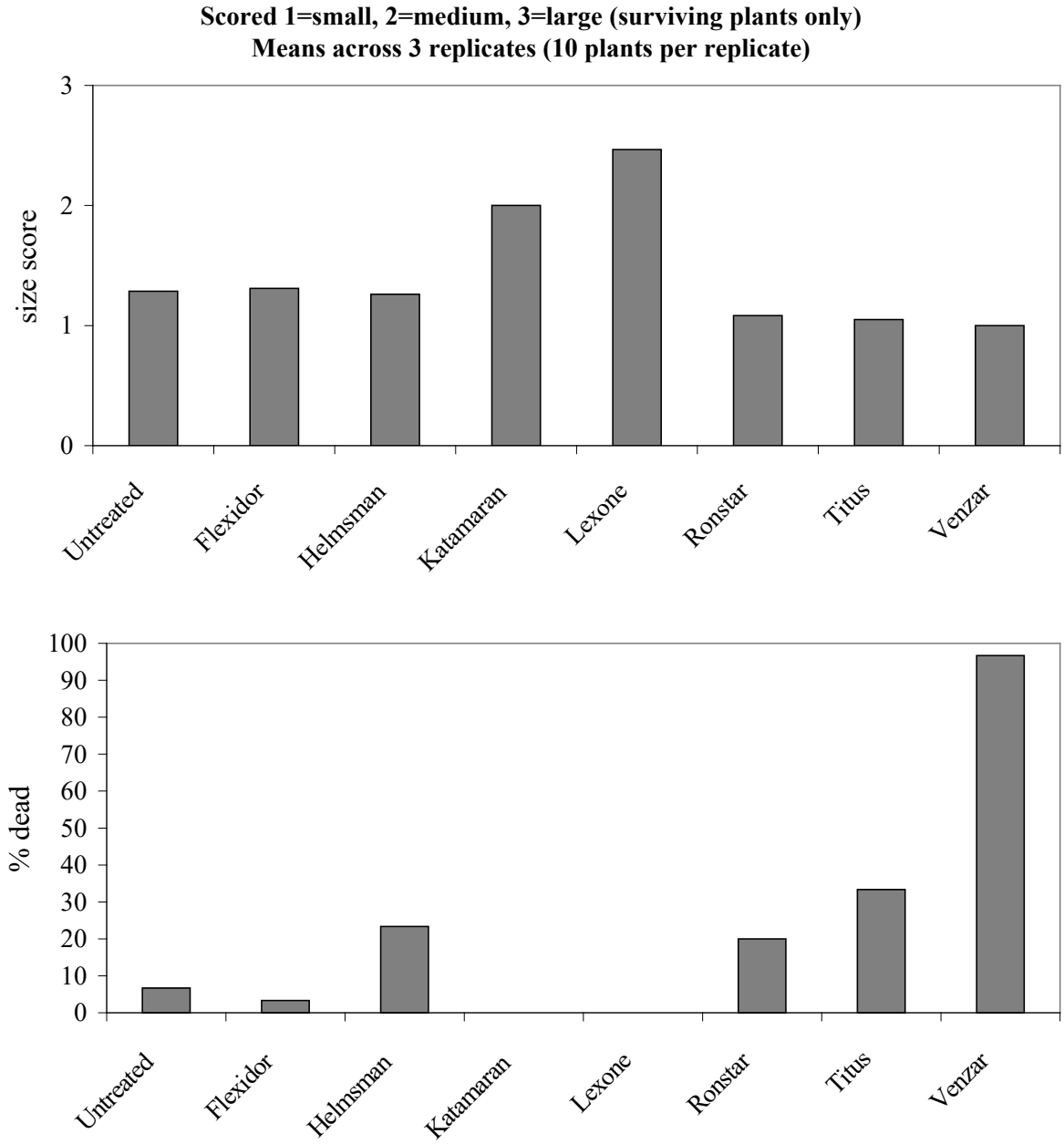


Fig 7 Size / quality of surviving plants and proportion dead at final assessment May 2002. Score 1 = poor, 5 = best except *Geranium, Hosta, Papaver & Penstemon* (score 1 - 3).

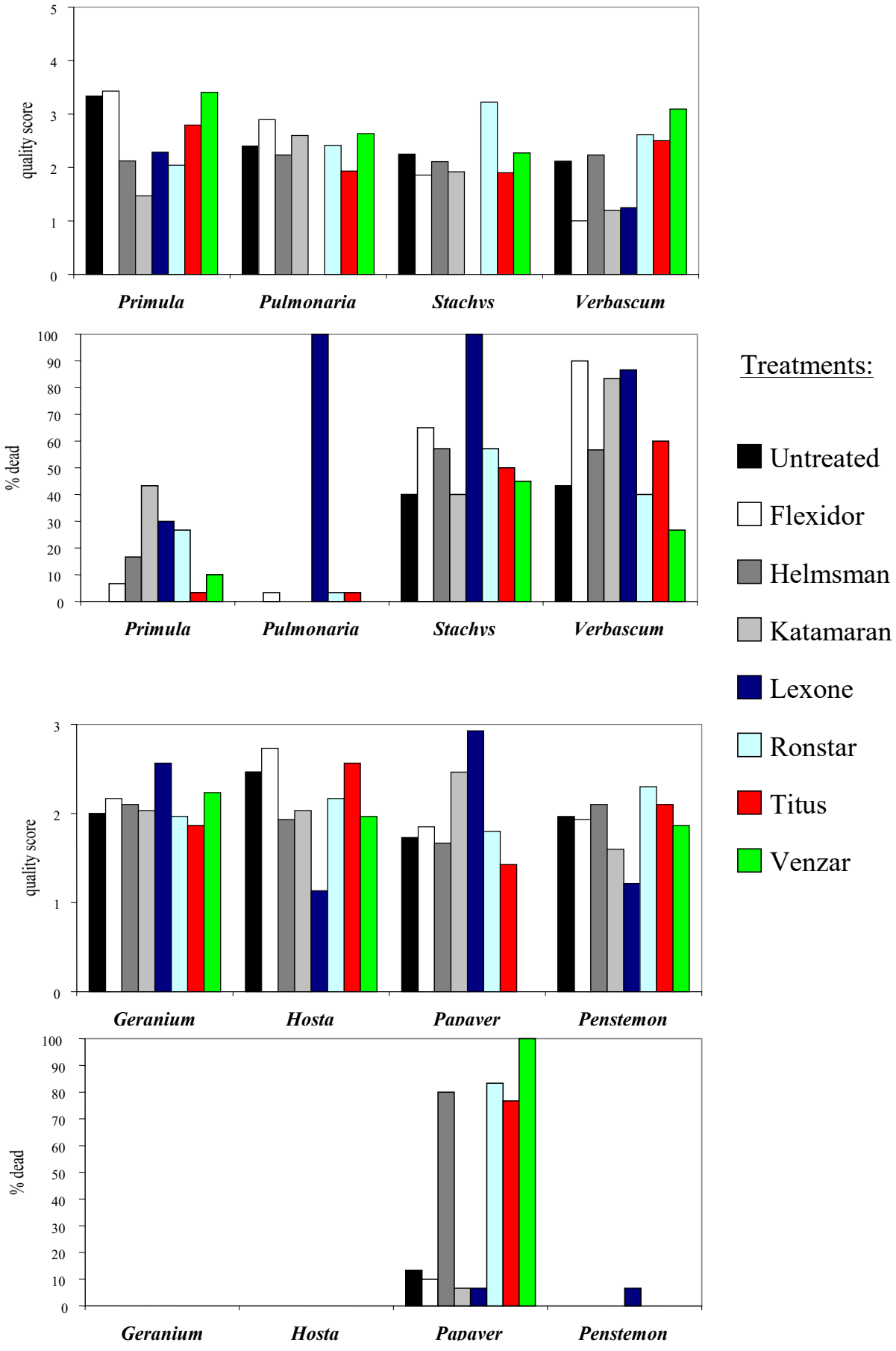
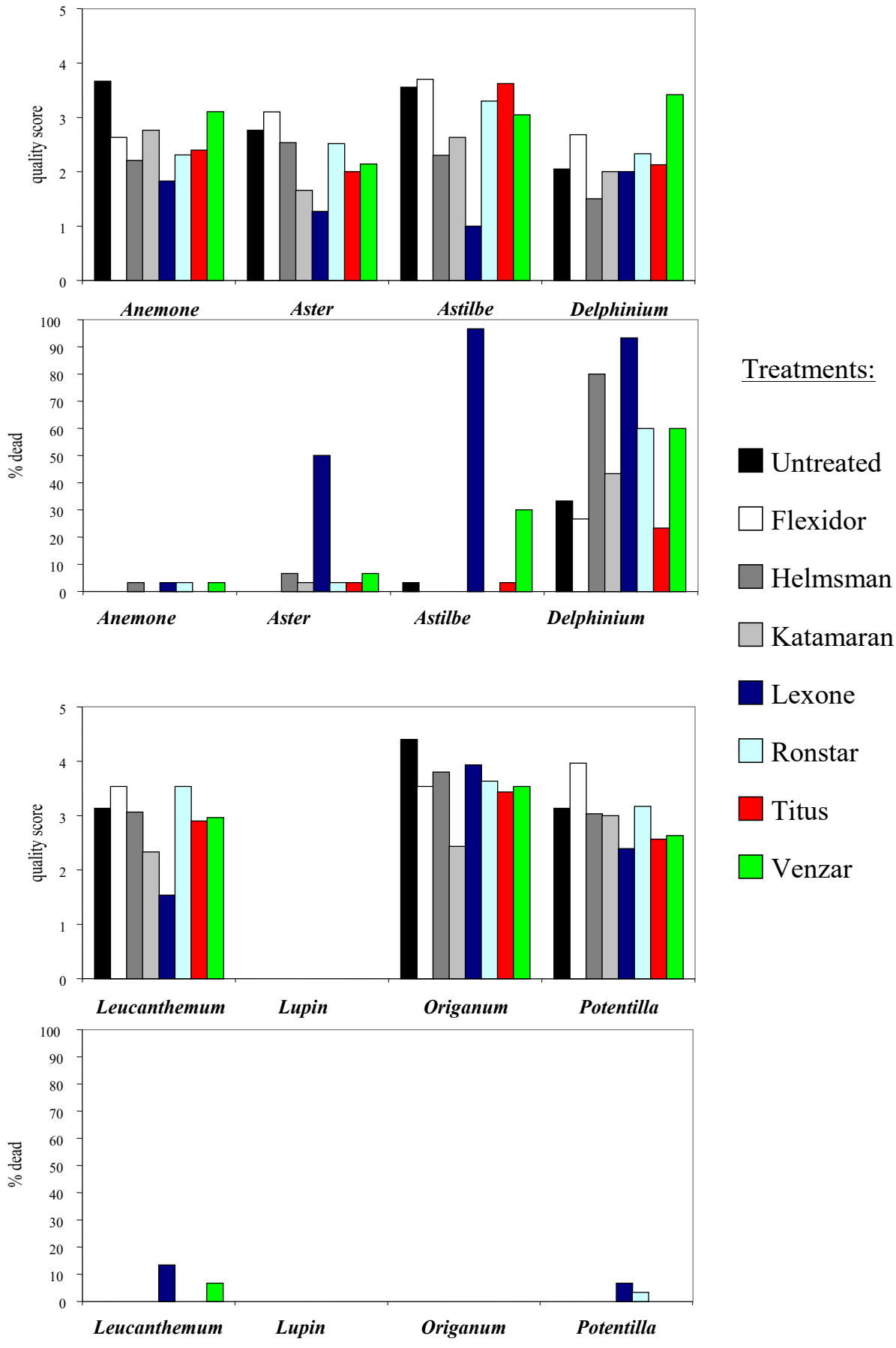


Fig 7 (continued)



DISCUSSION

Herbicide efficacy and safety

The emergence of willowherb, mouse-eared chickweed and some groundsel 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 and Katamaran, suggests that bittercress was at a particularly sensitive stage of germination at the first application.

While **Katamaran** was not the most effective herbicide, it showed some post-emergence activity particularly against groundsel and willowherb, and some suppression of weed except bittercress following autumn / winter applications. Because of its relative safety with most of the herbaceous subjects, it is worthy of re-trialling.

Helmsman is a mix of three active ingredients, and has shown excellent all-round performance on four of the five weed species. Its activity against groundsel in containers needs further testing. At the higher 15 g/m^2 rate used, product literature states that groundsel is still only moderately susceptible (in open ground soils). It is surprising, therefore, that groundsel was well controlled from the Sowings 2 and 3 in this trial, even allowing for the relatively low germination in the untreated controls.

Helmsman is currently only recommended for open ground shrubs, but the lack of phytotoxicity on the range of woody species tested, means it definitely has potential for container grown shrubs and will be further trialled for safety. It has less potential with herbaceous subjects, particularly as a summer application due to the distinctive white blotching of foliage. 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 for selected lines of herbaceous and other subjects as a dormant season treatment.

Stomp, 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, 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.

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 nursery shrub trial as a dormant season treatment for deciduous subjects and conifers.

In addition to the new Helmsman treatment, the standard **Ronstar / Flexidor** 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 *Papaver, Origanum, Primula* and *Hosta*. The herbaceous 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.

FURTHER WORK

Treatments for Part 2 nursery trials 2002 / 2003

The following weed control treatments are being trialled on a wider range of subjects under commercial conditions, with the main objective of testing for phytotoxicity, although observations on weed control will also be made.

Shrub trial – Darby Nursery Stock Ltd, Methwold, Thetford

1.	Untreated		
2.	Helmsman Granules	150 kg/ha	applied late May and September
3.	Katamaran	2.0 litres/ha	applied late May and September
4.	Ronstar Granules	200 kg/ha	applied late May and September
5.	Butisan S	2.5 litres/ha	applied late May and September
6.	Biotop	Mulch applied to 5mm depth applied late May	
7.	Flexidor 125	2.0 litres/ha	
	+ Butisan S	2.5 litres/ha	December treatment only
8.	Ronstar Liquid	4.0 litres/ha	December treatment only
9.	Lexone	0.75 kg/ha	December treatment only

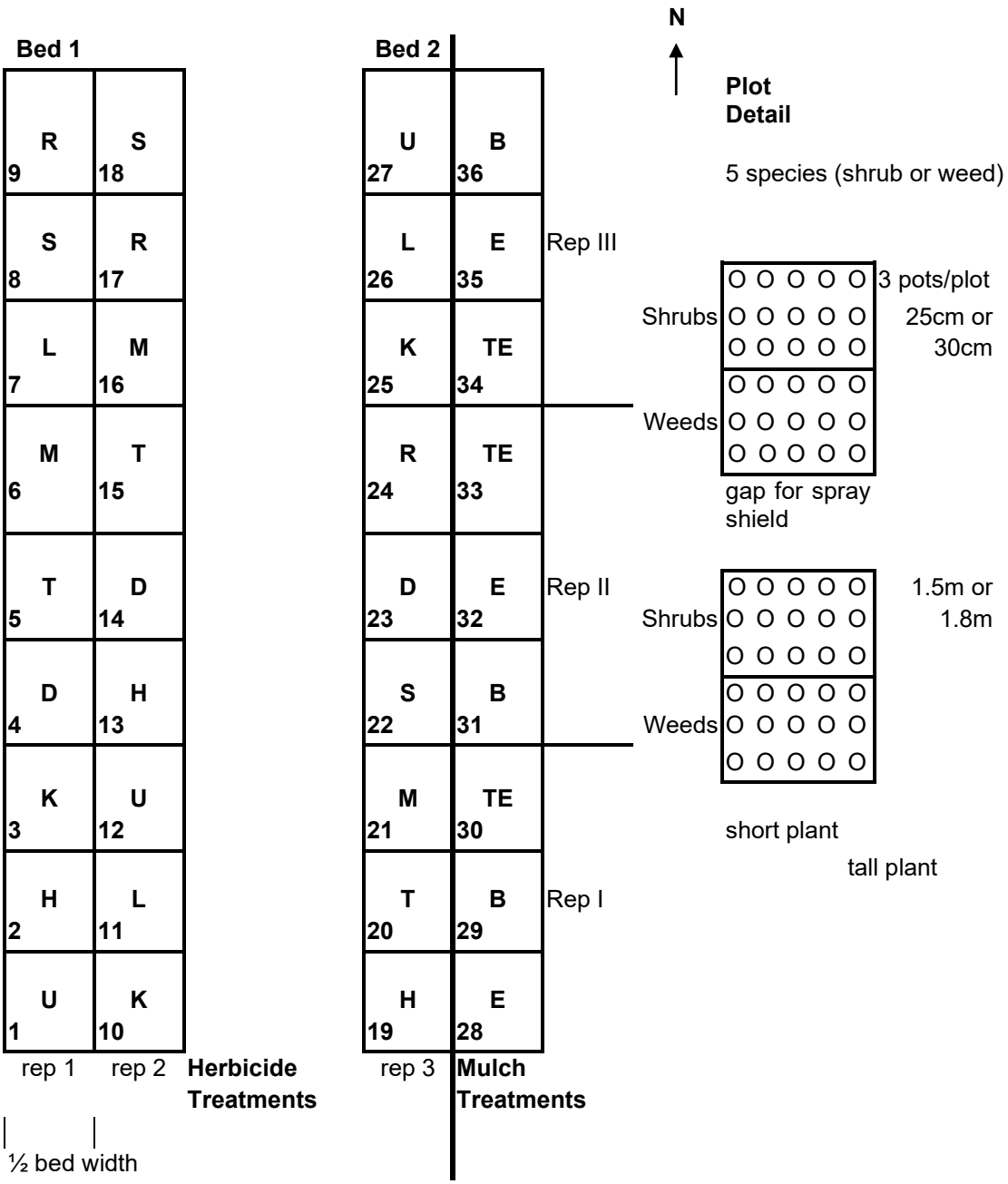
Herbaceous trial – Blooms Wholesale, Bressingham, Diss

1.	Untreated		
2.	Katamaran	2.0 litres/ha	applied late May and September
3.	Ronstar Granules	200 kg/ha	applied late May and September
4.	Titus	50 gm/ha	applied late May and September
5.	Flexidor 125	1.0 litres/ha	applied late May and September

All spray treatments applied in 2500 litres/ha water.

Appendices

Appendix 1a - HNS Woody Species Trial Layout

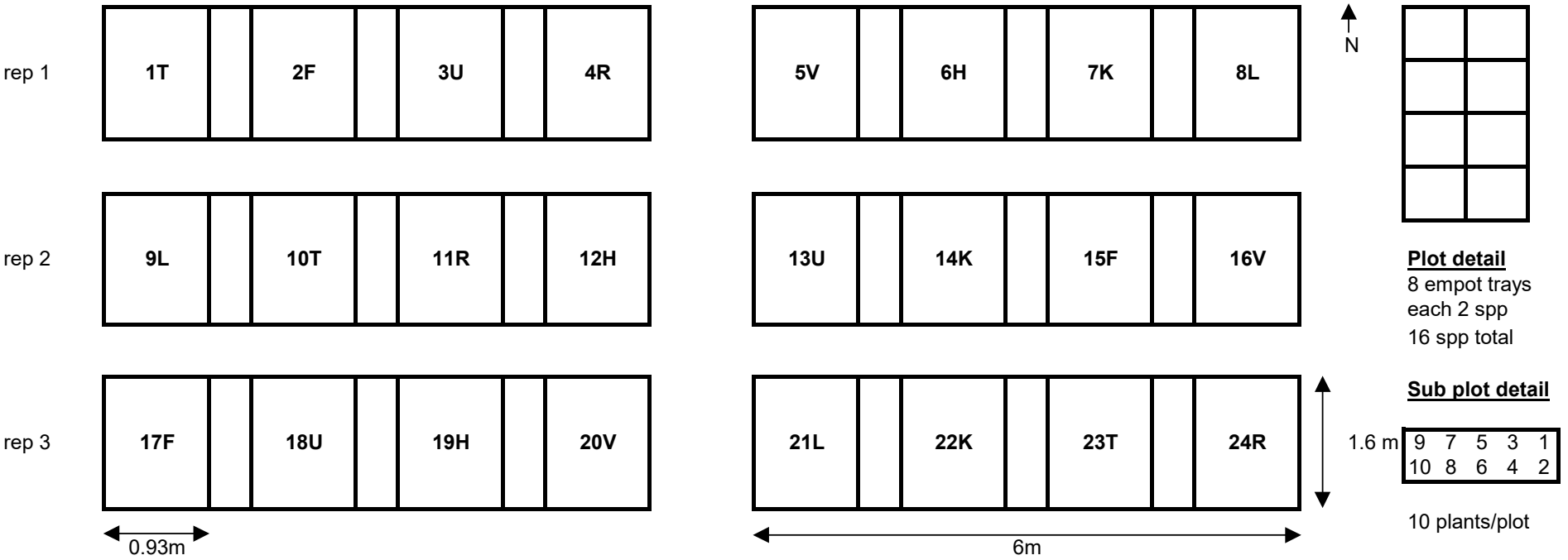


Treatment Key :

U - Untreated

D - Debut
H - Helmsman
K - Katamaran
L - Lexone
M - Monitor
R - Ronstar
S - Stomp
T - Titus
B - Biotop
E - Enviroguard
TE - Terrastar

Appendix 1b - Herbaceous Perennials Trial Layout



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 2

Table 1

Weed assessments - *Cardamine hirsuta* (hairy bittercress)

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	**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*	**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 applied in Sept.01

APPENDIX 2

Table 2 **Weed assessments - *Cerastium fontanum* (mouse-ear chickweed)**

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	**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*	**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 applied in Sept.01

APPENDIX 2

Table 3 **Weed assessments - *Epilobium ciliatum* (American willowherb)**

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	**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*	**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 applied in Sept.01

APPENDIX 2

Table 4

Weed assessments - *Poa annua* (annual meadow grass)
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	**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*	**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	Envirogua rd	**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 applied in Sept.01

APPENDIX 2

Table 5

Weed assessments - *Senecio vulgaris* (groundsel)

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*	**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 applied in Sept.01