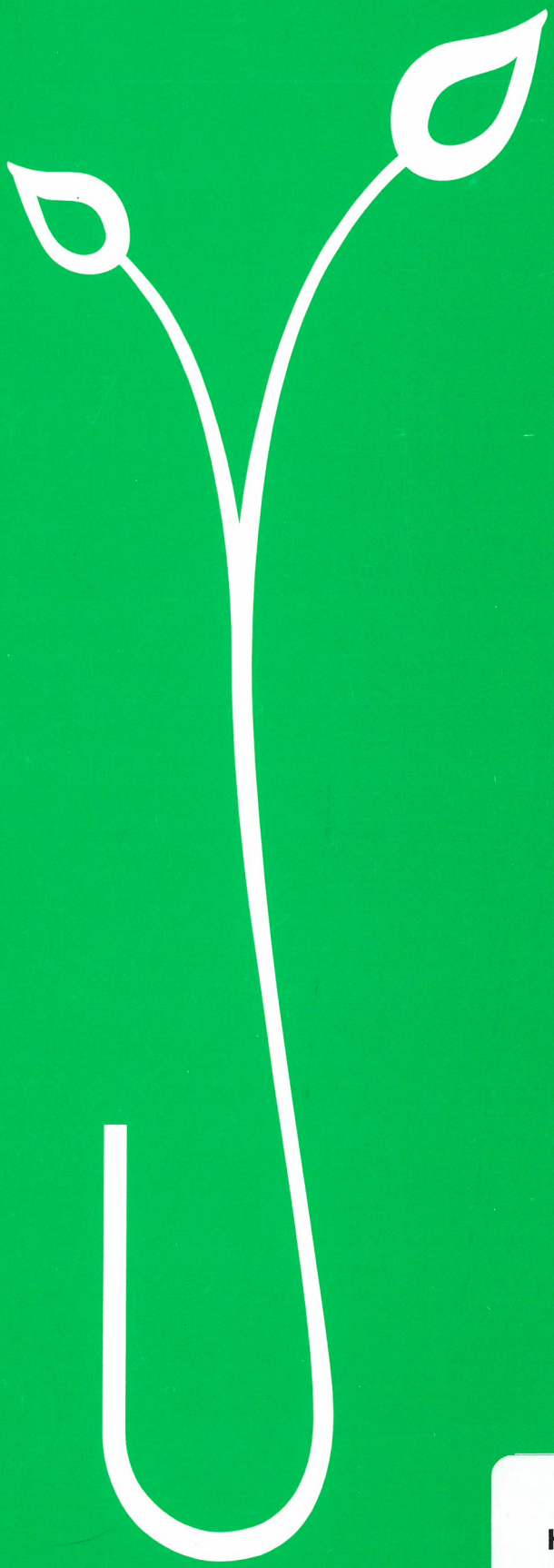

HDC

Horticultural Development Council

Research Report

HNS 74

Chemical weed control in container grown alpine plants

Final report 1998

Project title:	**Alpines: chemical weed control in container grown plants**
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Project number:	**HNS 74**
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1.0 PRACTICAL SECTION FOR GROWERS

1.1 Objectives and background

Hand weeding of container grown alpine plants is an expensive and time consuming task. Many alpine plants are difficult to hand weed in small pots on account of their growth habit and the very small volume of compost, much of which can be lost as weeds are removed. Commercial alpine crops are also often grown under overhead irrigation which encourages the development of weeds, liverwort and moss. Prostrate and deep rooted weeds can be especially troublesome.

Container grown alpine plants can be broadly categorised as either short term or long term crops. Weed control in the former is seldom a concern as the crops are normally marketed within weeks of potting during the spring and summer. It is important though to ensure that the original plug is weed free when potted on. By contrast weeds in longer term, slower growing or overwintered varieties can become a real problem for many growers and it is here that the greatest benefit is likely to be obtained from the successful application of weed control chemicals.

Pre-emergence weed control using residual herbicides offers genuine potential to reduce the costs of hand weeding, but it is seldom straightforward. Alpine growers face two particular problems with regard to chemical weed control. These are, a) the exceptionally wide range of varieties now in commercial production which complicates crop safety considerations and b) the small pot sizes in which many alpines are grown, which creates additional hazards as many residual herbicides act as root inhibitors. Furthermore, none of the residual herbicides currently used over container grown nursery stock carry specific label recommendations for treating alpine species and the application rates at which these materials are used on other nursery stock may be wholly inappropriate or unnecessary for alpine plants grown in small pots. Overall, there is a high degree of risk involved with chemical weed control in alpines.

Against this background, the primary objective of this project was to screen a number of residual herbicides and chemicals under commercial conditions outdoors in order to assess their potential for safe and effective weed control on a wide range of alpine plants. The first year work focused on a wide range of individual herbicide treatments, each treatment being applied at two different rates. The most promising treatments were then taken forward to a second year trial which embraced herbicide programmes and tank mixtures to see if further improvements could be made to the spectrum of weeds controlled, without compromising crop safety.

1.2 Summary of results

A number of residual herbicides applied as either individual treatments or in programmes and mixtures have emerged from this trial with commercial potential for effective weed control in outdoor container grown alpines.

First year trial (individual treatments)

All the treatments were applied two weeks after potting in mid August and repeated at twelve week intervals (making a total of three applications), with the exception of Kerb 50W and Kerb Granules which were applied once only, two weeks after potting. Each herbicide (apart from both the Kerb treatments) was also applied at two different rates, in order to examine the potential for safe and effective weed control at lower than usual commercial rates. If successful, then the lower rates may provide a greater degree of crop safety, in addition to reducing weed control costs.

The results from the Ronstar 2G granule treatments were disappointing. However, mouse-ear chickweed dominated the weed spectrum, and Ronstar 2G would not normally be expected to control this. Results from the Ronstar 2G treatments would have been better had this weed not been so dominant. Bittercress and liverwort control was good. There were no obvious signs of phytotoxicity, or deleterious effects on crop vigour. It should be noted however that the granules were knocked off the crop foliage to minimise the risk of damage, unlike in the second year trial.

Stefes Lenacil, Butisan S (full rate) and Kerb 50W each performed well in the first year, although some phytotoxicity from Stefes Lenacil was observed at both rates during the spring on *Erodium*, *Aubretia*, *Helianthemum* and *Sedum*. The damage manifested itself as an veinal chlorosis, most probably due to an uptake of the herbicide during a period of rapid growth in the warm, early spring conditions. Liverwort, though not a major problem, was well controlled by each of these materials, and in the case of Stefes Lenacil and Butisan S at both application rates. The Mogeton/Flexidor 125 combination provided moderate control of bittercress, and gave good control of chickweed and liverwort. Some phytotoxicity occurred on *Veronica prostrata*, most probably due to the Mogeton element as the symptoms were not noted where the Flexidor 125 was used alone. A slight reduction in vigour was noted with Flexidor 125 at the higher rate of application. Table 1 summarises the performance of each treatment during the first year trial.

Table 1

Summary for first year trial (individual treatments)

Trt	Product (s)	Weed control	L/wort/moss	Vigour/ flowering	Phytotoxicity
B	Mogeton/Flexidor 125	**	****	**	**
C	Ronstar 2G (20 g/m^2)	**	****	*	*
D	Ronstar 2G (10 g/m^2)	*	****	*	*
E	Axit GR (10 g/m^2)	***	***	*	*
F	Axit GR (5 g/m^2)	**	***	*	*
G	Flexidor 125 (0.1 ml/m^2)	**	*	**	**
H	Flexidor 125 (0.05 ml/m^2)	*	*	*	*
I	Butisan S (0.25 ml/m^2)	***	****	*	*
J	Butisan S (0.12 ml/m^2)	*	****	*	*
K	Stefes Lenacil (0.28 g/m^2)	****	****	***	***
L	Stefes Lenacil (0.15 g/m^2)	****	****	***	***
M	Kerb 50W (0.1 g/m^2)	***	****	*	*
N	Kerb Granules (3.8 g/m^2)	*	***	*	*

Key

Weed/ liverwort/moss control

* - poor control
** - partial control
*** - good control
**** - excellent control

Effect on vigour/flowering

* - No effect
** - limited effect
*** - obvious effect
**** - severe effect

Phytotoxicity

* - No damage
** - transient damage
*** - transient/permanent damage
**** - unsaleable

Second year trial (programmes and mixtures)

A number of different programmes and tank mixes were assessed in the second year in order to broaden the spectrum of weed control. The range of alpine varieties screened was very similar to those included during the first year of the work but the treatment interval was reduced from twelve weeks to nine weeks. The first round of applications however had to be delayed until late September in order to obtain and use well established plugs of the required range of species.

The main weeds present were similar to those noted in the first year trial and included bittercress, groundsel, mouse-ear chickweed and willowherb.

Unlike the first year, weed pressure was disappointing. Although there were sufficient weed numbers to allow a comparison of the general levels of weed control against the untreated control plots, it was difficult to make a full and reliable assessment of the different programmes.

Results from the Ronstar 2G programmes (ie, where Ronstar 2G was the initial herbicide used in the programme) were variable. The most effective treatments overall appeared to be those which embraced Stefes Lenacil, applied as either a single treatment alternating with Ronstar 2G or as a tank mix with Flexidor 125 alternated with Ronstar 2G at nine week intervals. Good control of mouse-ear chickweed in particular was largely responsible for the improved levels of weed control resulting from the inclusion of Stefes Lenacil. Ronstar 2G would not be expected to control any of the various species of chickweed.

The improved control achieved by the inclusion of Stefes Lenacil suggests that this may also bolster the capability of Flexidor 125 to control the more resistant mouse-ear chickweed. Though Stefes Lenacil can be phytotoxic especially when used during periods of active growth, the application of reduced rates during the autumn/winter period appeared to moderate its effect without compromising weed control.

Weed control from the Flexidor 125 programmes (ie, where Flexidor 125 was the initial herbicide, either individually or in a mixture) was also variable and it was difficult to establish any consistently clear differences between the various programmes due to the low weed pressure. Overall weed control was improved where Flexidor 125 was tank mixed with either Butisan S or Kerb 50W but the level of phytotoxicity though not serious, was also increased with both mixtures. Initial weed control was also improved where Stefes Lenacil was mixed with Flexidor 125.

Individual treatments of either Stefes Lenacil or Axit GR gave variable levels of weed control though Stefes Lenacil was used at a much reduced rate (1kg/ha).

Bittercress contributed significantly to weed numbers in the Stefes Lenacil plots (though compared to the untreated control plots, some degree of bittercress control was achieved), and willowherb was dominant in the Axit GR treatments. Bittercress control with Stefes Lenacil was considerably improved when the product was either tank mixed with Flexidor 125 or alternated as an individual treatment with Ronstar 2G. The level of willowherb was reduced where Axit GR was alternated with Butisan S in a nine week programme.

Liverwort pressure was much greater in the second year. This may be due in part to the lower background pressure from the broadleaved weeds and particularly wet weather during the winter months. The Ronstar 2G programmes each provided very good levels of liverwort control. The Flexidor 125 programmes and mixtures provided more variable levels of control although excellent results were achieved with the Flexidor 125 + Stefes Lenacil treatment, confirming again the value of Stefes Lenacil in controlling liverwort. Flexidor 125 alone would not be expected to control liverwort. Individual treatments of Stefes Lenacil at a reduced application rate (1 kg/ha) also gave excellent control of liverwort throughout.

Phytotoxicity was more prevalent in the second year and a number of important observations were made. *Campanula, Helianthemum, Phlox, Sedum* and *Thymus* each showed sensitivity to the Ronstar 2G treatments, though the granules were not removed from the crop foliage during the second year of the trial.

As in the first year, *Veronica* again showed sensitivity towards Flexidor 125. Damage was also seen on *Campanula, Dianthus* and *Thymus* when Flexidor 125 was mixed with Butisan S or Kerb 50W. Both Butisan S and Kerb 50W perhaps surprisingly, gave little damage when used as individual treatments in the first year. *Veronica* and *Phlox* were also sensitive to both individual and tank mix treatments of Stefes Lenacil. *Veronica, Phlox Helianthemum* and *Dianthus* each showed some sensitivity towards Axit GR to varying degrees.

The effects of the Flexidor 125 treatments appeared to carry through into the spring, with *Veronica* in particular showing a noticeable reduction in both plant size and flowering. Flowering was also delayed in the Flexidor 125 programmes with *Sedum* and *Thyme*.

Table 2 summarises the performance of each treatment during the second year trial.

Table 2

Summary for second year trial (programmes)

Trt	Product (s)	Weed control	L/wort/ moss	Vigour/ flowering	Phytotoxic
B	Ronstar2G/ Flexidor 125	**	***	**	**
C	Ronstar 2G/Flexidor 125 + Mogeton	**	***	**	**
D	Ronstar 2G/Flexidor 125 + Stefes Lenacil	***	****	**	**
E	Ronstar 2G/ Stefes Lenacil	***	****	**	**
F	Flexidor 125/ Butisan S	***	*	**	**
G	Flexidor 125 + Stefes Lenacil	**	****	***	***
H	Flexidor 125 + Butisan S	***	***	***	***
I	Flexidor 125 + Kerb 50W	***	**	***	***
J	Stefes Lenacil	*	****	**	**
K	Axit GR	**	**	**	**
L	Axit GR/Butisan S	***	**	**	**

Key

Weed/ liverwort/moss control

* - poor control
** - partial control
*** - good control
**** - excellent control

Effect on vigour/flowering

* - No effect
** - limited effect
*** - obvious effect
**** - severe effect

Phytotoxicity

* - No damage
** - transient damage
*** - transient/permanent damage
**** - unsaleable

1.3 Action points for growers

A number of herbicides applied as either individual treatments or combined within programmes or mixtures, have emerged from this work with the potential for providing commercially acceptable levels of weed control in overwintered alpines grown outdoors. However, there are a number of important practical points that growers should note and these are outlined below.

- Some alpine varieties are sensitive to particular herbicides as indicated in the initial work on alpines grown under protection at HRI Efford (HNS 35b). Though phytotoxicity in the ADAS trials (HNS 74) was not extreme, some of the treatment effects gave noticeable reductions in plant size and a delay in flowering.

- Ronstar 2G is capable of providing safe and effective weed control in container grown alpines provided the granules are not allowed to lodge or remain on the foliage after treatment. A light rinsing or brushing off is advisable as per the label recommendation. Where chickweed is a concern, Ronstar 2G will need to be combined in a programme with suitable products such as Flexidor 125 or Stefes Lenacil.

- Butisan S, Kerb 50W and Stefes Lenacil are each capable of providing high levels of weed control in alpines either as individual treatments (and in the case of Stefes Lenacil at reduced rates) or in programmes and mixtures. However, some varieties are sensitive to these materials and growers need to consider this point as well as the weed spectrum, when considering which treatments to use. Applications under cool conditions combined with a light rinsing off will improve the margin of crop safety.

- Flexidor 125 has potential for controlling weeds in container grown alpines but can pose problems with some subjects and so needs to be used carefully, *Veronica* appears particularly sensitive. It also needs to be combined either in programmes or mixtures in order to achieve the best results particularly if groundsel, grass weeds or liverwort are a problem. Butisan S, Kerb 50W, Stefes Lenacil and Mogeton are effective partners, depending on the weed spectrum and sensitivity of the varieties.

Note that Mogeton is a surface biocide and currently does not have a label approval for use as a herbicide over nursery stock.

- Stefes Lenacil applied as an individual treatment is capable of giving good control of both broad leaved weeds and liverwort at reduced rates. It can also be used in programmes or mixtures to bolster the weed control spectrum of other materials, for example Ronstar 2G or Flexidor 125. However, it can be phytotoxic on some varieties and close attention must be paid to both the timing of treatments and the rate of application. Low rates are safer and will provide excellent liverwort control but the control of broad leaved weeds will be compromised if the rate is reduced too far. Applications during periods of active crop growth should be avoided.

Growers wishing to experiment with these treatments should do so on a trial basis only. In the absence of specific label approvals for use over alpine varieties, the application of any of these treatments is made entirely at the growers own risk. Growers should also note that the treatments in this trial were applied to container grown alpines produced outdoors NOT under protection. Plants grown under protection are invariably softer and so may show greater sensitivity to the application of weed control chemicals.

1.4 Anticipated practical and financial benefits.

Safe and effective chemical weed control does offer a number of potential benefits to commercial growers and these are outlined below;

- Expensive and laborious hand weeding can be considerably reduced and possibly eliminated, creating opportunities to use this labour more profitably elsewhere on the nursery. This will also reduce the time consuming task of topping up weeded pots with fresh compost.

- Gross margins should also improve as labour inputs are reduced. Reduced labour inputs during the busy spring months are particularly beneficial

- Crop quality and presentation at point of sale will be considerably enhanced.

- Greater confidence with herbicides will be acquired by growers as they use and benefit from chemical weed control in alpine varieties.

- A greater understanding has been achieved through this project of the behaviour of residual herbicides in relation to alpine plants grown outdoors particularly with regard to crop safety, optimum rates and different herbicide combinations.

2.0 SCIENCE SECTION

2.1 Introduction

Hand weeding of container grown alpine plants is an expensive and time consuming task. Once allowed to establish, weeds can be difficult to remove from small pots without damaging the plant and disturbing the root system. Chemical weed control using residual herbicides offers genuine potential to overcome these problems although historically, growers have been reluctant to use them, largely on account of crop safety considerations. Longer term, overwintered alpine varieties are particularly susceptible to weed problems, and therefore research was targeted at these crops.

Initial screening work with a limited range of alpine varieties grown under protection was undertaken at HRI Efford during the period 1992-95 (ref HNS 35b, Alpines). This work identified a number of promising chemical treatments with potential for controlling weeds in alpine crops including, moss and liverwort. However, some of the more effective treatments were also phytotoxic when applied to alpines grown under protection. Many of the treatments used in the trial at Efford were aimed at controlling moss and liverwort, which can be a major threat to overwintered crops held under protection. Chemicals with specific activity against moss and liverwort such as Panacide M, Mogeton and Thianosan did not though provide control of the general range of weeds.

The most promising and least phytotoxic chemical for moss and liverwort control to emerge from the research work at Efford was Mogeton. This chemical however is only a surface biocide with recommendations for use on outdoor surfaces, and has no label approval for use on nursery stock. Of the herbicides trialled, Ronstar 2G gave good control of weeds as well as moss and liverwort, with relatively little phytotoxicity. The product also has a label approval for use on nursery stock including plants grown under well ventilated polythene structures.

The performance of Flexidor 125 in the Efford work suggested that it had some potential and was reasonably safe over the plants examined in the trial. However, it did at this stage need further assessment under commercial weed pressures. The lack of moss and liverwort control with Flexidor 125 meant that it would need to be used in combination with a product which has specific activity against moss or liverwort such as Mogeton, if either of these were a problem.

Stefes Lenacil gave excellent control of bittercress, moss and liverwort in the Efford work, but caused damage on several subjects. Kerb 50W, included

originally for its activity against grasses, also gave good control of liverwort, but was phytotoxic and caused unacceptable damage on several of the alpine varieties.

The screening work carried out at Efford, whilst identifying several promising treatments, also highlighted the fact that container grown hardy alpines can be more sensitive to chemicals than other hardy nursery stock species, and very few of the chemicals screened in the work proved entirely safe over the limited range of varieties used in the trials. This created the commercial dilemma of accepting the possibility of limited phytotoxicity in order to achieve the level of weed control required. A small reduction in vigour or plant size, or the presence of transient phytotoxicity symptoms for example, may be commercially acceptable in some circumstances.

The best treatments from the Efford screening work were brought forward into the HDC commercial nursery trials conducted by ADAS (HNS 74), in order to evaluate their potential further under commercial weed pressures. The inclusion of a wider range of crop species was also a high priority. The production schedule chosen for this project followed a similar pattern to that at Efford, with an overwintered crop potted on from plugs during August and irrigated overhead. The main difference between the Efford trial and the commercial nursery trial was that the latter focused on outdoor crops, where there may be a higher degree of crop safety on account of the growth not being as soft.

2.2 Materials and methods

Production system

Plug plants were potted on into 9 cm pots and set down outdoors on a sand base under overhead irrigation. The first year trial (individual herbicide treatments) was potted during the first week of August, but the potting date for the second trial (herbicide programmes) had to be delayed until mid September in order to obtain large, well rooted plugs of the required species for potting.

The location of the trial was S. W. & J. Van Dodeweerd, a specialist alpine nursery situated at Donington near Spalding in Lincolnshire.

Growing medium

The nursery's standard potting mix comprising medium grade sphagnum peat, 5% grit, starter fertiliser, controlled release fertiliser with trace elements, and magnesian limestone was used for the trial.

Start material

Plugs of ten commercially representative varieties, were hand potted into 9 cm pots for each trial.

Design

A randomised block design was used and each treatment was replicated three times. Each plot comprised four plants of ten commercially representative alpine subjects. The trial layouts for each year of the project are outlined at Figures 1 and 2.

Records

Treatments were assessed for the degree of weed control (weed counts before each application) and crop phytotoxicity (after each application). The weed control results were statistically analysed and the analyses are summarised at Appendices I and II.

First year treatments and trial layout

A) Untreated control

B) Mogeton, (quinoclamin), 1.0 g/m^2 + Flexidor 125 (isoxaben), 0.1 ml/m^2

C) Ronstar 2G, (oxadiazon), 20 g/m^2

D) Ronstar 2G, (oxadiazon), 10 g/m^2

E) Axit GR (previously Premiere Granules*, isoxaben + trifluralin), 10g/m^2

F) Axit GR (previously Premiere Granules*, isoxaben + trifluralin), 5g/m^2

G) Flexidor 125, (isoxaben), 0.1 ml/m^2

H) Flexidor 125, (isoxaben), 0.05 ml/m^2

I) Butisan S, (metazachlor), 0.25 ml/m^2

J) Butisan S, (metazachlor), 0.12 ml/m^2

K) Stefes Lenacil, (lenacil), 0.28 g/m^2

L) Stefes Lenacil, (lenacil), 0.15 g/m^2

M) Kerb 50W, (propyzamide), 0.1 g/m^2

N) Kerb Granules, (propyzamide), 3.8 g/m^2

Rates/ha

Ronstar 2G @ 200 kg & 100 kg
Flexidor 125 @ 1 litre & 0.5 litre
Mogeton @ 10 kg
Axit GR @ 100 kg & 50 kg*
Butisan S @ 2.5 litres & 1.25 litres
Stefes Lenacil @ 2.8 kg & 1.5 kg
Kerb 50W @ 1 kg
Kerb Granules @ 38 kg

* Premiere Granules, is the product name given in the Annual Report (1997) but since this work began, Axit GR has become the approved product for use in crop production and Premiere Granules in the landscape situation. To avoid confusion, the product name Axit GR has been used throughout this report. Both products contain the active ingredients isoxaben + trifluralin.

Figure 1

Trial Layout, first year trial

D	I	M
C	K	A
A	F	J
N	L	F
J	G	D
B	C	K
I	H	H
M	J	E
H	B	L
E	N	G
L	D	N
G	M	I
F	A	B
K	E	C

R1 R2 R3

A) Untreated Control
B) Mogeton (1.0 g/m^2) + Flexidor 125 (0.1 mls/m^2)
C) Ronstar 2G 20 g/m^2
D) Ronstar 2G 10 g/m^2
E) Axit GR 10 g/m^2
F) Axit GR 5 g/m^2
G) Flexidor 125 0.1 mls/m^2
H) Flexidor 125 0.05 mls/m^2
I) Butisan S 0.25 mls/m^2
J) Butisan S 0.12 mls/m^2
K) Stefes Lenacil 0.28 g/m^2
L) Stefes Lenacil 0.15 g/m^2
M) Kerb 50W 0.1 g/m^2
N) Kerb Granules 3.8 g/m^2

1680 plants in total comprising 4 plants of 10 commercially representative subjects per plot, 14 plots replicated three times.

Second year treatments (programmes & mixtures) and trial layout

A) Untreated control

B) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 every 9 weeks

C) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Mogeton 1.0 g/m^2 every 9 weeks

D) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

E) Ronstar 2G, 20 g/m^2 alternated with Stefes Lenacil, 0.1 g/m^2 every 9 weeks

F) Flexidor 125, 0.1 ml/m^2 alternated with Butisan S, 0.25 ml/m^2 every 9 weeks

G) Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

H) Flexidor 125, 0.1 ml/m^2 + Butisan S, 0.25 ml/m^2 every 18 weeks

I) Flexidor 125, 0.1 ml/m^2 + Kerb 50W, 0.1 g/m^2 every 9 weeks

J) Stefes Lenacil, 0.1 g/m^2 every 9 weeks

K) Axit GR, 10 g/m^2 every 9 weeks

L) Axit GR, 10 g/m^2 alternated with Butisan S, 0.25 ml/m^2 every 9 weeks

Rates/ha

Ronstar 2G @ 200 kg
Flexidor 125 @ 1 litre
Mogeton @ 10 kg
Axit GR @ 100 kg
Butisan S @ 2.5 litre
Stefes Lenacil @ 1 kg (reduced to 0.5 kg where tank mixed)
Kerb 50W @ 1 kg

Figure 2

Trial layout, second year

J	F	A
L	G	C
C	K	I
A	J	F
D	H	E
I	L	B
G	E	K
B	D	L
F	A	G
E	C	D
K	I	H
H	B	J

A) Untreated control
B) Ronstar 2G (20 g/m^2) alternated with Flexidor 125 (0.1 mls/m^2)
C) Ronstar 2G (20g/m^2) alternated with Flexidor 125 0.1 mls/m^2) + Mogeton (10 g/m^2)
D) Ronstar 2G (20g/m^2) alternated with Flexidor 125 (0.1mls/m^2) + Stefes Lenacil (0.05g/m^2)
E) Ronstar 2G (20g/m^2) alternated with Stefes Lenacil (0.1g/m^2)
F) Flexidor 125 (0.1mls/m^2) alternated with Butisan S (0.25 mls/m^2)
G) Flexidor 125 (0.1 mls/m^2) + Stefes Lenacil (0.05g/m^2)
H) Flexidor 125 (0.1 mls/m^2) + Butisan S (0.25 mls/m^2)
I) Flexidor 125 (0.1 mls/m^2) + Kerb 50W (0.1 g/m^2)
J) Stefes Lenacil (0.1 g/m^2)
K) Axit GR (10 g/m^2)
L) Axit GR (10 g/m^2) alternated with Butisan S (0.25 mls/m^2)

R1 R2 R3

All treatments at 9 week intervals except treatment H (18 weeks).

1440 plants in total comprising 4 plants of 10 subjects per plot, 12 plots replicated three times.

All spray treatments in both years of the trial were applied in 2,500 litres of water/ha. None of the spray treatments were washed off.

The granule treatments during the first year of the trial were applied directly to the compost surface, any granules that lodged in amongst the crop foliage were gently knocked off. In the second year of the trial, the granules were not removed from the crop foliage in order to replicate commercial practice where it may prove impractical to remove lodged granules from small plants on a large scale.

The initial treatments were applied two weeks after potting with subsequent applications made at 12 week intervals in the first year trial, reducing to nine weeks in the second trial (with the exception of the Flexidor 125 + Butisan S treatment, where applications were made at 18 week intervals.

The Kerb 50W and Kerb Granules treatments in the first year trial had a single application two weeks after potting in line with the current label approval, which allows just one application per crop. Repeat treatments on a trial basis were made in the second year trial where Kerb 50W was tank mixed with Flexidor 125.

Species treated

Aubretia 'Purple Cascade' ('Blue Cascade')
Campanula pulla
Dianthus 'Little Jock' ('Wyewoods Cream')
Erodium reichardii 'Roseum'
Helianthemum 'Wisley Pink' ('Ben Alder')
Phlox subulata 'Eva' ('Drumm' aka 'Tamaongalei')
Saxifraga 'Peter Pan'
Sedum spathulifolium 'Purpureum' (*Sedum acre* 'Minor')
Thymus serpyllum 'Highland Cream'
Veronica prostrata (*selleri*)

Names given in brackets refer to species and cultivars used in the second year as a result of the unavailability of the original species or cultivar.

2.3 Results and discussion

Weed control, first year trial with individual treatments

The main weeds present were mouse-ear chickweed and bittercress. Willowherb and groundsel were also present, but at much lower levels.

Liverwort was a potential problem, though the naturally spreading growth habit of several subjects for example, *Veronica prostrata*, *Saxifraga* 'Peter Pan', *Sedum spathulifolium* 'Purpureum', *Phlox subulata* 'Eva' and, *Thymus serpyllum* 'Highland Cream' provided a good degree of natural suppression.

Several herbicides performed well and proved capable of providing commercially acceptable levels of weed control throughout the trial. Stefes Lenacil (both rates), Kerb 50W, and Butisan S (standard rate, 2.5 l/ha) each gave high levels of weed control including liverwort, although weed numbers had begun to build up by the spring with the Kerb 50W treatment. Axit GR granules (isoxaben + trifluralin) gave reasonable weed and liverwort control when applied at the standard rate (100 kg/ha). The Mogeton + Flexidor 125 combination provided moderate control of bittercress, and gave good control of chickweed and liverwort. Had chickweed not been so dominant, the weed control results for both the Ronstar 2G treatments would have been very good, suggesting that there is scope for using the half rate application. Bittercress and liverwort control was also good in the Ronstar 2G treated plots, particularly at the standard treatment rate.

Statistical analysis of variance showed the total weed counts recorded after three months (November 96) to be significantly different and also at the nine month assessment (May 97). A summary of the analysis is presented in Table 1 at Appendix 1. With regard to the three month assessment of weed control taken in November, the Mogeton + Flexidor 125, Axit GR (both rates), Flexidor 125 (both rates), Butisan S (both rates), Stefes Lenacil (both rates) and Kerb 50W were all significantly different to the untreated control. The Butisan S (higher rate), Stefes Lenacil (both rates) and Kerb 50W were also significantly better than both Ronstar 2G treatments, Flexidor 125 (reduced rate), Butisan S (reduced rate) and Kerb Granules. The Kerb 50W was also significantly better than the Flexidor 125 applied at the 1 litre/ha.

With regard to the nine month assessments for weed control (May 97), all the treatments were significantly different to the untreated control apart from both the Ronstar 2G treatments and the Kerb Granules treatment. Both the Stefes Lenacil treatments and the higher rate Butisan S treatment results were significantly better than the Mogeton + Flexidor 125, both rates of Ronstar 2G, the reduced rates of Axit GR, Flexidor 125 and Butisan S and, the Kerb Granules treatment. The higher treatment rate applications of Axit GR and Flexidor 125 gave significantly better results than Ronstar 2G (both rates), reduced rate applications of both Flexidor 125 and Butisan S, and Kerb Granules. The Mogeton + Flexidor 125 treatment was significantly better than Ronstar 2G (both rates) and Kerb Granules.

Analyses of the two way factorial of treatment and dose on Ronstar 2G, Axit GR (previously Premiere Granules), Flexidor 125, Butisan S and Stefes Lenacil

gave significant treatment and dose effects for the nine month assessment (May 97). Axit GR, Flexidor 125, Butisan S and Stefes Lenacil gave significantly better treatment effects than the Ronstar 2G. Stefes Lenacil was also significantly better than each of the other treatments. Analysis of the three month data (November 96) showed similar treatment effects, with Stefes Lenacil also significantly better than Butisan S and Flexidor 125. No other values were significant. The results are summarised in Table 2 at Appendix 1.

Table 3 summarises the percentage weed control results relative to the untreated control

Table 3

Percentage weed control, first year trial

Treatment	Nov 96	Feb 97	May 97	Mean
A Untreated control	-	-	-	-
B Mogeton/Flexidor 125	67.56	53.00	50.90	57.15
C Ronstar 2G (20g/m^2)	9.46	42.00	18.86	23.44
D Ronstar 2G (10g/m^2)	5.40	20.00	9.56	11.65
E Axit GR (10g/m^2)	71.62	76.00	69.76	72.46
F Axit GR (5g/m^2)	70.27	72.50	53.48	65.41
G Flexidor 125 (0.1 ml/m^2)	60.81	60.50	69.25	63.52
H Flexidor 125 (0.05 ml/m^2)	33.78	34.00	36.69	34.82
I Butisan S (0.25 ml/m^2)	77.02	81.50	84.49	81.00
J Butisan S (0.12 ml/m^2)	44.60	37.50	36.95	39.68
K Stefes Lenacil (0.28g/m^2)	93.24	98.00	96.38	95.87
L Stefes Lenacil (0.15g/m^2)	90.54	97.00	90.43	92.65
M Kerb 50W (0.1g/m^2)	98.64	84.50	57.88	80.34
N Kerb Granules (3.8g/m^2)	68.91	52.50	23.77	48.39

Each weed control assessment was carried out just before the next chemical treatment was due.

Weed control, second year trial with weed control programmes

The weed pressure recorded during the second year of the trial was low and this made it difficult to clearly assess and interpret any major differences between the treatments. The main weed species that were present were similar to those recorded in the first year of the trial and included bittercress, groundsel, mouse-ear chickweed and willowherb. However, liverwort pressure was much greater than in the previous trial, most probably on account of the exceptionally wet winter though the relatively small numbers of broad leaved weeds, may also have provided an added opportunity for liverwort to develop.

Results from the Ronstar 2G programmes were variable. The most effective treatments overall appeared to be those which embraced Stefes Lenacil, applied either as an individual treatment, alternated with Ronstar 2G or as a tank mix with Flexidor 125 and alternated with Ronstar 2G at nine week intervals. Weed control was considerably enhanced when compared to the standard Ronstar 2G/ Flexidor 125 alternated programme. An inability to control mouse-ear chickweed was largely responsible for the poorer weed control resulting from this treatment. Groundsel numbers had also built up by the spring. Ronstar 2G alone would not be expected to control chickweed, and mouse-ear chickweed appears more resistant than common chickweed to Flexidor 125. Flexidor 125 also needs to be applied at the full label rate (2 litre/ha) for good groundsel control. This would however, increase the risk of phytotoxicity. Both weeds are embraced within the control spectrum of Stefes Lenacil.

Weed control from the Flexidor 125 programmes (ie, where Flexidor 125 was the initial treatment, either individually or in tank mixtures) was also variable and it is difficult to establish any consistently clear differences between the various programmes due to the low background pressure. Overall weed control was improved where Flexidor 125 was tank mixed with either Butisan S or Kerb 50W but the level of phytotoxicity though not serious, was also increased. Initial weed control was also improved where Stefes Lenacil was mixed with Flexidor 125.

The Flexidor 125 + Butisan S tank mix applied at 18 week intervals gave very good weed control overall, with weed numbers just starting to increase in the late spring. This treatment proved more effective overall than where the two materials were applied as individual, alternated treatments. In the latter case, groundsel in particular developed after each of the Flexidor 125 treatments. Weed control with the Flexidor 125 + Kerb 50W combination held up well until the late spring, when groundsel seedlings began to come through.

Individual treatments of either Stefes Lenacil or Axit GR gave variable weed control although Stefes Lenacil was used at a low rate (1 kg/ha), and still provided excellent liverwort control. Bittercress contributed significantly to weed numbers in the Stefes Lenacil plots and willowherb was dominant in the Axit GR treatments although it is again stressed that weed numbers generally were low throughout the trial. Bittercress control with Stefes Lenacil was considerably improved when the product was either tank mixed with Flexidor 125 or alternated as an individual treatment with Ronstar 2G. Willowherb numbers were reduced where Axit GR was alternated with Butisan S in a nine week programme.

Table 4 summarises the percentage weed control results relative to the untreated control for the second year trial.

Table 4

Percentage weed control, second year trial

Treatment	Nov 97	Jan 98	April 98	Mean
A Untreated control	-	-	-	-
B Ronstar 2G / Flexidor 125	33.33	37.50	53.22	41.35
C Ronstar 2G / Flexidor 125 + Mogeton	16.66	62.50	69.35	49.50
D Ronstar 2G / Flexidor 125 + Stefes Lenacil	50.00	100.00	77.42	75.80
E Ronstar 2G / Stefes Lenacil	66.66	100.00	69.35	78.67
F Flexidor 125/ Butisan S	50.00	62.50	80.64	64.38
G Flexidor 125 + Stefes Lenacil	83.33	50.00	58.06	63.79
H Flexidor 125 + Butisan S	100.00	75.00	64.51	79.83
I Flexidor 125 + Kerb 50W	83.33	75.00	51.61	69.98
J Stefes Lenacil	33.33	50.00	51.61	44.98
K Axit GR	00.00	62.50	75.80	46.10
L Axit GR/ Butisan S	66.66	50.00	77.42	64.69

All treatments applied at nine week intervals with the exception of treatment H (18 weeks).

Data for separate weed species counts taken from the first assessment in November was too sparse for statistical analysis, except mouse-ear chickweed and the total weed count, which using a Friedmans test (a non parametric test which ranks the effect of herbicides) was statistically non significant.

Analysis of the data taken from the second assessment in January, showed no significant difference in either individual species number or total counts using the Friedmans test. Analysis of the weed data from the final assessment in April, using the Friedmans non parametirc test where appropriate, showed that only bittercress and total weed count were significantly different. All the herbicide treatments gave significantly better levels of bittercress control than the untreated control. Bittercress control in the Flexidor 125 + Kerb 50W and

Stefes Lenacil individual programme was significantly inferior to the other herbicide treatments.

Summaries of the statistical analyses can be found at Appendix II

Liverwort control, first year trial

Liverwort did not establish to any significant extent during the first year trial although it did develop in some of the plots during the latter stages once the pots had been outside for several months over the winter.

The naturally spreading growth habit of several subjects for example, *Veronica prostrata*, *Saxifraga* 'Peter Pan', *Sedum spathulifolium* 'Purpureum', *Phlox subulata* 'Eva' and *Thymus serpyllum* 'Highland Cream' provided a good degree of natural suppression. This should be taken into account when interpreting the results obtained.

Most treatments gave good control where liverwort did have the opportunity to develop, particularly, Ronstar 2G at both rates of application, Stefes Lenacil at both the full and reduced rates, and Kerb 50W.

The Mogeton + Flexidor 125 tank mix also provided very good liverwort control. Flexidor 125 when used alone did not give good control at either rate. The Axit GR granule treatments also gave good control particularly at the full rate, although the level of control did diminish towards the end of the trial.

Moss did not develop to any significant extent during the trial in any of the plots.

Table 5 shows the mean percentage liverwort cover per pot for each treatment at each assessment and the mean percentage cover for the three assessments.

Table 5

Percentage liverwort cover, first year trial

Treatment	Nov 96	Feb 97	May 97	Mean
A Untreated control	8.25	9.58	26.95	14.92
B Mogeton + Flexidor 125	0.00	0.00	2.16	0.72
C Ronstar 2G (20g/m^3)	0.00	0.00	0.00	0.00
D Ronstar 2G (10g/m^2)	0.25	0.08	0.00	0.11
E Axit GR (10g/m^2)	1.58	1.24	7.49	3.43
F Axit GR (5g/m^2)	3.05	2.62	8.24	4.63
G Flexidor 125 (0.1 ml/m^2)	4.37	7.70	24.75	12.27
H Flexidor 125 (0.05 ml/m^2)	8.16	9.04	26.80	14.66
I Butisan S (0.25 ml/m^2)	0.16	0.00	0.00	0.05
J Butisan S (0.12 ml/m^2)	1.41	0.79	0.00	0.73
K Stefes Lenacil (0.28 g/m^2)	0.00	0.00	0.00	0.00
L Stefes Lenacil (0.15 g/m^2)	0.00	0.00	0.00	0.00
M Kerb 50W (0.1 g/m^2)	0.00	0.00	0.00	0.00
N Kerb Granules (3.8 g/m^2)	0.29	0.03	6.58	2.30

Liverwort control, second year trial

Liverwort was a much greater problem in the second year trial, encouraged to a degree by the exceptionally wet conditions during parts of the winter and early spring. This provided a good test of the various programmes and mixtures. The absence of significant numbers of broad leaved weeds for much of the trial allowed the liverwort to establish more easily and was also a contributory factor.

The Ronstar 2G programmes each gave very good levels of liverwort control and this was improved further by the introduction of Stefes Lenacil either as an alternate individual treatment, or as a tank mixture with Flexidor 125 alternated with Ronstar 2G at nine week intervals. The ability of Ronstar 2G to provide liverwort control in the initial period after potting (providing it is applied promptly) is important and often underestimated.

Stefes Lenacil also gave outstanding liverwort control when applied as a low rate (1 kg/ha) treatment at nine week intervals.

The alternated programme of Flexidor 125 and Butisan S gave disappointing control, due largely to the inability of Flexidor 125 to control liverwort. However, the 18 week tank mix treatment of Flexidor 125 + Butisan S gave very good control until the latter stages of the trial.

A statistical analysis of variance was carried out on the liverwort results and full details are outlined at Appendix II. The November results show that all the treatments significantly reduced the number of pots in which liverwort developed apart from the Flexidor 125/Butisan S programme. The Ronstar programmes, Flexidor 125 + Stefes Lenacil, Flexidor 125 + Butisan S mixture and, individual treatments of Stefes Lenacil at nine week intervals also gave significantly better results than either the Flexidor 125 + Kerb 50W or the two Axit GR programmes after 3 months.

Similar remarks apply to the assessment of percentage liverwort cover with the exception of the Ronstar 2G/Flexidor 125 programme which was not significantly better than either the Flexidor 125/Butisan S, Flexidor 125 + Kerb 50W or, Axit GR programmes. Also, the Ronstar 2G programmes, Flexidor 125 + Stefes Lenacil, Flexidor 125 + Butisan S and Stefes Lenacil applied as an individual treatment at nine week intervals, each gave a significant reduction in liverwort cover when compared to the Ronstar 2G/Flexidor 125 programme.

Statistical analysis of the January data indicated a similar pattern for both the number of pots with liverwort and the percentage cover. However, the Flexidor 125/Butisan S treatments had at this stage significantly reduced the number of pots with liverwort as compared to the control, unlike the earlier assessment but was it was also significantly inferior to the other treatments. With regard to percentage cover, the Flexidor 125/Butisan S, Flexidor 125 + Kerb 50W or Axit GR programmes showed no significant improvement over the control at this stage. The Ronstar 2G programmes, Flexidor 125 + Stefes Lenacil mixture and nine week applications of Stefes Lenacil alone were significantly better than the other treatments.

The final analysis taken from the April results showed that all treatments

produced significantly fewer pots with liverwort than the control. Also, the Flexidor 125/Butisan S treatment had significantly more pots with liverwort in than the other treatments. The Ronstar 2G programmes, Flexidor 125 + Stefes Lenacil, Flexidor 125 + Butisan S and individual treatments of Stefes Lencail significantly reduced the number of pots with liverwort in as compared to the Flexidor 125 + Kerb 50W mixture and the Axit GR programmes.

Statistical analyses of liverwort cover towards the end of the trial shows that the Ronstar 2G programmes, the Flexidor 125 + Stefes Lenacil, Flexidor 125 + Butisan S and individual treatments of Stefes Lenacil had each significantly reduced this when compared to the control. Of these treatments, each of the Ronstar 2G programmes (other than the Ronstar 2G/Flexidor 125 + Mogeton programme), the Flexidor 125 + Stefes Lenacil mixture and Stefes Lenacil alone were also significantly better than the Flexidor 125 + Butisan S treatment applied at 18 week intervals.

The Friedmans tests also showed significant differences in line with the analysis of variance, for the liverwort data for each assessment. A similar analysis of moss data was virtually non significant.

Though moss was not present in the trial to any major extent the assessments indicate that mixtures of Flexidor 125 with Stefes Lenacil applied at nine week intervals and Flexidor + Butisan S applied at 18 week intervals are each capable of giving good control, as are repeat treatments of Stefes Lenacil at the 1 kg/ha rate. Alternate programmes of Ronstar 2G / Flexidor 125 + Mogeton, Ronstar 2G / Flexidor 125 + Stefes Lenacil and Ronstar 2G / Stefes Lenacil also reduced the presence of moss when compared with the control plots. Results from two of the assessments also suggest that the Axit GR programmes can reduce moss colonisation.

Statistical analyses did show some significant treatment effects in respect of moss control. The November results show that all treatments with the exception of the Axit GR programmes and, perhaps surprisingly, the Ronstar 2G/Stefes Lenacil treatments significantly reduced the number of pots with moss when compared to the control. All treatments with the exception of the Axit GR programmes significantly reduced the degree of moss cover though there was no significant differences between the treatments.

The January analyses also produced some significant differences in respect of the number of pots containing moss. All the treatments significantly reduced the number of pots with moss apart from the Ronstar 2G/Flexidor 125 programme and they were also significantly better than the Flexidor 125 + Kerb 50W mixture. Values for the assessment of percentage pot cover were not statistically significant.

Analyses of the final results taken in April for the number of pots containing moss, show a repeat of the same significant differences. Results for percentage pot cover were again not significantly different.

Table 6 shows the mean percentage liverwort cover per pot for each treatment at each assessment and the mean percentage cover for the three assessments.

Table 6

Percentage liverwort cover, second year trial

Treatment	Nov 97	Jan 98	April 98	Mean
A Untreated control	9.50	19.30	27.00	18.60
B Ronstar 2G / Flexidor 125	6.70	0.00	0.00	2.23
C Ronstar 2G / Flexidor 125 + Mogeton	1.60	3.30	5.00	3.30
D Ronstar 2G / Flexidor 125 + Stefes Lenacil	3.30	0.00	0.00	1.10
E Ronstar 2G / Stefes Lenacil	0.00	0.00	0.00	0.00
F Flexidor 125/Butisan S	8.30	9.40	26.30	14.66
G Flexidor 125 + Stefes Lenacil	0.00	0 00	0.00	0.00
H Flexidor 125 + Butisan S	0.00	0.00	10.00	3.33
I Flexidor 125 + Kerb 50W	6.20	7.60	22.10	11.96
J Stefes Lenacil	0.00	0.00	0.00	0.00
K Axit GR	8.50	5.50	24.20	12.73
L Axit GR / Butisan S	7.90	10.00	25.60	14.50

Phytotoxicity, first year trial

Assessments for phytotoxicity were made following each treatment. No damage was recorded from any of the treatments during the assessments in September and November. However, noticeable damage did occur in some of the plots following the final round of treatments in mid February, which were assessed during early March.

Damage was noted on *Veronica prostrata* from the Mogeton + Flexidor 125 treatment. The main symptoms of damage were an interveinal yellowing of the foliage particularly in the shoot tips, distortion of the shoot tips and an overall lack of vigour. This damage appears to have been caused by the Mogeton element, as the symptoms were not typical of those usually associated with Flexidor 125, and were not apparent to any extent where Flexidor 125 had been used alone. Crop growth began early in the spring on account of the exceptionally warm weather, and it is likely that these conditions predisposed the plants to chemical damage. Symptoms of damage had receded by early May, although saleability had been markedly delayed.

Significant damage was also recorded from the Stefes Lenacil during the final assessment in May. The key symptom was a veinal yellowing on several subjects including *Aubretia, Erodium, Helianthemum* and *Sedum.* These symptoms were still apparent in early June. It seems likely that significant uptake of the Stefes Lenacil had occurred during a period of rapid plant growth during the unusually warm, early spring after the final treatment was applied in mid February. As these treatments also provided excellent weed control including liverwort, the second year work embraced lower rates of Stefes Lenacil in an attempt to improve the margin of crop safety without compromising weed control.

The Flexidor 125 treatments did not cause any significant damage, although a slight paling of the foliage and a reduction in vigour was noted on *Veronica prostrata* and *Aubretia* at the higher application rate during the March assessment. These symptoms persisted into early May.

Variable plug quality, particularly with the *Aubretia* and *Thymus* accounted for some plant losses during the early stages of the trial. Some of the *Sedum*, perhaps unsurprisingly, struggled to overwinter outdoors successfully.

On the whole, crop damage was not as widespread as one might expect given the range of treatments. However, the treatments were applied to crops grown outdoors rather than under the protection of a glasshouse or polythene tunnel, where herbicide sensitivity may be greater. Ronstar 2G, Axit GR, Butisan S and both Kerb formulations all appeared to be relatively safe to the subjects

included in the trial. It is perhaps very surprising, that no damage was evident in the Butisan S treated plots, particularly at the standard rate. Overall, this contrasts with the Efford screening work where very few of the chemicals screened proved entirely safe to the limited range of subjects in the trial. However, the Efford work was carried out under protection where growth was liable to be much softer and susceptible to damage from chemicals.

Phytotoxicity, second year trial

Phytotoxicity was more prevailant during the second trial. This was due to some degree to the introduction of tank mixtures as distinct from individual treatments. Also, the granule treatments, namely Ronstar 2G and Axit GR, were not unlike in the first year trial, knocked or rinsed off the crop foliage. This was intended to act as a comparison to the first year and to replicate commercial practice on a large scale, where it may prove impractical to remove any herbicide granules lodged within the crop foliage. Certainly, damage from both products whilst not terminal, was greater in the second year.

Foliar damage was observed on a range of subjects following application of Ronstar 2G, these included *Campanula* (slight discoloration of some shoot tips/leaves), *Phlox* (paling of leaves and shoot tips), *Saxifraga* (some leaf spotting/scorching where granules had lodged) *Sedum* (scorching/death of some shoot tips) and *Thymus* (significant shoot tip death and leaf discolouration). Damage had not been seen during the earlier trial where the granules had not been allowed to lodge in the foliage.

Some phytotoxicity was observed within the Flexidor 125 programmes, with noticeable damage consistently seen in *Veronica* (significant leaf blotching, marbling, twisting and shoot distortion) from both individual applications and tank mixtures. Damage was also seen in *Thymus* (shoot tip scorching and some senesence) where Flexidor 125 was mixed with either Butisan S or Kerb 50W but not where Flexidor 125 was applied alone. *Campanula* (slight leaf/shoot tip senesence) and *Dianthus* (slight distortion/paling in bands of some leaves) also showed some sensitivity where Flexidor 125 was tank mixed with either Butisan S or Kerb 50W. Some damage was also seen in *Phlox* (yellowing/banding) following treatment with the Flexidor 125 + Kerb 50W mixture.

It is again perhaps surprising that more damage was not seen where Butisan S was used given it's potential to cause damage to woody nursery stock when used over soft growth at the standard rate. It is worth recording that the Butisan S applications in the second year were applied during the safer, autumn/winter period when the plants were not in full, active growth. It should also be noted that the trial treatments were applied to crops grown outdoors rather than under protection where growth is softer and perhaps more liable to

show herbicide sensitivity.

Following some noticeable phytotoxicity in the first trial, the Stefes Lenacil rate was reduced to 1 kg/ha where applied as an individual treatment, and 0.5 kg/ha where the product was used in tank mixtures in order to try to reduce the potential for phytotoxicity without compromising weed control. To a large degree this appears to have helped, with damage being restricted to *Phlox* (slight yellowing and reddening of leaves) and *Veronica* (purpling, spotting and blotching of leaves) following the first treatment in September, during which time the weather conditions were warm and crop growth was still quite active (damage from lenacil tends to occur through rapid uptake during spells of warm weather and active growth).

Damage was not seen from the Stefes Lenacil treatments on either *Aubretia, Erodium* or *Helianthemum* unlike in the first year, when higher rates were used and damage was noticed following the final treatment, which coincided with a spell of warm weather in early spring.

Some damage did result from the Axit GR treatments, with *Veronica* again showing leaf purpling and spotting, quite possibly caused by the isoxaben element in the product, the same active ingredient as contained in Flexidor 125. As with the Ronstar 2G treatments, the Axit GR granules were not brushed or rinsed off the foliage after application as this may prove impractical with alpine varieties on a large commercial scale. Label recommendations for both products make it clear that granules must not be allowed to lodge in the foliage and where this occurs, they should be carefully brushed off.

A slight shoot tip paling symptom was also seen in the *Dianthus* and *Helianthemum* after the initial application of Axit GR in September though this was not serious. There was also a transitory yellowing/purpling discolouration of the foliage observed in the *Phlox* following the final treatment and further discolouration in the *Veronica.* Both subjects by this stage were also showing a reduction in size compared to those in the control plots, particularly *Phlox.* These symptoms occurred in both the single Axit GR treatment and where Axit GR was alternated with Butisan S.

Vigour assessment, first year.

A vigour assessment was made on the 10th of March and is outlined at Table 7. The plants were scored on a scale of 0-5.

Table 7

Vigour assessments, March 1997

	Treatments													
Subject	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
Aubretia	3.5	2	3	4.5	3.5	2.5	2.5	2.5	3	3	3	3	4.5	4
Campanula	4	4	4	4	4	4	3.5	4	3	3.5	3.5	4	4	4
Dianthus	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Erodium	4	3	3	3.5	3.5	3.5	3.5	3	3	3.5	3	3	4	4
Helianthemum	4	4	4	4	4.5	4	4	3.5	3.5	4	3	3	5	4.5
Phlox	4	4	4	4	3.5	3.5	4	4	4	4	4	3.5	4.5	4.5
Saxifraga	5	5	5	5	5	5	4.5	4.5	4	5	5	4.5	5	5
Sedum	5	5	5	4.5	4.5	5	4.5	4	4	4.5	3.5	3.5	5	4.5
Thymus	5	4.5	5	4.5	4	4	4.5	3.5	4	3.5	4.5	4	4.5	4.5
Veronica	5	2	5	5	4	4	3	4	4	4	5	5	5	5

0 = Dead
1 = Very poor quality
2 = Poor quality
3 = Average quality, not yet saleable
4 = Good quality, saleable now as first grade plants
5 = Very good quality, saleable now as first grade plants.

Key to treatments

A) Untreated control

B) Mogeton, (quinoclamin), 1.0 g/m^2 + Flexidor 125 (isoxaben), 0.1 ml/m^2

C) Ronstar 2G, (oxadiazon), 20 g/m^2

D) Ronstar 2G, (oxadiazon), 10 g/m^2

E) Axit GR (previously Premiere Granules*, isoxaben + trifluralin), 10g/m^2

F) Axit GR (previously Premiere Granules*, isoxaben + trifluralin), 5g/m^2

G) Flexidor 125, (isoxaben), 0.1 ml/m^2

H) Flexidor 125, (isoxaben), 0.05 ml/m^2

I) Butisan S, (metazachlor), 0.25 ml/m^2

J) Butisan S, (metazachlor), 0.12 ml/m^2

K) Stefes Lenacil, (lenacil), 0.28 g/m^2

L) Stefes Lenacil, (lenacil), 0.15 g/m^2

M) Kerb 50W, (propyzamide), 0.1 g/m^2

N) Kerb Granules, (propyzamide), 3.8 g/m^2

Rates/ha

Ronstar 2G @ 200 kg & 100 kg
Flexidor 125 @ 1 litre & 0.5 litre
Mogeton @ 10 kg
Axit GR @ 100 kg & 50 kg*
Butisan S @ 2.5 litres & 1.25 litres
Stefes Lenacil @ 2.8 kg & 1.5 kg
Kerb 50W @ 1 kg
Kerb granules @ 38 kg

Problems with availability restricted the choice of varieties. There was some variation in the size and quality of the *Aubretia* plugs (seed raised) at potting and this needs be taken into account when interpreting the scores. This variability did account for several losses which were sustained during the early

part of the trial, and has contributed to the lower scores presented in Table 7. The growth of *Aubretia* is also notoriously difficult to control in the spring after overwintering, and a large number of the trial plants deteriorated quickly after flowering. This also contributed to the lower scores which with the exception of the Mogeton + Flexidor 125 and Stefes Lenacil treatments were not a result of herbicide damage.

The majority of the *Erodium roseum* plugs were very small when potted and appeared to lack vigour throughout the trial. Again, this contributed to the lower scores, although clear phytotoxic damage (veinal chlorosis) did occur from both the Stefes Lenacil treatments.

Some of the *Sedum* plants struggled to establish and overwinter outdoors, this also contributed to some of the lower scores. That said, significant damage was noted from Stefes Lenacil treatments following the February application. Symptoms included a paling of the foliage coupled with veinal yellowing and a reduction in vigour.

Vigour, second year trial

A vigour assessment was made on the 9th April and is outlined at Table 8. The plants were scored on a scale of 0-5.

Table 8

Vigour assessments, April 1998

	Treatments											
Subject	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Aubretia	5.0	4.5	4.5	4.5	4.5	5.0	5.0	5.0	5.0	4.0	3.5	4.5
Campanula	3.5	3.0	3.5	4.0	4.0	3.5	3.5	1.5	4.0	4.5	3.5	3.5
Dianthus	4.5	4.0	4.0	4.5	4.5	3.5	5.0	3.5	4.5	4.5	4.5	3.5
Erodium	5.0	4.5	4.5	5.0	4.0	5.0	5.0	4.5	5.0	4.5	5.0	4.5
Helianthemum	3.0	1.5	2.0	2.0	1.5	2.5	2.5	3.0	1.5	2.5	3.0	3.0
Phlox	4.5	5.0	4.5	4.5	5.0	4.5	5.0	5.0	5.0	4.5	3.5	3.5
Saxifraga	5.0	5.0	5.0	5.0	4.5	5.0	5.0	4.5	5.0	4.5	5.0	5.0
Sedum	5.0	5.0	5.0	5.0	5.0	4.0	5.0	4.0	4.0	5.0	5.0	5.0
Thymus	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0
Veronica	5.0	4.5	5.0	4.5	5.0	3.5	3.5	2.5	3.5	5.0	3.5	3.5

0 = Dead
1 = Very poor quality
2 = Poor quality
3 = Average quality, not yet saleable
4 = Good quality, saleable now as first grade plants
5 = Very good quality, saleable now as first grade plants.

Key to treatments

A) Untreated control

B) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 every 9 weeks

C) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Mogeton 1.0 g/m^2 every 9 weeks

D) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

E) Ronstar 2G, 20 g/m^2 alternated with Stefes Lenacil, 0.1 g/m^2 every 9 weeks

F) Flexidor 125, 0.1 ml/m^2 alternated with Butisan S, 0.25 ml/m^2 every 9 weeks

G) Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

H) Flexidor 125, 0.1 ml/m^2 + Butisan S, 0.25 ml/m^2 every 18 weeks

I) Flexidor 125, 0.1 ml/m^2 + Kerb 50W, 0.1 g/m^2 every 9 weeks

J) Stefes Lenacil, 0.1 g/m^2 every 9 weeks

K) Axit GR, 10 g/m^2 every 9 weeks

L) Axit GR, 10 g/m^2 with Butisan S, 0.25 ml/m^2 every 9 weeks

Rates/ha

Ronstar 2G @ 200 kg
Flexidor 125 @ 1 litre
Mogeton @ 10 kg
Axit GR @ 100 kg
Butisan S @ 2.5 litre
Stefes Lenacil @ 1 kg (reduced to 0.5 kg where tank mixed)
Kerb 50W @ 1 kg

The consistently low scores recorded for *Helianthemum* were due to variable plug quality which led to poor growth and establishment (some did not survive the winter months) rather than being directly attributable to any herbicide

treatment.

The effects of the Flexidor 125 programmes on the vigour of the *Veronica* carried through into the spring and early summer. Plant size was reduced as compared to the untreated controls and, more noticeably, flowering was markedly delayed. The size of the *Veronica* plants was considerably reduced in the plots treated with the Flexidor 125 + Butisan S tank mixture. This mixture also delayed flowering in the *Sedum*. Where Flexidor 125 was alternated with Butisan S, the *Dianthus* whilst of an acceptable saleable quality, showed a slight reduction in plant size, and flowering in the *Sedum* was noticeably delayed when compared to those plants in the untreated control plots. Flowering of both the *Sedum* and *Thymus* was also delayed by the Flexidor 125 + Kerb 50W treatments.

Earlier growth checks to *Phlox* as a result of the Axit GR and Axit GR / Butisan S treatments also persisted through into the spring. The plants though saleable, showed a slight reduction in size when compared to the untreated controls. *Veronica* also showed some sensitivity to the Axit GR treatments with leaf symptoms (purple spotting / blotching, distortion) close to those seen in the Flexidor 125 programmes, indicating a reaction to the isoxaben element perhaps.

Early leaf and shoot damage with *Phlox*, *Sedum*, *Saxifraga* and *Thymus* from the Ronstar 2G treatments had receded and good quality saleable plants were recorded by the spring. The *Phlox* had also recovered from the slight foliar marking caused by the Stefes Lenacil treatments.

Discussion

A number of chemicals have emerged from this work with the potential to provide effective weed and liverwort control in overwintered alpine varieties grown outdoors. However, some alpine varieties are clearly sensitive to particular herbicides as indicated in the initial work on alpines grown under protection at HRI Efford (HNS 35b). Though phytotoxicity in the commercial nursery trial undertaken by ADAS (HNS 74) was not severe, some of the treatments for example, the Flexidor 125 programmes on *Veronica*, *Sedum* and *Thymus* gave noticeable reductions in plant size and a delay in flowering. It is important for nurserymen to be aware of these potential effects when considering chemical weed control programmes.

Whilst low weed pressures during the second year made it difficult to assess and compare the performance of the different programmes and mixtures, the results from the trial overall have been very encouraging. The first year work clearly identified a number of individual herbicide treatments which represent realistic options for alpine growers to consider depending upon weed spectrum

and pressure. There are however gaps within the weed control spectrum of each herbicide, and some of these were exposed during the trial. The choice of herbicide will largely depend on weed spectrum, although the varietal sensitivities highlighted in the trial must also be considered. Individual herbicide treatments may be particularly suitable for short season crop where weed pressure and spectrum are limited. For very short term crops which have a vigorous habit, a single herbicide application after potting may suffice.

Clearly materials such as Ronstar 2G and Stefes Lenacil have scope to be used effectively at reduced rates without compromising weed control significantly. Ronstar 2G for example provided good control of liverwort and broad leaved weeds when applied at half the label rate at 12 week intervals. The ability of Ronstar 2G to control liverwort is often underestimated though it must be applied promptly after potting. In addition to reducing any attendant risk of phytotoxicity, the use of the reduced rate also gives scope for nurserymen to reduce treatment costs.

Stefes Lenacil, Butisan S and Kerb 50W each gave good results when applied as individual treatments. Stefes Lenacil at the 1.5 kg/ha rate gave comparable results to the higher 2.8 kg/ha rate but broad leaved weed control did suffer when this was reduced still further (1 kg/ha at 9 week intervals) during the second year in order to improve crop safety. However, liverwort control remained excellent at this reduced rate. Clearly, the key to success with lenacil lies in the choice of the application rate and careful timing. Damage is more likely to occur with sensitive varieties such as *Aubretia*, *Erodium*, *Helianthemum*, when the herbicide is applied at higher rates during periods of rapid growth. In the case of *Phlox* and *Veronica*, phytotoxicity was still noted even in response to the lowest (1 kg/ha) rate after the initial application during warm conditions in September.

Both Kerb 50W and Butisan S also gave high levels of weed and liverwort control when applied as individual, repeated treatments. Butisan S applied as an individual treatment at the higher rate during the first year trial gave good levels of weed control, with surprisingly little phytotoxicity. Butisan S is known to cause scorch on soft foliage on hardy nursery stock and for this reason, it is usually considered to be an autumn/winter treatment to minimise the risk of any damage. The reduced, and hence safer rate, used in the first trial produced a significantly lower level of weed control. Butisan S does not have a label recommendation for use on container plants and so remains a grower risk treatment.

Kerb 50W provided safe and effective weed control including liverwort, when applied as a single, individual treatment after potting in the first trial. Results with the granular formulation were not as good and although the product appeared safe to the species and cultivars used in in the trial, commercially

acceptable levels of weed control were not achieved. Neither of the Kerb formulations have a label recommendation for use on container grown nursery stock, and so remain grower risk treatments.

Results from the Ronstar 2G and Flexidor 125 treatments both as individual applications and in programmes, were variable throughout though there were reasons for this. Weed control levels achieved by the Ronstar 2G treatments in the first trial clearly suffered on account of mouse-ear chickweed being quite dominant, a weed Ronstar 2G would not normally be expected to control. This weed also appears to have more resistance to Flexidor 125 perhaps than the common chickweed, which Flexidor 125 will reliably control.

Where the weed pressure is high and the spectrum diverse, to achieve the best results, both materials need to be harnessed alongside other suitable products such as Stefes Lenacil, Butisan S or Kerb 50W either within programmes or in the case of Flexidor 125, in mixtures.

Very encouraging results were obtained from programmes where Ronstar 2G was applied as the first herbicide after potting and then alternated with Stefes Lenacil, either as an individual treatment or as a tank mixture with Flexidor 125.

Flexidor 125 also gave good levels of weed control when tank mixed with Butisan S and applied at 18 week intervals though the risk of phytotoxicity is likely to increase and this mixture should certainly be avoided during the spring and summer period.

The need for Flexidor 125 to be combined with another product capable of controlling liverwort highlighted in the earlier Efford trial, was again underlined in this project. Groundsel control is also a potential weakness where Flexidor 125 is used at rates below that recommended on the label. Applications of Flexidor 125 alone will not control grass weeds, mixtures with Kerb 50W should address this whilst both Stefes Lenacil and Butisan S can be expected to control annual grasses and bolster groundsel control with reduced rates of Flexidor 125.

Both Ronstar 2G and Flexidor 125 can be phytotoxic on certain alpine varieties, particularly Flexidor 125, where reductions in plant size and delays in flowering can persist from winter applications well into the spring. *Veronica*, which appears particularly sensitive to chemical treatments is a case in point.

Damage from the Ronstar 2G treatments in the trial only occurred where the granules were allowed to remain on the crop foliage following application and so the removal of any lodged granules by either rinsing off or brushing as recommended on the label, will considerably improve the margin of crop safety.

Axit GR granules gave encouraging weed control results initially in the first trial when used at both full and half rates, but weed numbers had built up by the spring in the half rate treated plots. Chickweed control was good at both treatment rates, but bittercress control was only moderate at the higher rate and disappointing at the reduced rate. As this product contains isoxaben it should give good pre-emergence control of bittercress, and changing to the 9 week treatment programme during the second year gave better control. Potential weaknesses highlighted in the trial were willowherb and liverwort control. Willowherb numbers were reduced when Axit GR was alternated with Butisan S in the second year though perhaps surprisingly, this combination gave no improvement with liverwort control. *Veronica* and *Phlox* each showed some sensitivity to the Axit GR programmes and to a lesser degree, *Dianthus* and *Helianthemum.*

The variability of some of the young plants in particular, *Aubretia, Thymus, Erodium* and *Sedum* in the first year of the trial and *Helianthemum* in the second year, complicated some the assessments for vigour. The failure of some plants to establish successfully after potting in the first trial could be attributed more to their indifferent start quality than the direct effects of the chemicals. Though the level of direct phytotoxicity damage was surprisingly low in the first year work, this stress factor may also have predisposed some of the plants to a percentage of the chemical damage that did occur. Problems with availability necessitated the use of these plants which although not top quality appeared at the time of potting to offer reasonable prospects for making saleable plants.

Tables 9 and 10 overleaf provide summaries of the efficacy and effects of the treatments used in both years of the trial.

Table 9

First year trial (individual treatments)

Trt	Product (s)	Weed control	L/wort/moss	Vigour/ flowering	Phytotoxicity
B	Mogeton/Flexidor 125	**	****	**	**
C	Ronstar 2G (20 g/m^2)	**	****	*	*
D	Ronstar 2G (10 g/m^2)	*	****	*	*
E	Axit GR (10 g/m^2)	***	***	*	*
F	Axit GR (5 g/m^2)	**	***	*	*
G	Flexidor 125 (0.1 ml/m^2)	**	*	**	**
H	Flexidor 125 (0.05 ml/m^2)	*	*	*	*
I	Butisan S (0.25 ml/m^2)	***	****	*	*
J	Butisan S (0.12 ml/m^2)	*	****	*	*
K	Stefes Lenacil (0.28 g/m^2)	****	****	***	***
L	Stefes Lenacil (0.15 g/m^2)	****	****	***	***
M	Kerb 50W (0.1 g/m^2)	***	****	*	*
N	Kerb Granules (3.8 g/m^2)	*	***	*	*

Key

Weed/ liverwort/moss control

* - poor control
** - partial control
*** - good control
**** - excellent control

Effect on vigour/flowering

* - No effect
** - limited effect
*** - obvious effect
**** - severe effect

Phytotoxicity

* - No damage
** - transient damage
*** - transient/permanent damage
**** - unsaleable

Table 10

Second year trial (programmes)

Trt	Product (s)	Weed control	L/wort/ moss	Vigour/ flowering	Phytotox
B	Ronstar 2G/ Flexidor 125	**	***	**	**
C	Ronstar 2G/ Flexidor 125 + Mogeton	**	***	**	**
D	Ronstar 2G/Flexidor 125 + Stefes Lenacil	***	****	**	**
E	Ronstar 2G/ Stefes Lenacil	***	****	**	**
F	Flexidor 125/ Butisan S	***	*	**	**
G	Flexidor 125 + Stefes Lenacil	**	****	***	***
H	Flexidor 125 + Butisan S	***	***	***	***
I	Flexidor 125 + Kerb 50W	***	**	***	***
J	Stefes Lenacil	*	****	**	**
K	Axit GR	**	**	**	**
L	Axit GR/Butisan S	***	**	**	**

Key

Weed/ liverwort/moss control

* - poor control
** - partial control
*** - good control
**** - excellent control

Effect on vigour/flowering

* - No effect
** - limited effect
*** - obvious effect
**** - severe effect

Phytotoxicity

* - No damage
** - transient damage
*** - transient/permanent damage
**** - unsaleable

2.4 Conclusions

There are a number of important conclusions that can be drawn from this work. Several residual herbicides have emerged with genuine commercial potential to provide effective weed control when applied as either individual treatments or in programmes and mixtures to alpine varieties grown outdoors.

A number of alpine varieties were clearly sensitive to some of the chemicals examined and there is potential for phytotoxic damage to occur. Though phytotoxicity was not severe, some materials can markedly reduce plant size and cause a delay in flowering in addition to causing shoot tip damage and transitory foliar effects. This presents a commercial dilemma for growers to consider, accepting the possibility of limited phytotoxicity, in order to achieve the level of weed control required. A small reduction in vigour or size, or the presence of transient phytotoxicity symptoms for example, may be commercially acceptable in some circumstances.

Though a greater degree of phytotoxicity was noted in the second year work which embraced programmes and mixtures, the results do not necessarily indicate that these may be significantly more phytotoxic than repeated individual treatments. Much of the damage observed in the work with programmes and mixtures for example, resulted from granular treatments being allowed to lodge in the crowns and plant foliage unlike during the first trial, when these were brushed off, as per the label recommendations. Sensitivity to Stefes Lenacil was also considerably reduced in the second trial when the application rate was reduced for both individual and tank mix treatments.

The trial has presented growers with a number of options for achieving commercially acceptable levels of weed control with herbicides. The decision as to whether to use individual treatments or combinations harnessed within programmes will be governed by the prevailing weed spectrum and pressure, the timing of application in relation to crop growth, the duration of the crop and varietal sensitivity. The use of programmes or tank mixtures which harness products with complementary weed control spectrums is advisable where a broad weed spectrum exists.

Programmes based around Ronstar 2G and Flexidor 125 (where chickweed and bittercress are a serious threat) are to be recommended subject to crop tolerance considerations. Complementary herbicides however need to be chosen carefully and take full account of the prevailing weed spectrum. For example, Ronstar 2G will not control either common or mouse- ear chickweed or, pearlwort (which though not present in the trial, is an increasing weed problem on commercial nurseries). Flexidor 125 cannot be expected to control grass weeds and whilst generally effective against chickweed, bittercress and

pearlwort, is only moderately effective against willowherb, a weed now also increasingly seen on commercial nurseries. Flexidor 125 will not control liverwort and must be used at the full label rate (which could be very phytotoxic to some alpine varieties) to achieve good control of groundsel.

In the trial, combinations of Ronstar 2G followed by either individual treatments of Stefes Lenacil or tank mixtures of Stefes Lenacil with Flexidor 125 were particularly effective. Stefes Lenacil embraces a broad weed spectrum and bolstered the control of mouse-ear chickweed during the trial. Liverwort control was also improved.

Groundsel control however is a potential weakness of the programmes assessed in the trial. Stefes Lenacil and Flexidor 125 when used at reduced rates for example, provide only moderate control and this was highlighted during the trial which examined both products separately and in mixtures. Ronstar 2G and Butisan S are therefore likely to be important products where groundsel is a serious concern.

Butisan S and Kerb 50W both have broad weed control spectrums and are likely to be important components of programmes, depending on weed spectrum. Each product provided commercially acceptable levels of weed control in the trial when tank mixed with Flexidor 125. Importantly, Butisan S has the ability to provide enhanced groundsel control but it can be phytotoxic and the timing of applications must be carefully considered. Willowherb control can also be improved with the use of Butisan S though this weed was not significant in the trial.

Kerb 50W also warrants close consideration for inclusion within herbicide programmes, particularly where grass weeds are a serious concern. Chickweed is also embraced within the control spectrum of Kerb 50W. This product also gave very good levels of weed control during the first year work when used as a single, individual treatment.

Given the scope of Stefes Lenacil to combine excellent liverwort control with acceptable control of broad leaved weeds, this material has considerable potential for use in alpine production, particularly when included within programmes and mixtures. It is unlikely to be entirely successful as an individual treatment on account of the need to use higher rates which are likely to be phytotoxic particularly if used during periods of active growth. It is also only moderately effective against groundsel, an important weed problem for container growers. Careful attention must be paid to the timing and rate of application with Stefes Lenacil. As with all of the treatments, a light rinsing off with plain water is advisable to minimise the risks of phytotoxic damage occurring.

Weed control with the half or reduced rate herbicide applications assessed during the first year trial were generally disappointing, with the exception of Ronstar 2G and Stefes Lenacil. Lower rate applications of Butisan S, Flexidor 125 and Axit GR at final assessment were disappointing overall in respect of weed control, though liverwort control was good with the exception of Flexidor 125, which would not be expected to control liverwort.

It should be noted that weed pressure in the second year of the trial made it difficult to fully assess and reliably compare some of the treatment effects. This needs to be taken into account when interpreting the results. Any further work should embrace the best programmes from this trial and, if required use introduced weed seeds in order to fully test the treatments.

APPENDIX 1

SUMMARY OF STATISTICAL ANALYSES, FIRST YEAR TRIAL

Table 1

Analysis of variance of mean weed scores

Treatment	Code	Nov 96	Feb 96	May 97
Untreated control	A	24.7	66.7	129.0
Mogeton + Flexidor 125	B	8.0	31.3	63.3
Ronstar 2G @ 20 g/m^2	C	22.3	38.7	104.7
Ronstar 2G @ 10 g/m^2	D	23.3	53.3	116.7
Axit GR @ 10 g/m^2	E	7.0	16.0	39.0
Axit GR @ 5 g/m^2	F	7.3	18.3	60.0
Flexidor 125 @ 0.1 ml/m^2	G	9.7	26.3	39.7
Flexidor 125 @ 0.05 ml/m^2	H	16.3	44.0	81.7
Butisan S @ 0.25 ml/m^2	I	5.7	12.3	20.0
Butisan S @ 0.12 ml/m^2	J	13.7	41.7	81.3
Stefes Lenacil @ 0.28 g/m^2	K	1.7	1.3	4.7
Stefes Lenacil @ 0.15 g/m^2	L	2.3	2.0	12.3
Kerb 50W @ 0.1 g/m^2	M	0.3	10.3	54.3
Kerb Granules @ 3.8 g/m^2	N	17.0	35.0	98.3
DF		13	13	13
p-value		0.052	0.354 n/s	0.015
SED		8.03	25.50	33.62

n/s = non significant at p = 0.05

Table 2

Analysis of variance for two way factorial of treatment and dose

Factor/Treatment	Nov 96*	Feb 96*	May 97*
Factor 1**			
Ronstar 2G	22.8	46.0	110.7
Axit GR	7.2	17.2	49.5
Flexidor 125	13.0	35.2	60.7
Butisan S	9.7	27.0	50.7
Stefes Lenacil	2.0	1.7	8.5
DF	4.0	4.0	4.0
P - value	0.016	0.155 n/s	0.002
SED	5.43	17.44	19.83
Factor 2 **			
High herbicide rate	12.6	31.9	70.4
Low herbicide rate	9.3	18.9	41.6
DF	1	1	1
P - value	0.344 n/s	0.256 n/s	0.034
SED	3.43	11.03	12.54
Factor 3 **			
Interaction			
P - value	0.917 n/s	0.919 n/s	0.639 n/s

Notes

* Mean treatment values for each recording date - these values are the mean scores of the low and high application rate recordings

** Factor 1 = analysis of mean treatments (mean value of high and low rates)

** Factor 2 = analysis of high herbicide rate
analysis of low herbicide rate

** Factor 3 = analysis of interaction between herbicide and rate on weed control

n/s = not significant at p = 0.05

APPENDIX 11

SUMMARY OF STATISTICAL ANALYSES SECOND YEAR TRIAL (PROGRAMMES)

Key to treatment codes in tables 1-6

A) Untreated control

B) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 every 9 weeks

C) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Mogeton 1.0 g/m^2 every 9 weeks

D) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

E) Ronstar 2G, 20 g/m^2 alternated with Stefes Lenacil, 0.1 g/m^2 every 9 weeks

F) Flexidor 125, 0.1 ml/m^2 alternated with Butisan S, 0.25 ml/m^2 every 9 weeks

G) Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks

H) Flexidor 125, 0.1 ml/m^2 + Butisan S, 0.25 ml/m^2 every 18 weeks

I) Flexidor 125, 0.1 ml/m^2 + Kerb 50W, 0.1 g/m^2 every 9 weeks

J) Stefes Lenacil, 0.1 g/m^2 every 9 weeks

K) Axit GR, 10 g/m^2 every 9 weeks

L) Axit GR, 10 g/m^2 with Butisan S, 0.25 ml/m^2 every 9 weeks

Rates/ha

Ronstar 2G @ 200 kg
Flexidor 125 @ 1 litre
Mogeton @ 10 kg
Axit GR @ 100 kg
Butisan S @ 2.5 litre
Stefes Lenacil @ 1 kg (reduced to 0.5 kg where tank mixed)

Kerb 50W @ 1 kg

Key to weed spp in tables 1, 3 & 5

An = Annual meadow grass
Bc = Bittercress
Ch = Chickweed
Ms = Mouse-ear chickweed
Gd = Groundsel
Wh = Willowherb
Rh = Rush
Dk = Dock
SP = Speedwell spp.
Th = Thistle

Key to moss and liverwort codes in tables 2,4 & 6

NpotsL = Number of pots with liverwort
Mean % cL = Mean % cover with liverwort
Npots TL = Number of pots with traces of liverwort

NpotsM = Number of pots with moss
Mean%cM = Mean % cover with moss
Npots TM = Number of pots with traces of moss

Table 1

November 1997.

Weed data.

	Weed species code										
Treat	An	Bc	Ch	Ms	Gd	Wh	Rh	Dk	Sp	Th	Total
A	0.667	0.667	0.0	0.00	0.000	0.667	0.0	0.0	0.0	0.0	2.00
B	0.000	0.333	0.0	1.00	0.000	0.000	0.0	0.0	0.0	0.0	1.33
C	0.000	0.000	0.0	1.67	0.000	0.000	0.0	0.0	0.0	0.0	1.67
D	0.000	0.333	0.0	0.33	0.000	0.333	0.0	0.0	0.0	0.0	1.00
E	0.000	0.000	0.0	0.33	0.000	0.333	0.0	0.0	0.0	0.0	0.67
F	0.000	0.333	0.0	0.00	0.667	0.000	0.0	0.0	0.0	0.0	1.00
G	0.000	0.000	0.0	0.00	0.333	0.000	0.0	0.0	0.0	0.0	0.33
H	0.000	0.000	0.0	0.00	0.000	0.000	0.0	0.0	0.0	0.0	0.00
I	0.000	0.000	0.0	0.00	0.000	0.333	0.0	0.0	0.0	0.0	0.33
J	0.000	1.000	0.0	0.33	0.000	0.000	0.0	0.0	0.0	0.0	1.33
K	0.333	0.333	0.0	0.33	0.000	1.000	0.0	0.0	0.0	0.0	2.00
L	0.000	0.667	0.0	0.00	0.000	0.667	0.0	0.0	0.0	0.0	1.33
DF*	11	11	11	11	11	11	11	11	11	11	11
p*	0.037	0.231 n/s	0.0	0.230 n/s	0.064 n/s	0.211 n/s	0.0	0.0	0.0	0.0	0.540 n/s
SED*	0.188	0.393	0.0	0.607	0.201	0.399	0.0	0.0	0.0	0.0	0.964

* Analysed by ANOVA

n/s = not significant at p = 0.05

Table 2

November 1997

Liverwort and moss.

	Liverwort and moss codes.					
Treat	NpotsL	Mean%cL	Npots_TL	NpotsM	Mean%cM	Npots_TM
A	7.33	9.47	10.33	1.33	5.00	2.00
B	1.00	6.67	0.67	0.33	1.67	1.67
C	0.67	1.67	0.00	0.33	1.67	1.00
D	1.33	3.33	1.33	0.67	1.67	1.67
E	0.00	0.00	2.00	1.00	1.67	0.67
F	7.00	8.33	10.00	0.33	1.67	2.33
G	0.00	0.00	0.00	0.00	0.00	0.00
H	0.00	0.00	0.00	0.00	0.00	0.00
I	3.67	6.23	2.67	0.33	1.67	2.00
J	0.00	0.00	0.00	0.00	0.00	1.00
K	5.67	8.53	7.67	1.33	5.00	1.33
L	4.67	7.92	3.67	1.33	5.00	1.33
DF*	11	11	11	11	11	11
p*	<0.001	<0.001	<0.001	0.094 n/s	0.008	0.066 n/s
SED*	1.163	<2.218	1.359	0.546	1.465	0.735
Fs	29.65	26.8	30.37	19.2	20.67	17.45
p	0.002	0.005	0.001	0.058 n/s	0.037	0.095 n/s

*Analysed by ANOVA.

n/s = not significant at p = 0.05

Table 3

January assessment

Weed data.

	Weed species code										
Trt	An	Bc	Ch	Ms	Gd	Wh	Rh	Dk	Th	Sp	Total
A	0.0	1.33	0.0	0.00	0.000	0.000	0.333	0.0	0.0	1.0	2.67
B	0.0	0.00	0.0	1.67	0.000	0.000	0.000	0.0	0.0	0.0	1.67
C	0.0	0.00	0.0	1.00	0.000	0.000	0.000	0.0	0.0	0.0	1.00
D	0.0	0.00	0.0	0.00	0.000	0.000	0.000	0.0	0.0	0.0	0.00
E	0.0	0.00	0.0	0.00	0.000	0.000	0.000	0.0	0.0	0.0	0.00
F	0.0	0.33	0.0	0.00	0.000	0.667	0.000	0.0	0.0	0.0	1.00
G	0.0	0.00	0.0	0.67	0.667	0.000	0.000	0.0	0.0	0.0	1.33
H	0.0	0.33	0.0	0.00	0.000	0.333	0.000	0.0	0.0	0.0	0.67
I	0.0	0.33	0.0	0.00	0.333	0.000	0.000	0.0	0.0	0.0	0.67
J	0.0	0.67	0.0	0.67	0.000	0.000	0.000	0.0	0.0	0.0	1.33
K	0.0	0.33	0.0	0.00	0.000	0.667	0.000	0.0	0.0	0.0	1.00
L	0.0	1.00	0.0	0.00	0.000	0.333	0.000	0.0	0.0	0.0	1.33
DF*	11	11	11	11	11	11	11	11	11	11	11
p*	0.0	0.338 n/s	0.0	0.142 n/s	0.477 n/s	0.103 n/s	0.477 n/s	0.0	0.0	0.0	0.340 n/s
SED*	0.0	0.563	0.0	0.599	0.293	0.275	0.1361	0.0	0.0	0.0	0.931

* Analysed by ANOVA

n/s not significant at p = 0.05

Table 4

January assessment

Liverwort and moss data.

	Liverwort and moss codes					
Treat	NpotsL	Mean%cL	Npots_TL	NpotsM	Mean%cM	Npots_TM
A	24.33	27.1	7.67	1.67	7.50	0.00
B	0.00	0.00	2.33	1.67	5.53	0.33
C	0.67	5.00	2.67	0.00	0.00	0.67
D	0.00	0.00	0.00	0.67	5.00	0.33
E	0.00	0.00	0.00	0.67	5.00	1.00
F	13.33	26.30	4.00	0.00	0.00	0.00
G	0.00	0.00	0.00	0.00	0.00	0.67
H	1.33	10.00	1.67	0.00	0.00	0.67
I	8.00	22.10	1.33	1.00	6.67	5.00
J	0.00	0.00	0.00	0.00	0.00	2.33
K	7.67	24.30	6.67	0.33	3.33	0.67
L	3.67	25.70	4.33	0.00	0.00	0.67
DF*	11	11	11	11	11	11
p*	<0.001	<0.01	<0.01	0.023	0.160 n/s	<0.001
SED*	3.877	6.53	1.072	0.555	3.370	0.706
Fs	26.42	25.28	27.39	20.46	22.12	11.32
p	0.006	0.008	0.004	0.039	0.023	0.417 n/s

* Analysed by ANOVA

n/s = not significant at p = 0.05

Table 5

April 1998

Weed data.

	Weed species code										
Trt	An	Bc	Ch	Ms	Gd	Wh	Ru	Dk	Sp	Th	Total
A	0	13.67	0.000	1.00	5.67	0.00	0.333	0	0.00	0	20.67
B	0	0.33	0.000	3.67	5.67	0.00	0.000	0	0.00	0	9.67
C	0	0.00	0.000	2.00	4.33	0.00	0.000	0	0.00	0	6.33
D	0	0.00	0.000	0.00	4.67	0.00	0.000	0	0.00	0	4.67
E	0	0.00	0.000	1.33	5.00	0.00	0.000	0	0.00	0	6.33
F	0	1.33	0.000	0.33	1.67	0.67	0.000	0	0.00	0	4.00
G	0	1.67	0.000	0.33	6.00	0.00	0.000	0	0.67	0	8.67
H	0	1.33	0.000	0.33	5.33	0.33	0.000	0	0.00	0	7.33
I	0	3.67	0.333	0.00	5.33	0.67	0.000	0	0.00	0	10.00
J	0	4.00	0.000	0.33	2.67	0.00	0.000	0	3.00	0	10.00
K	0	1.33	0.000	0.33	2.00	1.33	0.000	0	0.00	0	5.00
L	0	1.67	0.000	0.00	2.33	0.67	0.000	0	0.00	0	4.67
DF*	11	11	11	11	11	11	11	11	11	11	11
p *	0	<0.01	0.477 n/s	0.073 n/s	0.632 n/s	0.349 n/s	0.477 n/s	0	0.520 n/s	0	<0.00 1
SED*	0	1.802	0.1361	1.072	2.512	0.567	0.136	0	1.267	0	2.908
Fs	-	22.37	-			-	-	-	-	-	20.30
p	-	0.022	-			-	-	-	-	-	0.041

* Analysed by ANOVA.

n/s = not significant at p = 0.05

Table 6

April 1998

Liverwort and moss data.

	Liverwort and moss codes.					
Treat	NpotsL	Mean%cL	Npots_TL	NpotsM	Mean%cM	Npots_TL
A	24.33	27.1	7.67	1.67	7.50	0.00
B	00.00	00.0	2.33	1.67	5.53	0.33
C	00.67	05.0	2.67	0.00	0.00	0.67
D	00.00	00.0	0.00	0.67	5.00	0.33
E	00.00	00.0	0.00	0.67	5.00	1.00
F	13.33	26.3	4.00	0.00	0.00	0.00
G	00.00	00.0	0.00	0.00	0.00	0.67
H	01.33	10.0	1.67	0.00	0.00	0.67
I	08.00	22.1	1.33	1.00	6.67	5.00
J	00.00	00.0	0.00	0.00	0.00	2.33
K	07.67	24.3	6.67	0.33	3.33	0.67
L	03.67	25.7	4.33	0.00	0.00	0.67
DF*	11	11	11	11	11	11
p*	<0.001	<0.001	<0.001	0.023	0.160 n/s	<0.001
SED*	3.877	6.53	1.072	0.555	3.370	0.706
Fs	28.02	26.07	30.03	19.29	16.87	18.65
p	0.003	0.006	0.002	0.056 n/s	0.112 n/s	0.068 n/s

* Analysed by ANOVA.[1] Residual plot is borderline.

n/s = not significant at p = 0.05

APPENDIX 11I

WEED COUNT ASSESSMENT SHEETS, FIRST YEAR 96/7

Key to treatment codes

A) Untreated control
B) Mogeton, (quinoclamin), 1.0 g/m^2 + Flexidor 125 (isoxaben), 0.1 ml/m^2
C) Ronstar 2G, (oxadiazon), 20 g/m^2
D) Ronstar 2G, (oxadiazon), 10 g/m^2
E) Axit GR (previously Premiere Granules, isoxaben + trifluralin), 10g/m^2
F) Axit GR (previously Premiere Granules, isoxaben + trifluralin), 5g/m^2
G) Flexidor 125, (isoxaben), 0.1 ml/m^2
H) Flexidor 125, (isoxaben), 0.05 ml/m^2
I) Butisan S, (metazachlor), 0.25 ml/m^2
J) Butisan S, (metazachlor), 0.12 ml/m^2
K) Stefes Lenacil, (lenacil), 0.28 g/m^2
L) Stefes Lenacil, (lenacil), 0.15 g/m^2
M) Kerb 50W, (propyzamide), 0.1 g/m^2
N) Kerb Granules, (propyzamide), 3.8 g/m^2

Rates/ha

Ronstar 2G @ 200 kg & 100 kg
Flexidor 125 @ 1 litre & 0.5 litre
Mogeton @ 10 kg
Axit GR @ 100 kg & 50 kg*
Butisan S @ 2.5 litres & 1.25 litres
Stefes Lenacil @ 2.8 kg & 1.5 kg
Kerb 50W @ 1 kg
Kerb granules @ 38 kg

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

November 1996

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Ann.Md.Grass.	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Bittercress	16	10	2	26	8	12	7	10	12	33	5	5	1	25
Chickweed	0	0	0	0	1	1	0	0	0	0	0	0	0	0
M/ear Chickweed	49	1	53	42	5	4	10	30	5	4	0	0	0	21
Groundsel	3	3	12	0	0	4	6	2	0	2	0	2	0	1
Willowherb	3	4	0	1	4	0	2	2	0	1	0	0	0	1
Rush	3	4	0	0	3	1	1	5	0	0	0	0	0	3
Dock	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Thistle	0	1	0	1	0	0	2	0	0	0	0	0	0	0
TOTAL	74	24	67	70	21	22	29	49	17	41	5	7	1	51

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

February 1997

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Ann.Md.Grass.	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Bittercress	62	81	0	4	28	39	7	7	12	117	4	5	31	69
Chickweed	1	0	0	0	0	6	0	0	0	0	0	0	0	0
M/ear Chickweed	128	0	116	154	12	7	47	116	25	6	0	0	0	32
Groundsel	1	7	0	0	0	1	8	2	0	0	0	1	0	1
Willowherb	5	2	0	1	5	0	14	3	0	1	0	0	0	1
Rush	2	2	0	1	3	2	2	4	0	0	0	0	0	2
Dock	1	1	0	0	0	0	1	0	0	0	0	0	0	0
Thistle	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	200	94	116	160	48	55	79	132	37	125	4	6	31	105

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

May 1997

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Ann. Md. Grass.	0	0	0	1	0	0	0	3	0	1	0	0	0	0
Bittercress	203	163	2	15	91	166	29	6	36	224	14	18	122	83
Chickweed	0	0	0	0	0	0	1	0	0	0	0	0	0	0
M/ear Chickweed	175	5	312	334	15	8	73	213	24	4	0	0	35	185
Groundsel	1	9	0	0	3	1	7	4	0	15	0	19	2	13
Willowherb	4	6	0	0	4	1	6	13	0	0	0	0	0	3
Rush	3	3	0	0	4	3	2	5	0	0	0	0	2	11
Dock	1	1	0	0	0	0	1	1	0	0	0	0	1	0
Thistle	0	3	0	0	0	1	0	0	0	0	0	0	1	0
TOTAL	387	190	314	350	117	180	119	245	60	244	14	37	163	295

APPENDIX IV

WEED COUNT ASSESSMENT SHEETS, SECOND YEAR 97/8

Key to treatment codes

A) Untreated control
B) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 every 9 weeks
C) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Mogeton 1.0 g/m^2 every 9 weeks
D) Ronstar 2G, 20 g/m^2 alternated with Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks
E) Ronstar 2G, 20 g/m^2 alternated with Stefes Lenacil, 0.1 g/m^2 every 9 weeks
F) Flexidor 125, 0.1 ml/m^2 alternated with Butisan S, 0.25 ml/m^2 every 9 weeks
G) Flexidor 125, 0.1 ml/m^2 + Stefes Lenacil, 0.05 g/m^2 every 9 weeks
H) Flexidor 125, 0.1 ml/m^2 + Butisan S, 0.25 ml/m^2 every 18 weeks
I) Flexidor 125, 0.1 ml/m^2 + Kerb 50W, 0.1 g/m^2 every 9 weeks
J) Stefes Lenacil, 0.1 g/m^2 every 9 weeks
K) Axit GR, 10 g/m^2 every 9 weeks
L) Axit GR, 10 g/m^2 with Butisan S, 0.25 ml/m^2 every 9 weeks

Rates/ha

Ronstar 2G @ 200 kg
Flexidor 125 @ 1 litre
Mogeton @ 10 kg
Axit GR @ 100 kg
Butisan S @ 2.5 litre
Stefes Lenacil @ 1 kg (reduced to 0.5 kg where tank mixed)
Kerb 50W @ 1 kg

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

November 97

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L
An.Md.Grass.	2	0	0	0	0	0	0	0	0	0	1	0
Bittercress	2	1	0	1	0	1	0	0	0	3	1	2
Chickweed	0	0	0	0	0	0	0	0	0	0	0	0
M/ear Chickweed	0	3	5	1	1	0	0	0	0	1	1	0
Groundsel	0	0	0	0	0	2	1	0	0	0	0	0
Willowherb	2	0	0	1	1	0	0	0	1	0	3	2
Rush	0	0	0	0	0	0	0	0	0	0	0	0
Dock	0	0	0	0	0	0	0	0	0	0	0	0
Veronica	0	0	0	0	0	0	0	0	0	0	0	0
Thistle	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	6	4	5	3	2	3	1	0	1	4	6	4

LIVERWORT & MOSS ASSESSMENT

Liverwort	A	B	C	D	E	F	G	H	I	J	K	L
No.pots with l/wort	22	3	2	4	0	21	0	0	11	0	17	14
Mean % cover/pot	9.5	6.7	1.6	3.3	0	8.3	0	0	6.2	0	8.5	7.9
No.pots with traces	31	2	0	4	6	30	0	0	8	0	23	11
Moss												
No.pots with moss	4	1	1	2	3	1	0	0	1	0	4	4
Mean % cover/pot	5	5	1.6	1.6	1.6	1.6	0	0	1.6	0	5	5
No.pots with traces	6	5	3	5	2	7	0	0	6	3	4	4

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

January 98

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L
An.Md.Grass.	0	0	0	0	0	0	0	0	0	0	0	0
Bittercress	4	0	0	0	0	1	0	1	1	2	1	3
Chickweed	0	0	0	0	0	0	0	0	0	0	0	0
M/ear Chickweed	0	5	3	0	0	0	2	0	0	2	0	0
Groundsel	0	0	0	0	0	0	2	0	1	0	0	0
Willowherb	0	0	0	0	0	2	0	1	0	0	2	1
Rush	1	0	0	0	0	0	0	0	0	0	0	0
Dock	0	0	0	0	0	0	0	0	0	0	0	0
Thistle	0	0	0	0	0	0	0	0	0	0	0	0
Veronica	3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8	5	3	0	0	3	4	2	2	4	3	4

LIVERWORT & MOSS ASSESSMENT

Liverwort	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
No.pot with l/wort	51	0	1	0	0	25	0	0	11	0	10	4
Mean % cover/pot	19.3	0	3.3	0	0	9.4	0	0	7.6	0	5.5	10
No.pot with traces	17	4	2	1	1	12	0	3	13	0	16	15
Moss												
No.pots with moss	6	3	1	2	0	2	0	0	0	0	0	3
Mean % cover/pot	5	15	1.6	1.6	0	3.3	0	0	0	0	0	1.6
No.pot with traces	0	0	1	2	3	3	0	2	5	2	0	1

HNS 74 ASSESSMENT FOR WEED TYPE AND NUMBER

April 98

WEED TYPE	A	B	C	D	E	F	G	H	I	J	K	L
An.Md.Grass.	0	0	0	0	0	0	0	0	0	0	0	0
Bittercress	41	1	0	0	0	4	5	4	11	12	4	5
Chickweed	0	0	0	0	0	0	0	0	1	0	0	0
M/ear Chickweed	3	11	6	0	4	1	1	1	0	1	1	0
Groundsel	17	17	13	14	15	5	18	16	16	8	6	7
Willowherb	0	0	0	0	0	2	0	1	2	0	4	2
Rush	1	0	0	0	0	0	0	0	0	0	0	0
Dock	0	0	0	0	0	0	0	0	0	0	0	0
Veronica	0	0	0	0	0	0	2	0	0	9	0	0
Thistle	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	62	29	19	14	19	12	26	22	30	30	15	14

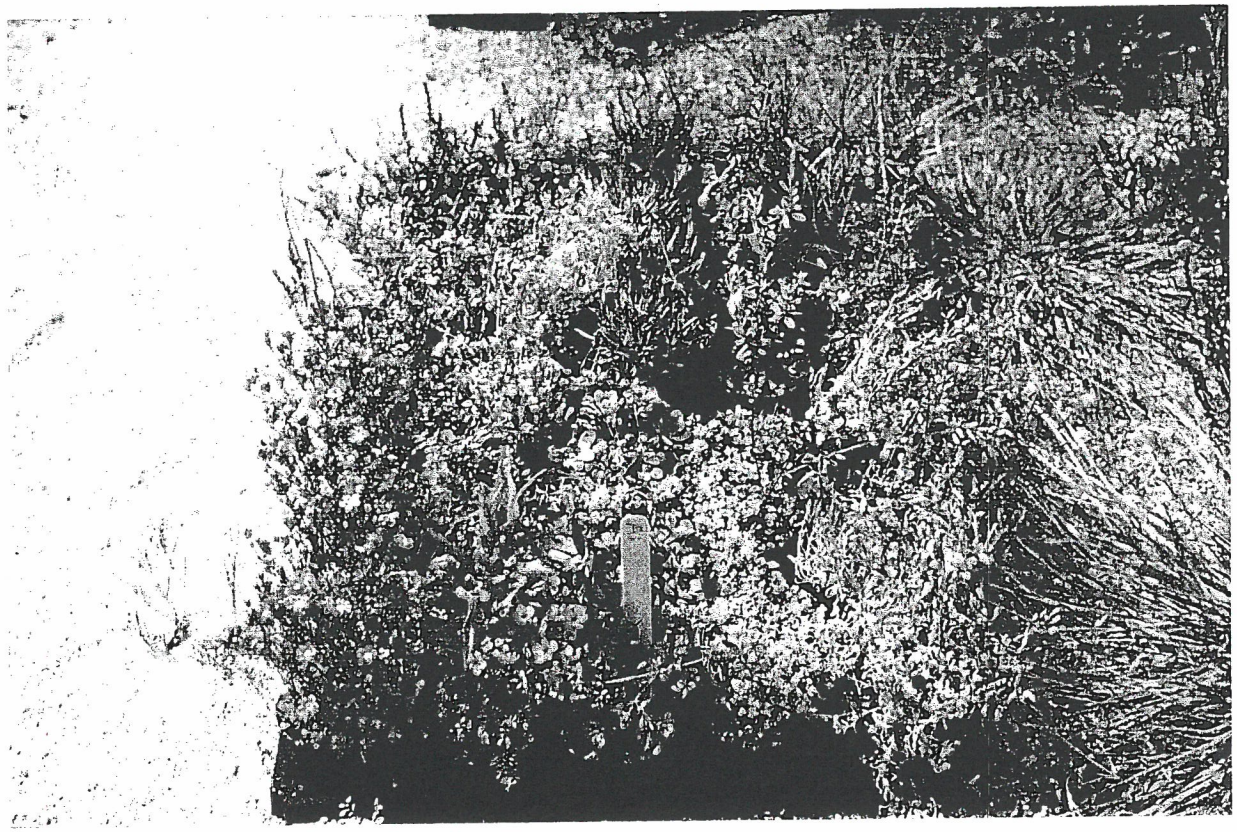
LIVERWORT & MOSS ASSESSMENT

Liverwort	A	B	C	D	E	F	G	H	I	J	K	L
No.pot with l/wort	73	0	2	0	0	40	0	4	24	0	23	11
Mean % cover/pot	27	0	5	0	0	26.3	0	10	22.1	0	24.2	25.6
No/ pot with traces	23	7	6	0	0	12	0	5	4	0	20	13
Moss												
No.pots with moss	5	5	0	2	2	0	0	0	3	0	1	0
Mean % cover/pot	7.5	5.5	0	5	5	0	0	0	6.6	0	3.3	0
No.pot with traces	0	1	2	1	3	0	2	2	15	7	2	2

APPENDIX V

PHOTOGRAPHS

Plate 1



Untreated control at final assessment of first year trial, May 97

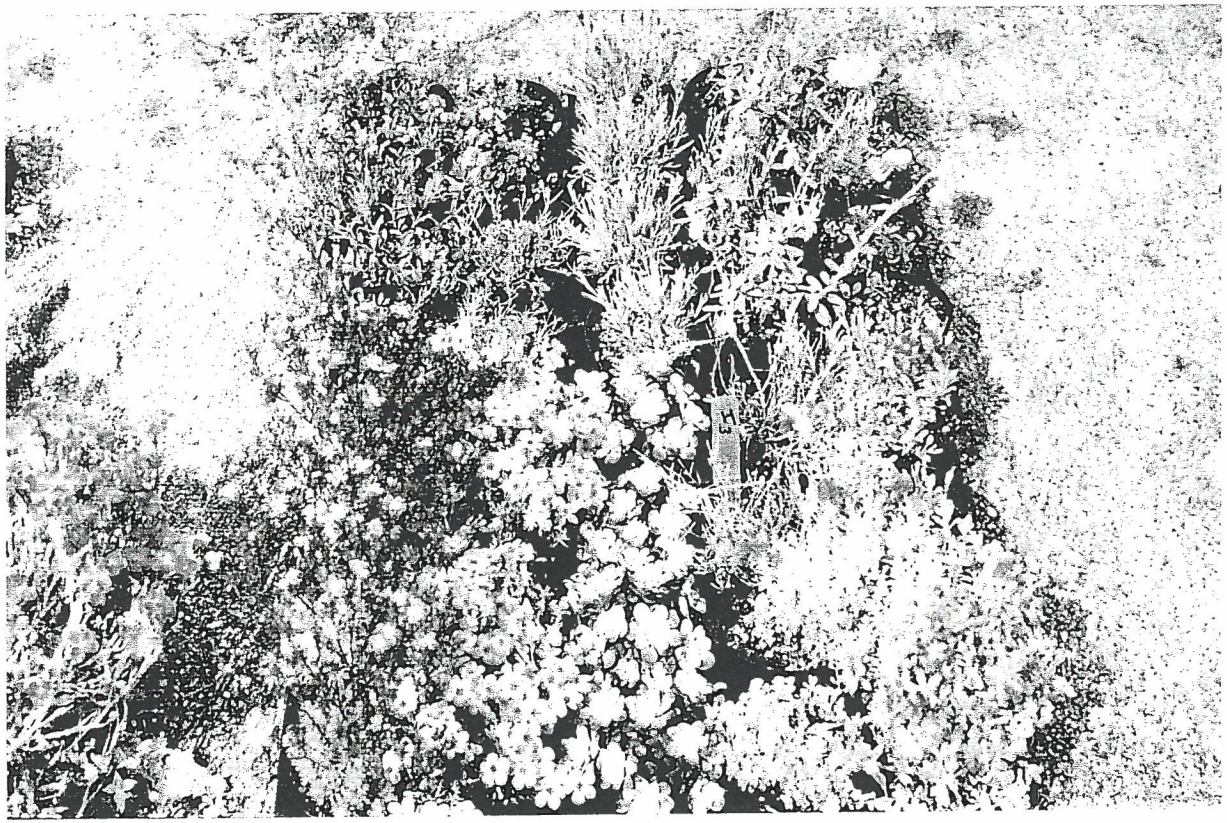
Plate 2

Ronstar 2G, 10g/m^2 at final assessment of first year trial, May 97

Plate 3

Ronstar 2G, 20g/m^2 at final assessment of first year trial, May 97

Plate 4



Butisan S, 0.25 mls/m^2 at final assessment of first year trial, May 97

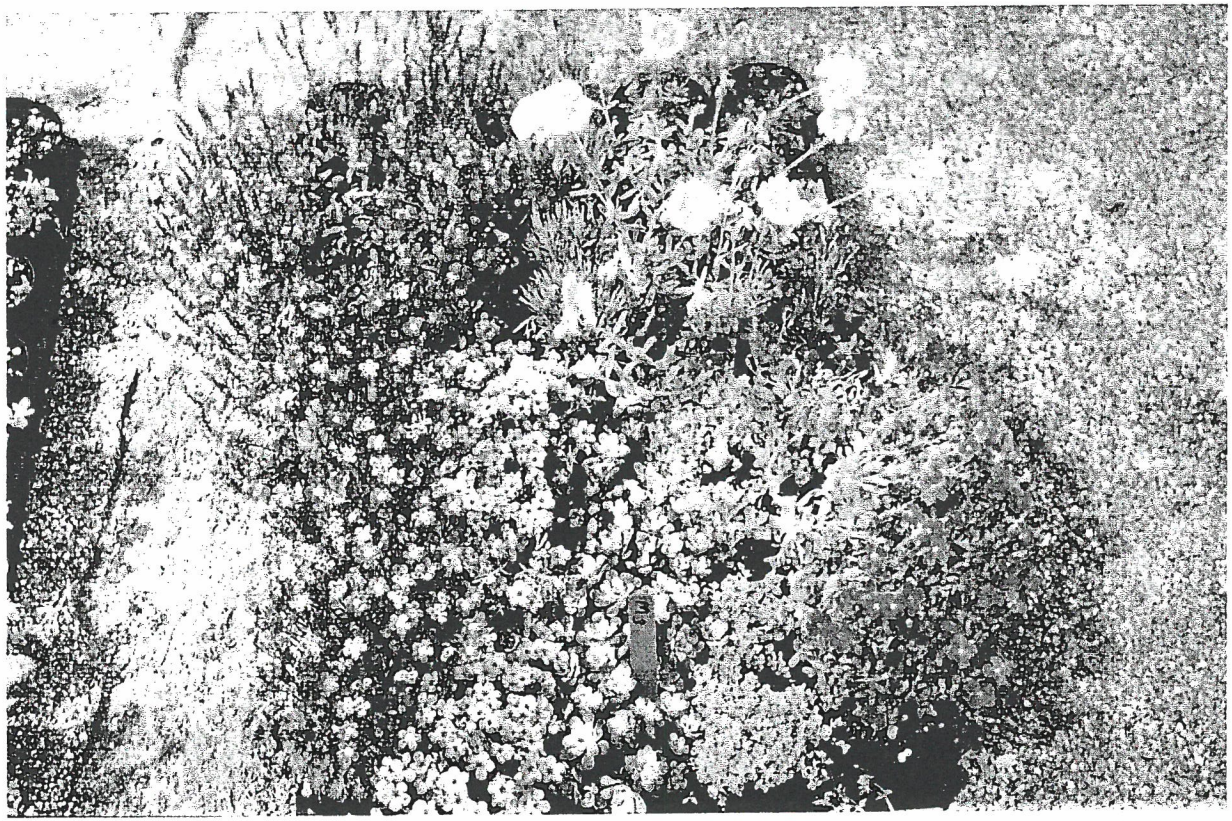
Plate 5

Stefes Lenacil, 0.28 g/m^2 at final assessment of first year trial, May 97

Plate 6

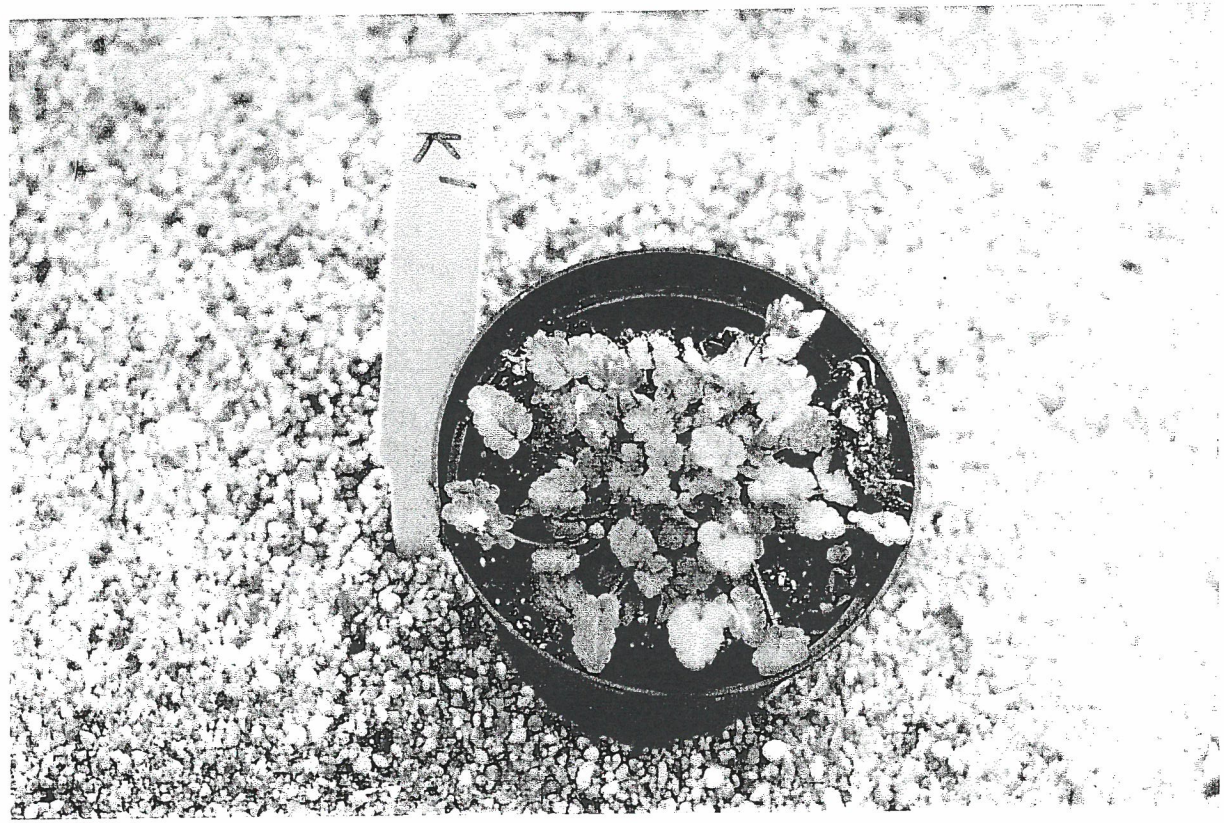
Stefes Lenacil, 0.15 g/m^2 at final assessment of first year trial, May 97

Plate 7



Kerb 50W, 0.1 g/m^2 at final assessment of first year trial, May 97

Plate 8

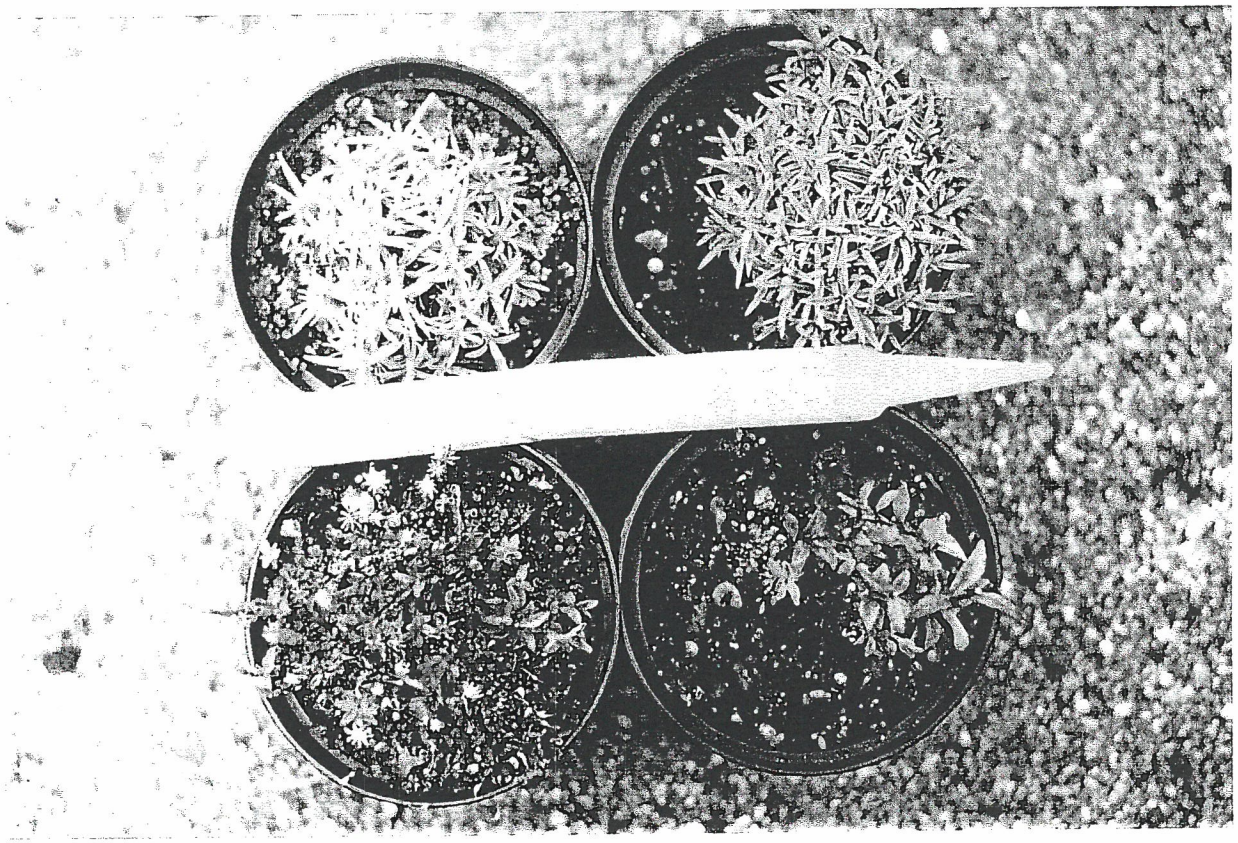


Stefes Lenacil, 0.28 g/m^2 at final assessment of first year trial, showing damage on *Erodium reichardii* 'Roseum'

Plate 9

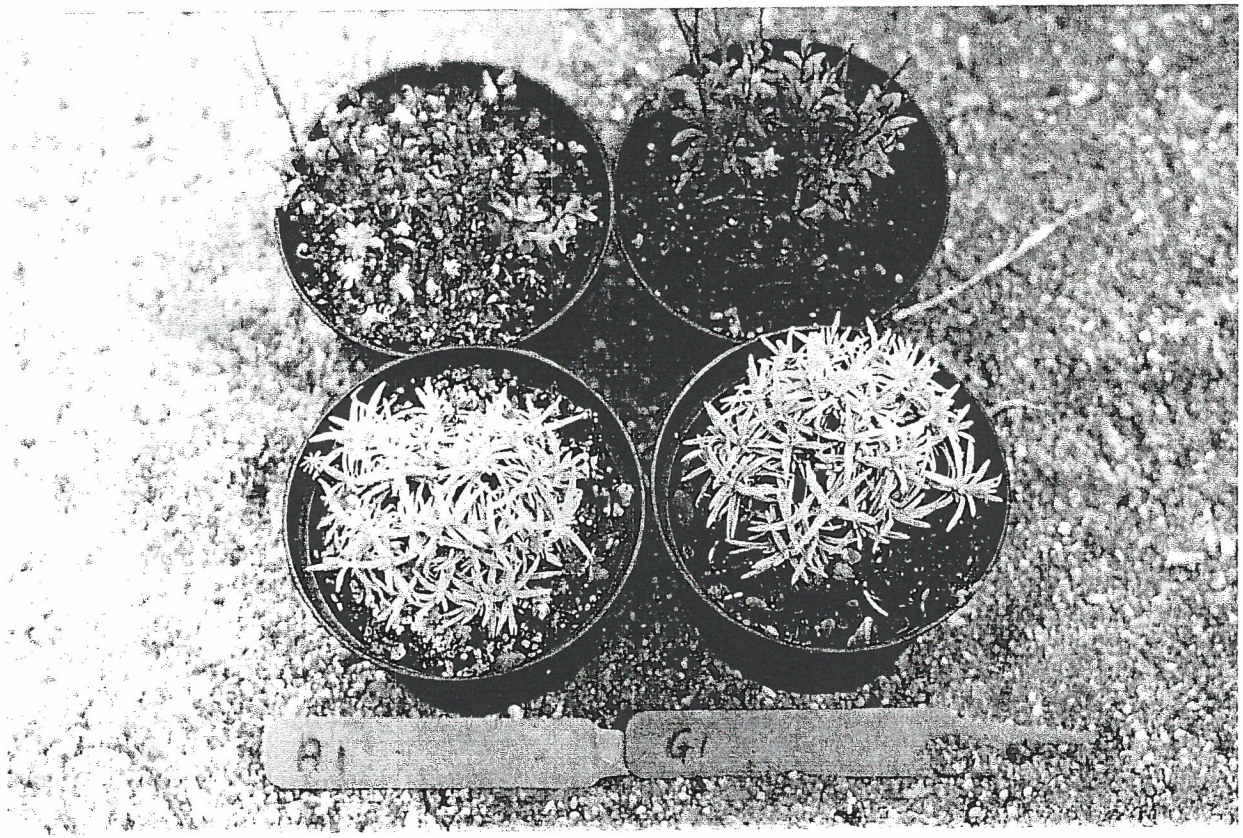
Untreated control (A1) with Ronstar 2G/ Stefes Lenacil (*Dianthus*) at final assessment of second year trial, April 98

Plate 10



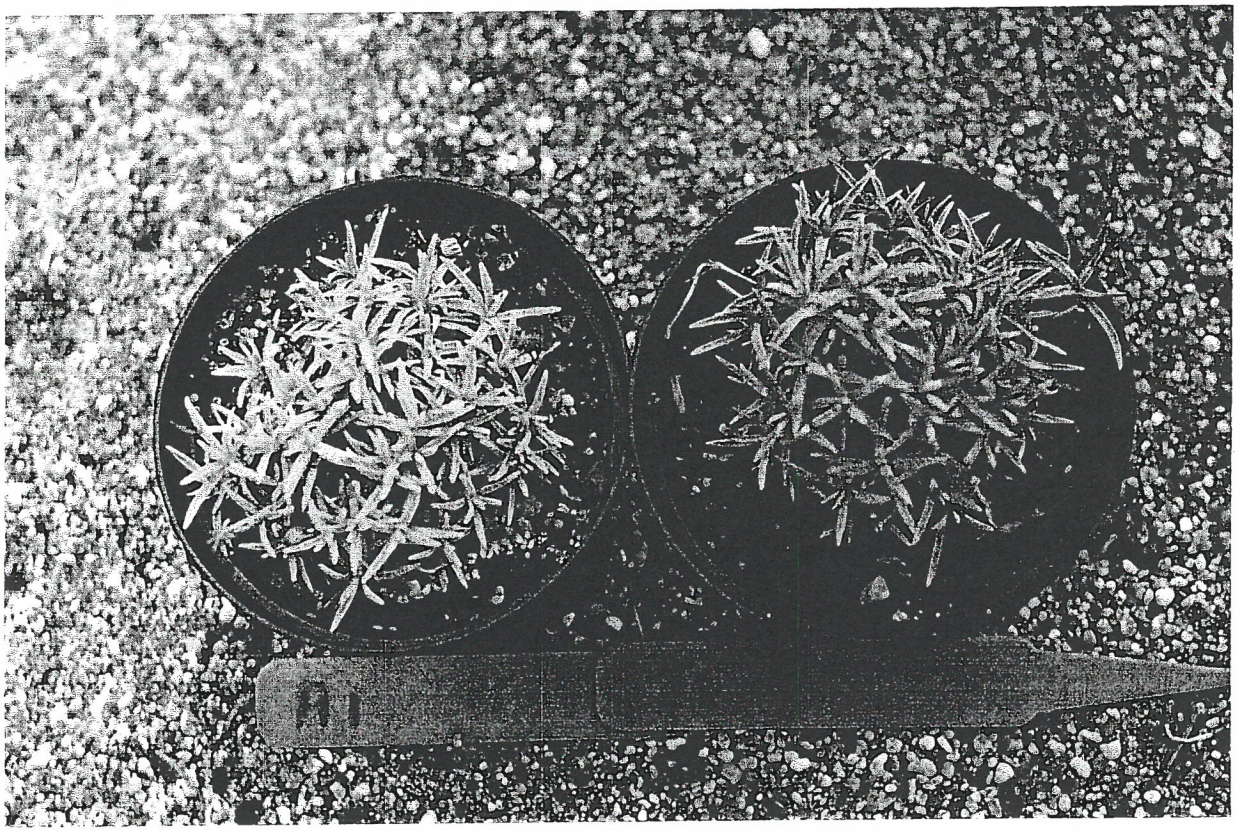
Untreated control (A1) with Ronstar 2G/Stefes Lenacil (*Dianthus & Campanula*) at final assessment of second year trial, April 98

Plate 11



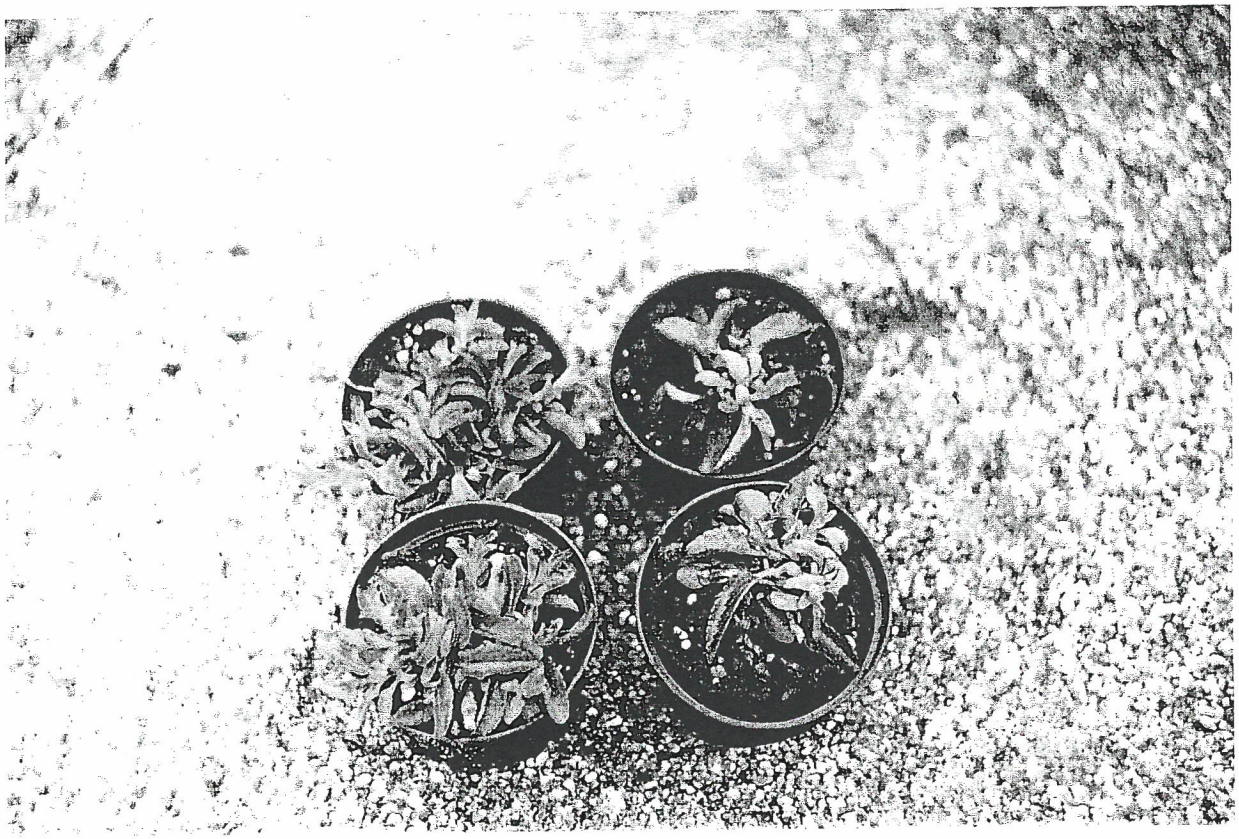
Untreated control (A1) with Flexidor 125 + Butisan S (*Dianthus & Campanula*) at final assessment of second year trial, April 98

Plate 12



Untreated control (A1) with Stefes Lenacil, individual treatments, (*Dianthus*) at final assessment of second year trial, April 98

Plate 13

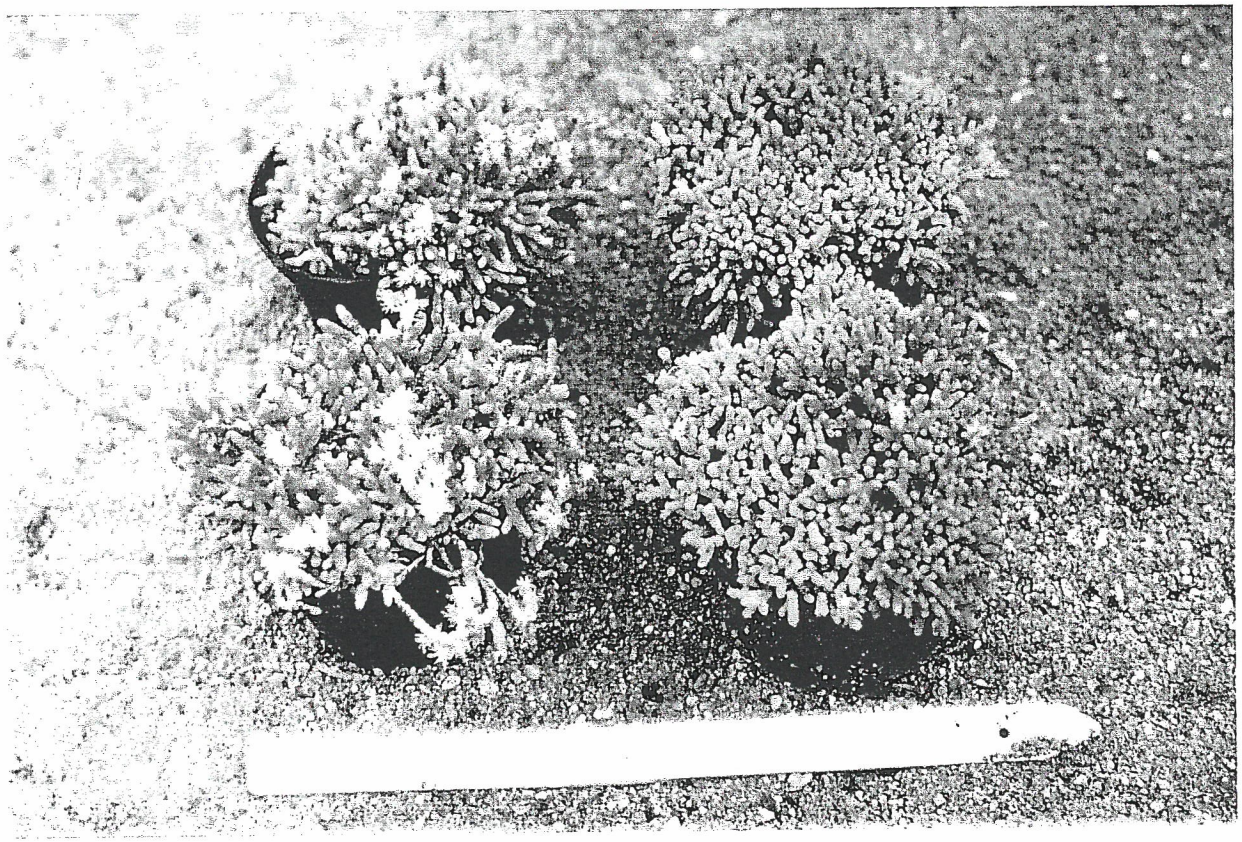


Untreated control (A1) with Flexidor 125/Butisan S (*Veronica*), second year trial, March 98

Plate 14

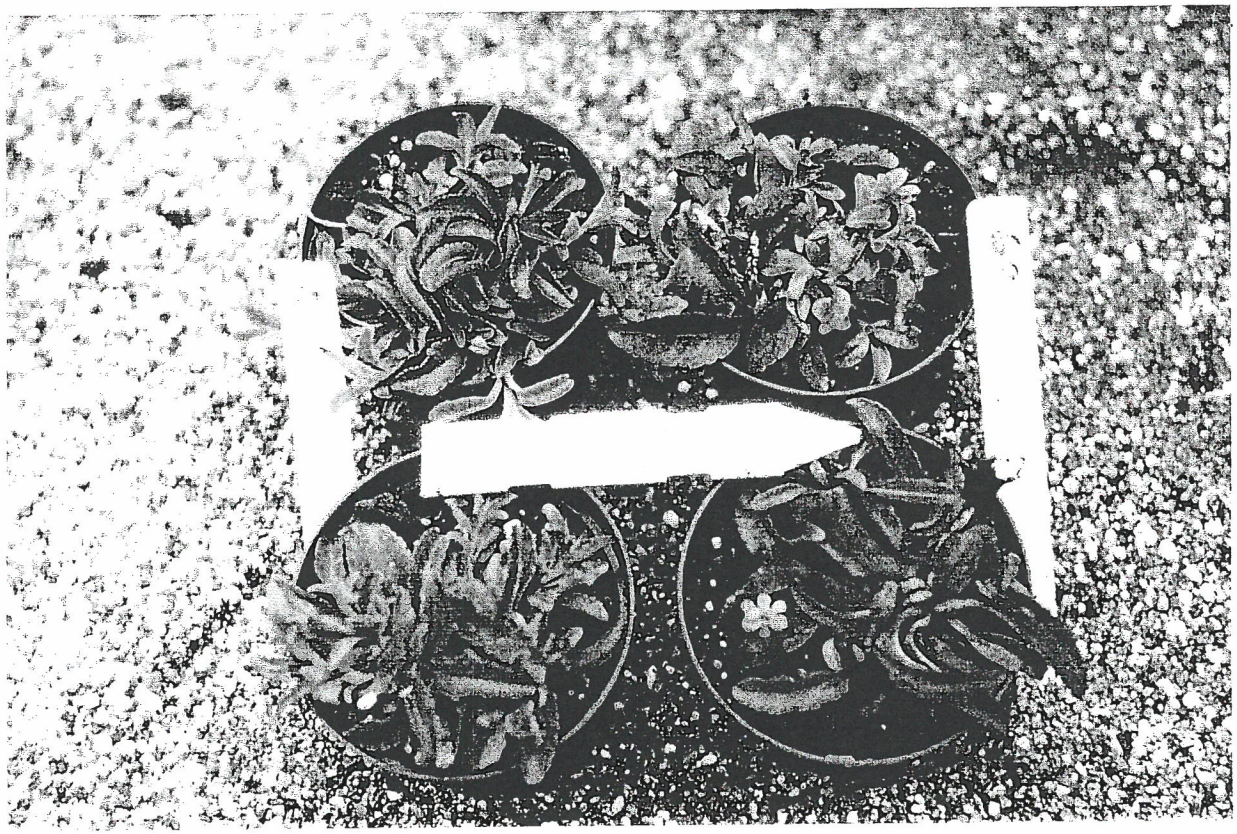
Untreated control (A2) with Flexidor 125/Butisan S (*Veronica*), second year trial, June 98

Plate 15



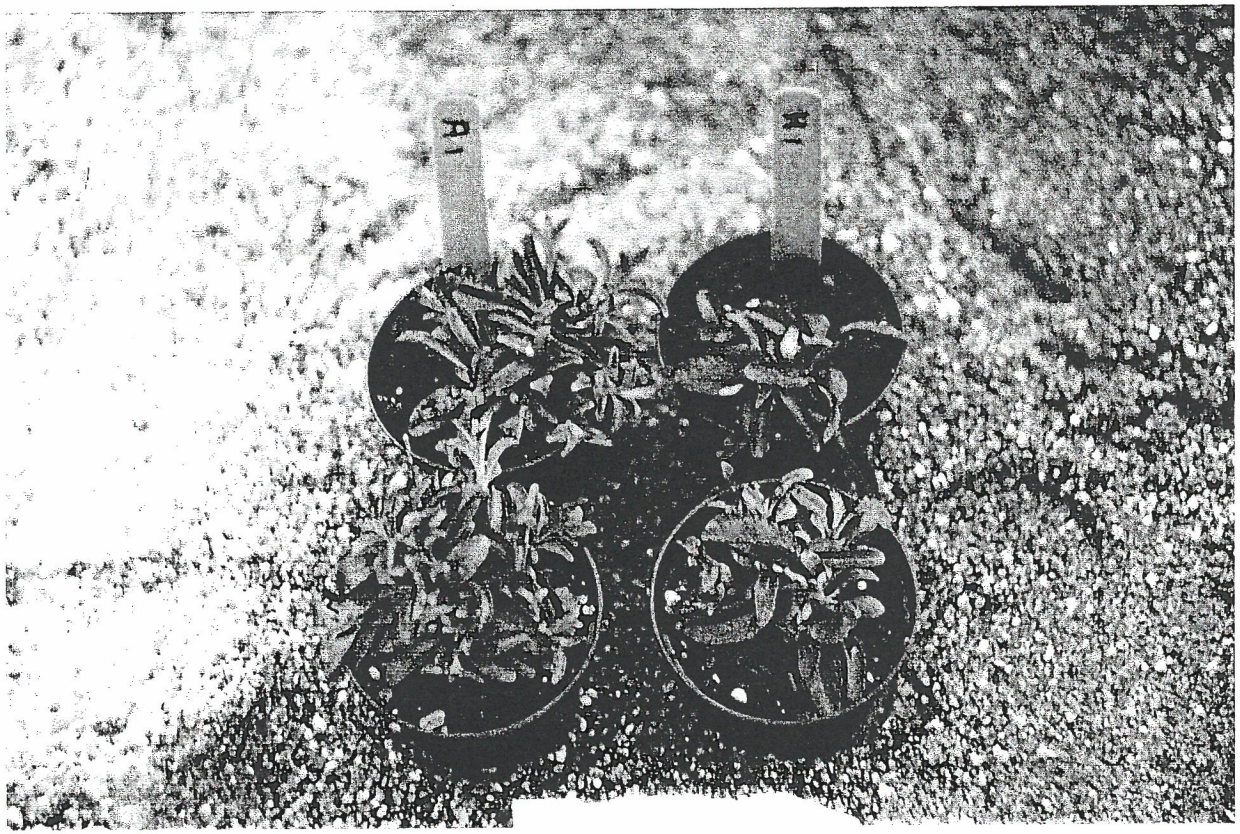
Untreated control (A3) with Flexidor 125/Butisan S (*Sedum*), second year trial, June 98

Plate 16



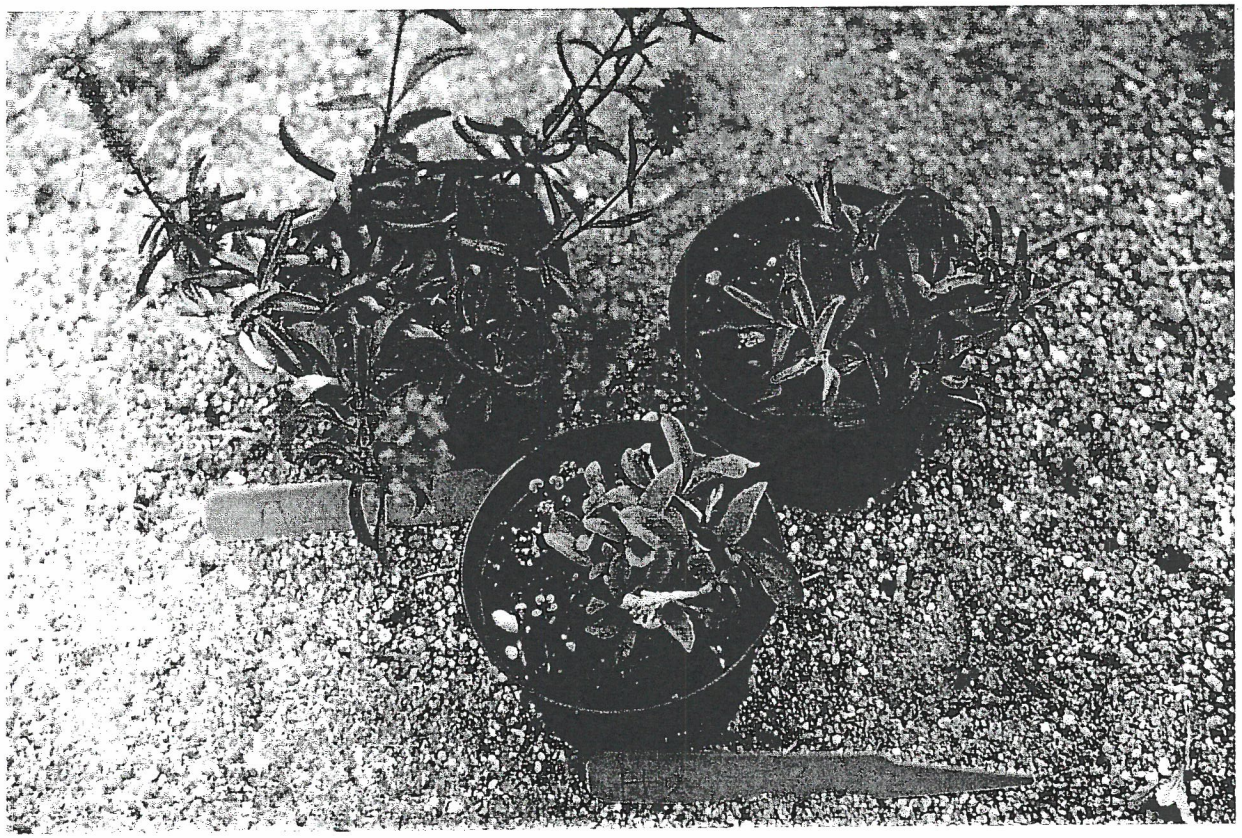
Untreated control (A3) with Flexidor 125 + Stefes Lenacil (*Veronica*), second year trial, March 98

Plate 17



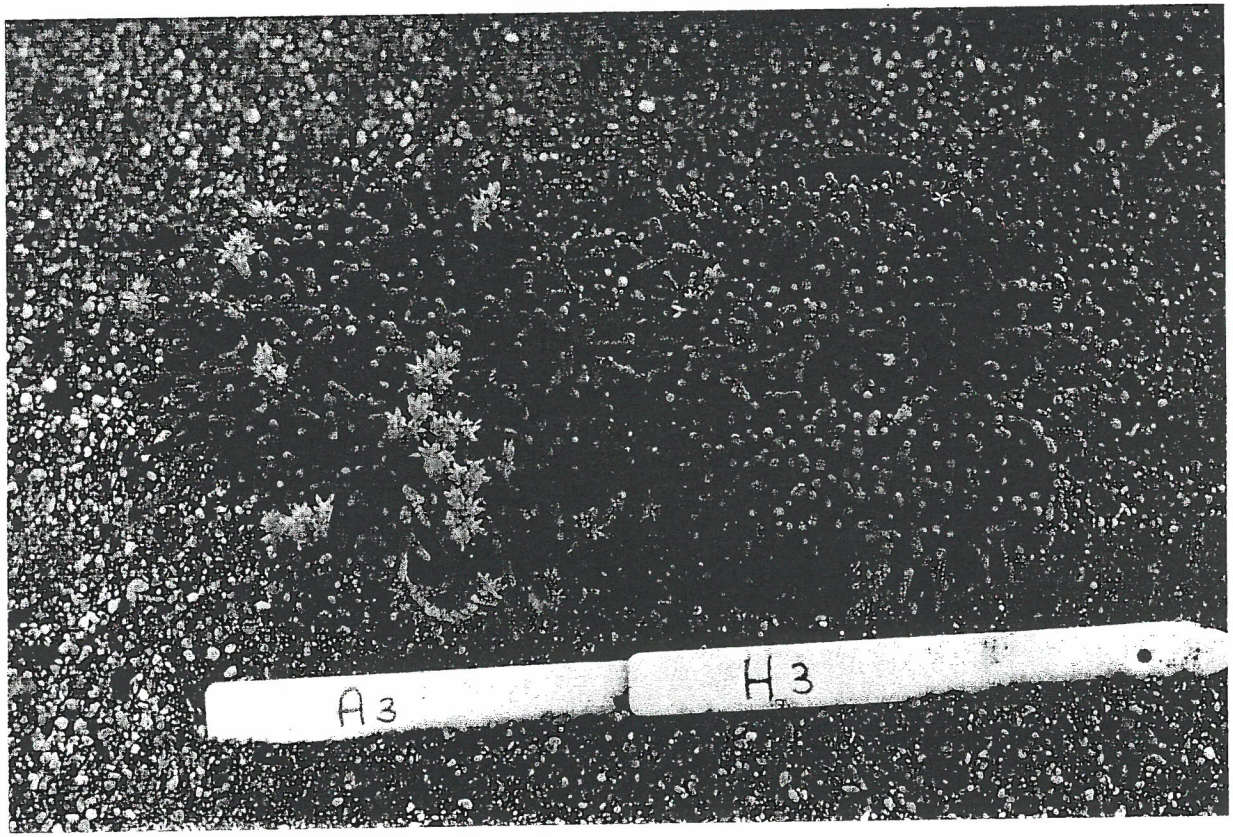
Untreated control (A1) with Flexidor 125 + Butisan S (*Veronica*), second year trial, March 98

Plate 18



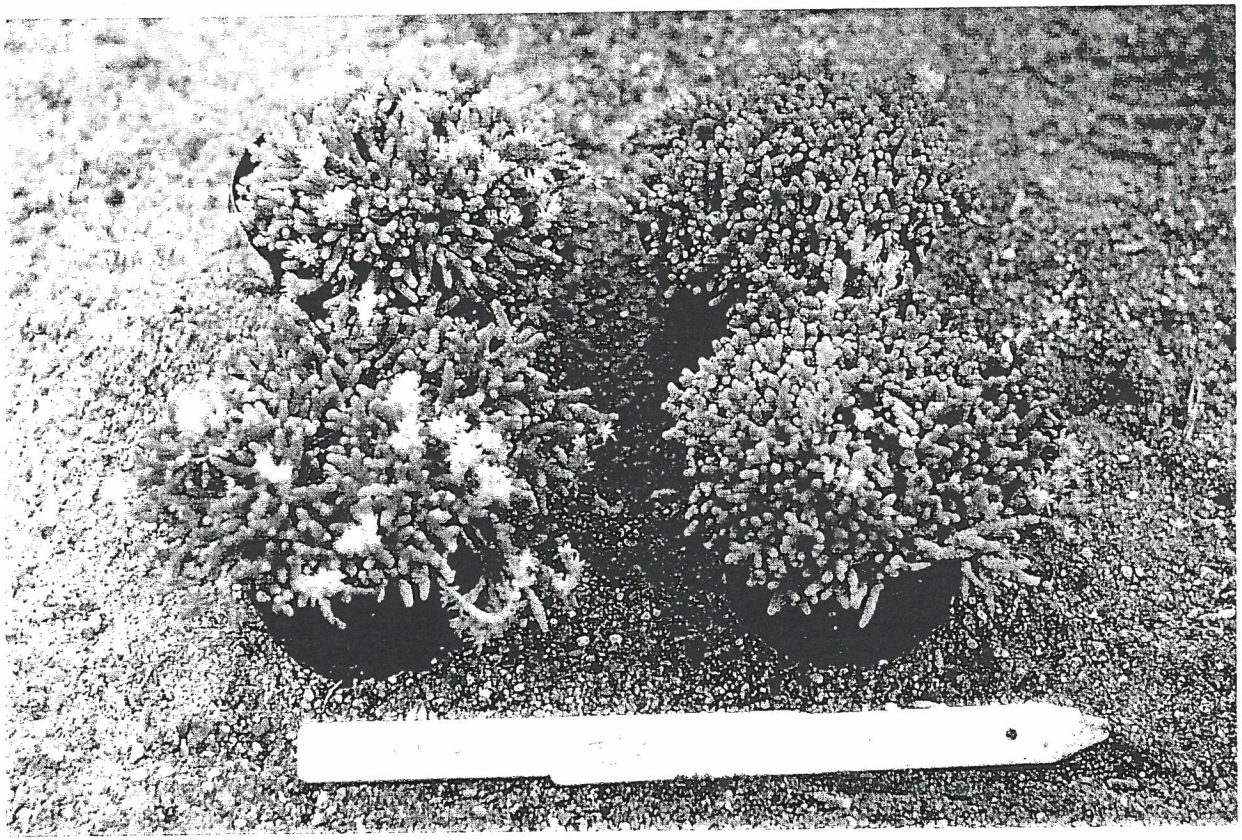
Untreated control (A2) with Flexidor 125 + Butisan S (*Veronica*), June 98

Plate 19



Untreated control (A3) with Flexidor 125 + Butisan S (*Sedum*), June 98

Plate 20



Untreated control (A3) with Flexidor 125 + Kerb 50W (*Sedum*), June 98