Project Title:	**Nursery stock propagation: control of moss, liverwort and algae**
Project Number:	**HNS 93**
Project Leaders:	**Margaret Scott, HRI Efford** — **David Hutchinson, ADAS**
Report:	**Final Report - December 2001**
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Location:	**Year 1 - HRI Efford, Lymington, Hants SO41 0LZ**
	Year 2 - Commercial trialling: **New Place Nurseries Ltd, Pulborough, West Sussex**; **Hewton Nursery, Bere Alston, Yelverton, Devon**; **Northern Liner Co, Out Rawcliffe, Nr Garstang, Preston**
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Key words:	**Hardy shrubs, container grown, propagation, liners, protected cropping, weed control, moss control, liverwort control, algae control, herbicides, chemical control**

CONTENTS

FOREWORD

Few subjects in everyday nursery stock production create as much discussion as the costs and rates associated with the preparation of stock for despatch.

A large proportion of these costs is spent cleaning off the surface of pots, removing moss, liverwort and other weeds. In today's market, zero tolerance of the above is equally applicable to a nursery receiving a consignment of liners as it is to garden centre taking delivery of saleable stock.

It is therefore little surprise that, with so much stock for both markets produced under protection, this project has created so much interest from growers.

The project looked at various treatments with the potential for control of moss, liverwort and weed in rooted plugs through to the finished liner stage under protection.

Funded by the HDC, the first phase of the project was carried out at HRI Efford before progressing to commercial trialling on three nurseries around the country. Throughout all stages, Margaret Scott and David Hutchinson have directed the project with their customary efficiency and enthusiasm, ably assisted by the Efford team, and in particular Sarah Williams.

This report offers some detailed information and advice that is easy to implement. However, more importantly, at a time when the industry must reduce labour input, restrict chemical and herbicide treatments and use water more efficiently, it points the direction that growers should follow in the future.

John Hedger, New Place Nurseries
Project Co-ordinator

DISCLAIMER

Inclusion of products in these trials does not necessarily mean that they have approval for use with the specific crops, or have clearance for use under protection. Manufacturers' literature must be consulted, always read the label.

Where a product has clearance for use on another crop under similar conditions, then it may be used on ornamentals at the growers' own commercial risk under the off-label arrangements for *'Long Term Arrangements for Extension of Use* (2000)'.

ACKNOWLEDGEMENTS

This has been a major programme of work with involvement and expertise input from a large number of people across sites. The teamwork that evolved was essential to the success of the project. The authors would like to thank everyone involved from HRI Efford and ADAS, but particularly the three nurseries for allowing the work to be undertaken on their sites, and the nursery staff for managing the trials so well. Special thanks go to Mark Pearce at New Place Nurseries, Steve Watson at Hewton Nursery and Chris Connah at Northern Liners.

Our thanks also to John Hedger at New Place Nurseries for the co-ordination of the project.

PRACTICAL SECTION FOR GROWERS

Commercial benefits of the project

The project has identified a number of chemicals/herbicides with potential for control of moss, liverwort and weeds in rooted plugs and liners grown under protection. Some of the most promising, however, do not yet have approval for use under protection. Irrigation management to provide a 'drier' growing environment was shown to be a key component in reducing moss, liverwort and weed pressure, and used in conjunction with the chemical/herbicide treatments, significantly reduced or even eliminated the problem. Accreditation schemes are increasing and costs of cleaning pots of weeds is estimated to be one third of the total dispatch costs, so significant savings are possible by developing improved weed control strategies.

The industry is faced with the loss of a number of key chemicals over the next few years as active ingredients are withdrawn, which together with environmental pressures to reduce the use of pesticides, will force the issue regarding alternative strategies. Development of irrigation regimes to reduce dependence on their use is an exciting option, and has the added benefits of reducing disease pressure and manipulation of plant growth to produce more compact plants.

Background and objectives

The project was aimed at reducing incidence of moss, liverwort and weeds in rooted plugs and liners of HNS grown under protection, towards addressing the increasingly important goal towards 'zero tolerance' to weeds within accreditation schemes; and reducing the cost of cleaning the pots at dispatch.

Moss and liverwort have become an increasingly serious problem where holding rooted plugs pre-potting, and on into the liner growth. With plugs, difficulties in achieving uniformity of watering and presence of empty cells from cutting failure, accelerates colonisation of moss and liverwort, which is difficult to completely hand clean before potting. Some debris and inoculum inevitably gets carried over to the liner, where it rapidly re-establishes, especially with overhead irrigation and in overwintered crops.

There are few chemicals/herbicides with approval for use under protection, especially for young plants that will, potentially, be more sensitive, since their growth will be softer. There are a number of chemicals/herbicides with activity against moss and liverwort, and these were trialled to gauge their promise for taking forward.

The objective of the work was to develop strategies for providing weed free, but especially moss and liverwort free, rooted plugs and liners.

The work was done in two phases, with detailed work at HRI Efford, followed by commercial trialling on three Association of Liner Producers (ALP) nurseries around the country. The project was collaborative between HRI and ADAS.

Summary of results and conclusions

Year 1 : Detailed trialling at HRI Efford during 1999/2000 identified a number of chemicals/herbicides with potential including

Rate/m^2 (sprays applied in 200 mls water)

		Plugs	Liners
*	Panacide M	2.5 ml	2.5 ml
*	Mogeton	1.4 g	1.4 g
*	Lenacil 80 W	-	0.15 g
*	Axit GR	-	10.0 g
*	Diuron	0.0125g	0.0125g
*	Ronstar 2G	20.0g	20.0 g

Panacide M and Mogeton were applied every 6 weeks, the Lenacil 80 W, Diuron, Axit GR and Ronstar 2G every 12 weeks.

Year 2 : These treatments were trialled in 2000/2001 on 3 specialist liner nursery sites located in Sussex, Devon and Lancashire, across a range of 14 HNS species.

The main findings were as follows :

- Moss and liverwort proved the main problems in the plug stage, with Panacide M and Mogeton proving the most effective treatments.
- In the liner stage, management of 'drier' watering regimes produced a marked reduction in moss, liverwort and weed presence. This can be seen in figure 1, Site C managing a considerably drier regime than the other two. Development of methodologies to implement this strategy will be an important step forward in reducing reliance on chemicals.
- Herbicide programmes were more effective where weed inoculum was reduced
- Liverwort was easier to control than moss.

- Effective control depended on matching treatment to weed species present. Results for moss and liverwort control are also shown in figures 2 and 3.

➢ Panacide M, and particularly Mogeton, gave reasonable control of moss and liverwort, but not weeds.

➢ Lenacil 80 W proved the most effective herbicide, controlling moss, liverwort and weeds (except Pearlwort), but proved phytotoxic to some species when applied to softer growth (Golden *Forsythia, Euonymus* 'Harlequin', *Ceanothus*).

➢ Ronstar 2G gave effective control of Hairy Bittercress (*Cardamine hirsuta*) and Annual Meadow Grass (*Poa annua*), but not Pearlwort (*Sagina procumbens*), nor in this trial moss or liverwort.

➢ Diuron, even at the low rate used here (0.0125g/m^2), which was a quarter of that normally used on the larger containers, still proved too phytotoxic, and control of moss and liverwort was lost.

➢ Axit GR controlled Annual Meadow Grass and Pearlwort, but appeared less effective against Hairy Bittercress, and gave little control of moss or liverwort.

Action points for growers

- Consider developing and implementing controlled irrigation regimes to provide drying back between waterings to reduce weed pressure. Results from the HortLINK programme (HNS 97) on improving efficiency of water use in HNS (HNS 97) should provide information on how this might be achieved in the future

- Prevention is better than cure relative to controlling moss and liverwort. Start prevention programmes early to keep pots clean for longer.

- While a number of herbicides looked promising for use with liners under protection, manufacturers labels must be checked, since few chemical/herbicides have approval for use under protection. This needs addressing once their potential for efficacy and safety of use is verified.

- Whenever new chemicals are introduced into the nursery programme it is essential to test them over a small number of plants from the full range grown to check for safety. With the diverse range of species/cultivars in HNS there will always be some that could prove sensitive.

Anticipated practical and financial benefits

- Reducing weed pressure will provide cost savings in hand weeding during production, plus the costs of cleaning pots at dispatch. At present, one third of the cost of dispatch is reckoned to be involved in cleaning pots of moss, liverwort and weeds. With dispatch accounting for an estimated 12% of production costs, a saving of 4% of total costs is significant. Industry wide, based on a farm gate value of around £325 million for container production, this would equate to a potential saving of £13 million, mainly on labour costs.

- Introducing more controlled irrigation strategies will have added benefits of reducing disease risk and provide some manipulation of plant growth to produce more compact, quality plants, thus helping to counteracting the internode stretch common under protection.

- Greater use of cultural methods to reduce moss, liverwort and weeds, will address the environmental issues of reduced pesticide use.

Figure 1. Moss and liverwort

Severity of background infection - untreated liners

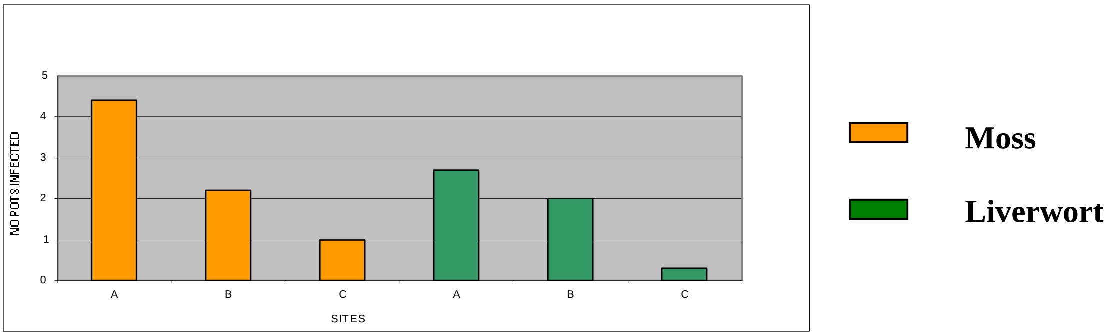
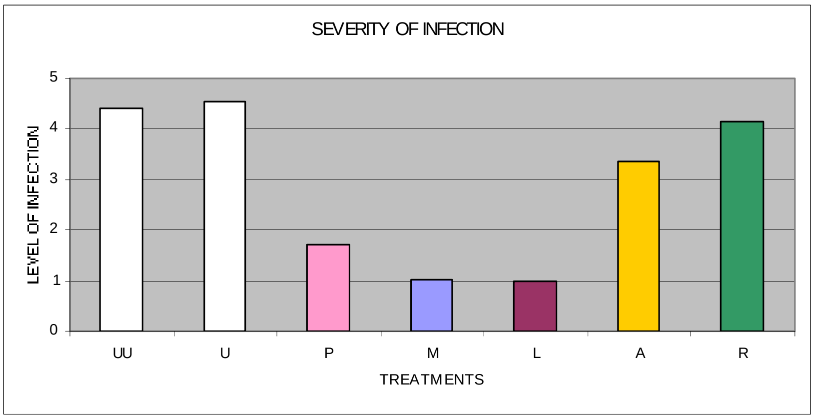


Figure 2. Moss Control

Efficacy of treatments by April 2001



Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

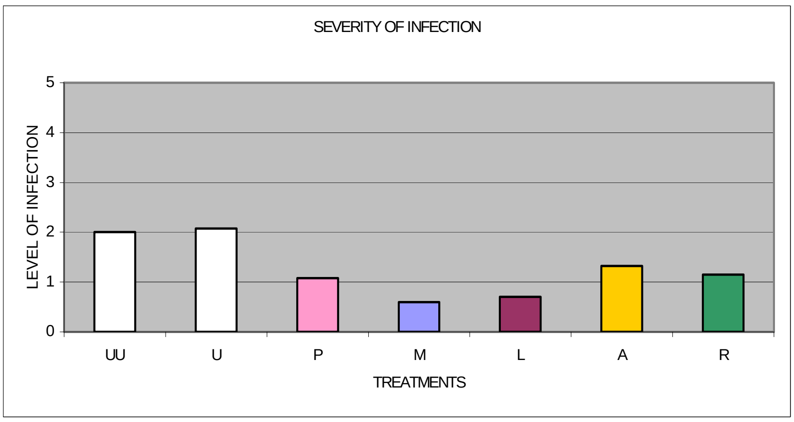
L = Lenacil 80 W

A = Axit GR

R = Ronstar 2G

Figure 3. Liverwort control

Efficacy of treatments by April 2001



Overall summary of efficacy of treatments against moss, liverwort and weeds

Key: **x** nil • slight • • moderate • • • good control

Treatment	Rate/m^2	Moss	Liverwort	Annual M. Grass	Hairy Bittercress	Pearlwort	Deposit
Plugs							
Panacide M	**2.5 mls**	• • •	• •	-	-	-	x
Mogeton	**1.4 g**	• • •	• •	-	-	-	4
Diuron @	**0.025 g**	• • •	• • •	-	-	-	x
Diuron @	**0.0125 g**	x	•	-	-	-	x
Ronstar 2 G	**20.0 g**	• •	• •	-	-	-	x
Bravo	**0.75 g**	• •	• •	-	-	-	4
Jet 5	**25 ppm**	•	•	-	-	-	x
Enigma Anolyte	**pH 6.0**	x	•	-	-	-	x
Bark mulch	**5 mm**	• • •	• •	-	-	-	x
Liners							
Controlled irrigation		• • •	• • •				
Panacide M	**2.5 mls**	• •	• • •	x	x	x	x
Mogeton	**1.4 g**	• • •	• • •	x	x	x	4
Diuron	**0.025 g**	• • •	• • •	-	-	-	x
Lenacil 80 W	**0.15 g**	• • •	• • •	• • •	• •	•	x
Axit GR	**10.0 g**	•	•	• • •	•	• • •	x
Ronstar 2G	**20.0 g**	•	•	• • •	• •	•	x

Notes :

- While controlled irrigation reduced weed presence, direct comparison of effects on individual weed species was not possible in this trial since their presence varied between nurseries.
- Plugs – Poor control of moss where plugs were already contaminated at the start of the trial, since treatments were designed for prevention rather than eradication of existing infestations.
- Always consult the manufacturers literature to check that the product has approval for use under the conditions for which it is required. Where a product has clearance for use on another crop **grown under similar conditions**, then it may be used on ornamentals at the growers' own commercial risk under the off-label arrangements for 'Long Term Arrangements for Extension of Use (2000).

Overall summary of safety of use of a range of chemicals investigated during the course of the Efford and commercial trials - PLUGS

Key for phytotoxicity: 4 nil • some • • moderate • • • severe

Chemical Rate/m^2	Panacide M 2.5 ml	Mogeton 1.4 g	Diuron 0.025 g	Diuron 0.0125 g	Ronstar 2G 20.0 g	Bravo 0.75 g	Jet 5 25 ppm	Anolyte
Efford								
***Azalea* 'Blue Danube'**	4	4	• • •	-	4	4	4	4
***Cytisus* 'Burkwoodii'**	4	• •	• • •	-	4	4	4	4
***Euonymus fortuneir* 'Silver Queen'**	4	4	4	-	4	4	4	4
Commercial								
***Berberis thunbergii* 'Aurea'**	4	•	-	• • •	•	-	-	-
***Euonymus fortunei* 'Harlequin'**	4	4	-	4	4	-	-	-
***Forsythia intermedia* 'Golden Times'**	4	4	-	4	4	-	-	-
***Hypericum moserianum* 'Tricolor'**	4	4	-	•	4	-	-	-
***Pyracantha coccinea* 'Red Column'**	4	4	-	4	4	-	-	-
***Camellia japonica* 'Brushfields Yellow'**	4	•	-	4	4	-	-	-
***Choisya ternata* 'Sundance'**	•	4	-	•	•	-	-	-
***Elaeagnus pungens* 'Maculata'**	4	4	-	4	4	-	-	-
***Ilex aquifolium* 'Ferrox Argentea'**	4	4	-	•	4	-	-	-
Magnolia stellata	4	4	-	•	4	-	-	-
***Ceanothus* 'Yankee Point'**	4	4	-	4	4	-	-	-
Cotoneaster horizontalis	4	4	-	4	4	-	-	-
***Hebe albicans* 'Red Edge'**	4	4	-	4	4	-	-	-
***Hypericum moserianum* 'Tricolor'**	4	4	-	4	4	-	-	-
Pernettia mucronatum	4	4	-	4	4	-	-	-

Overall summary of safety of use of a range of chemicals investigated during the course of the Efford and commercial trials - LINERS

Key for phytotoxicity 4 nil • some • • moderate • • • severe

Chemical **Rate/m²** ***Type of growth***	**Panacide M** **4.0 ml**	**Mogeton** **1.4 g**	**Diuron** **0.025 g**	**Lenacil 80 W** **0.15 g** ***Soft***	**Lenacil 80 W** **0.15 g** ***Mature***	**Axit GR** **10.0 g**	**Ronstar 2G** **20.0 g**
Efford							
***Azalea* 'Blue Danube'**	4	4	4	-	4	4	4
***Cistus* 'Silver Pink'**	4	4	4	-	4	4	4
Cotoneaster conspicuus	4	4	4	-	4	4	4
***Cytisus* 'Burkwoodii'**	4	4	• •	-	4	4	4
***Euonymus fortunei* 'Silver Queen'**	4	4	• •	-	•	4	4
***Mag. soulangeana* 'Rustica Rubra'**	4	4	4	-	4	4	4
Prunus lusitania	4	4	4	-	4	4	4
***C. law.* 'Columnaris Glauca'**	4	4	•	-	4	4	4
Commercial							
***Berberis thunbergii* 'Aurea'**	4	4	-	4	4	4	4
***Euonymus fortunei* 'Harlequin'**	4	4	-	• • •	4	4	4
***Forsythia x intermedia* 'Golden Times'**	4	4	-	• • •	4	4	4
***Hypericum moserianum* 'Tricolor'**	4	4	-	4	4	4	4
***Pyracantha coccinea* 'Red Column'**	4	4	-	4	4	4	4
***Camellia japonica* 'Brushfields Yellow'**	4	4	-	4	4	4	4
***Choisya ternata* 'Sundance'**	4	4	-	4	4	4	4
***Elaeagnus pungens* 'Maculata'**	4	4	-	•	4	4	4
***Ilex aquifolium* 'Ferrox Argentea'**	4	4	-	4	4	4	4
Magnolia stellata	4	4	-	4	4	4	4
***Ceanothus* 'Yankee Point'**	4	4	-	• • •	4	4	4
Cotoneaster horizontalis	4	4	-	4	4	4	4
***Hebe albicans* 'Red Edge'**	4	4	-	4	4	4	4
***Hypericum moserianum* 'Tricolor'**	4	4	-	4	4	4	4
Pernettia mucronatum	4	4	-	4	4	4	4

Plate 1

General view of Efford liner trial

0 1 3 5

Moss assessment scores

0 1 3 5

Liverwort assessment scores

Plate 2 (Efford Trial)

***Cytisus* 'Burkwoodii'**

Untreated

Panacide M @ 2.5 ml/m^2

***Chamaecyparis lawsoniana* 'Columnaris Glauca'**

Untreated

Panancide M @ 2.5 ml/m^2

Plate 3

General view of plug stage of commercial trialling

Applying treatments to plugs

5 3 1
Moss assessment scores

5 3 1
Liverwort assessment scores

Plate 4

General view of commercial liner trials

Trial assessments

***Ceanothus* 'Yankee Point'**

Lenacil 80 W damage

Lenacil 80 W veinal chlorosis @ 0.15g/m^2

Plate 5

Lenacil 80 W damage to soft growth in full flush

Untreated **Lenacil 80 W @ 0.15g/m^2**

Forsythia 'Aurea'

Untreated **Lenacil 80 W @ 0.15g/m^2**

***Euonymus fortunei* 'Harlequin'**

SCIENCE SECTION

Introduction

Moss and liverwort growth has become an increasing problem on container HNS over the past decade, particularly so in the propagation and liner phases of production under protection. At the same time introduction of accreditation schemes, and consequent adoption of codes of practice to improve standards, has meant that production of clean, weed free pots has become an important component of this initiative.

While moss and liverwort can appear during propagation, especially with slower rooting material, it becomes a major problem after rooting where plugs can be held prior to potting, often for extended periods. This can result in cuttings almost becoming smothered by this growth. The problem has increased with the move to plugs, rather than trays for rooting, and with the incorporation of controlled release fertilizers in the rooting media. Difficulties in achieving uniform watering in plugs accelerates the colonisation, particularly if there are empty cells from cutting failure, which remain wetter. While the moss and liverwort is usually cleaned off by hand at potting, it is impossible to remove it all without damaging the root system. Hence inoculum carries over to the liner stage, where it becomes an equally serious problem, especially under overhead irrigation, which remains the system most used in the industry.

Algal or bacterial slime growth can also be a problem during propagation under mist or fog, not only for nozzle blockages and causing pathways to become slippery and a H&S hazard, but also as a slime film over foliage. This hardens and flakes off when cuttings are weaned, but is unsightly, and in extreme cases has caused hardening of foliage and limited new growth. Again it generally occurs over time with slower rooting species, and especially those with rougher or hairy surfaces. (e.g. *Elaeagnus pungens* ‘Maculata’, Evergreen *Azalea* ‘Blue Danube’, *Rhododendron*). There appears to have been an increase in this problem over recent years. Causal agent and source have not yet been identified, though water pipes close to the surface, which often warm up during the summer, may be part of the problem.

Hand cleaning is a time consuming, costly operation, and at point of dispatch nurseries have estimated that one third of the cost of plant preparation for marketing is due to the need to remove moss, liverwort and weeds. This is often accompanied by removal of a significant proportion of the mix, which then needs a remedial topping up. Hence prevention of the problem has major implications for cost savings.

There are very few herbicides/chemicals with approval for use with container nursery stock, particularly under protection, and especially during propagation, where cutting material is at its most sensitive stage of growth. However, a number of chemicals have demonstrated their potential for weed control, particularly moss and liverwort, in the later stages of container production (HNS 35b, HNS 35f), and these were investigated for their efficacy and safety of use during propagation, holding plugs pre-potting, and during the liner phase of growth. Other herbicides, while giving excellent control of moss and liverwort, have proved more phytotoxic (e.g. Diuron), and this was included at lower rates to see if safety of use could be improved without compromising control. A non-chemical method of control was also included (mulch).

The ***objectives*** of the work were, therefore, to develop strategies for cost effective production of quality, clean, weed free young plant material, by examining efficacy and safety of a range of chemicals for slime, moss, liverwort and weed control from propagation through to the liner stages of growth.

The programme of work was done in two phases over a 3 year period:

- Detailed trial work screening a range of chemical / herbicide treatments at the different stages of production was done at HRI Efford in years 1-2

- The best treatments from the detailed programme were then trialled in years 2-3 on three commercial nurseries.

PART 1

1^{ST} YEAR TRIALS AT HRI EFFORD

PART 1: 1st YEAR TRIALS AT HRI EFFORD

A. CONTROL OF SLIME DURING PROPAGATION

Objective

This stage looked specifically at potential of disinfectants, applied through the mist lines, as a means of keeping these lines free of slime problems.

Materials and methods

Cuttings of a range of species were taken in late August 1998, and rooted in QP modular trays, (cell size according to species), under mist in a double skinned polythene tunnel, following a rooting hormone treatment of 1000 ppm Synergol 'quick dip'.

Rooting media was a 50% peat:50% fine pine bark mix with 0.75 kg/m^3 Osmocote 3-4 month mini granules incorporated.

A minimum base temperature of 18^o C was set, but the double clad tunnel was unheated.

A routine fungicide programme was applied every 14 days, comprising a rotation of Rovral (iprodione), Octave (prochloraz), Elvaron (dichlofluanid) and Benlate (benomyl).

Treatments

Species	Evergreen *Azalea* 'Blue Danube'	QP 96 (cell volume 40 mls)
	Cytisus 'Burkwoodii'	QP 150 (cell volume 30 mls)
	Euonymus fortunei 'Silver Queen'	QP 77 (cell volume 55 mls)

Disinfectants

Untreated control

Panacide M (dichlorophen) dosed in tank at 25 ppm

Jet 5 dosed in tank at 25 ppm

Enigma water treatment using the 'Anolyte'* form at a pH around 6.0

*(*Water treatment in which an electrical current is passed through an anode across which water, with small amounts of concentrated saline solution added, is passed to produce an 'anolyte' solution. This has a powerful disinfectant property, and by adjusting the electrical current can be produced over a range of pH values. The Company, Enigma (UK) Ltd., have loaned the Neptune equipment necessary to produce the anolyte for the trial).*

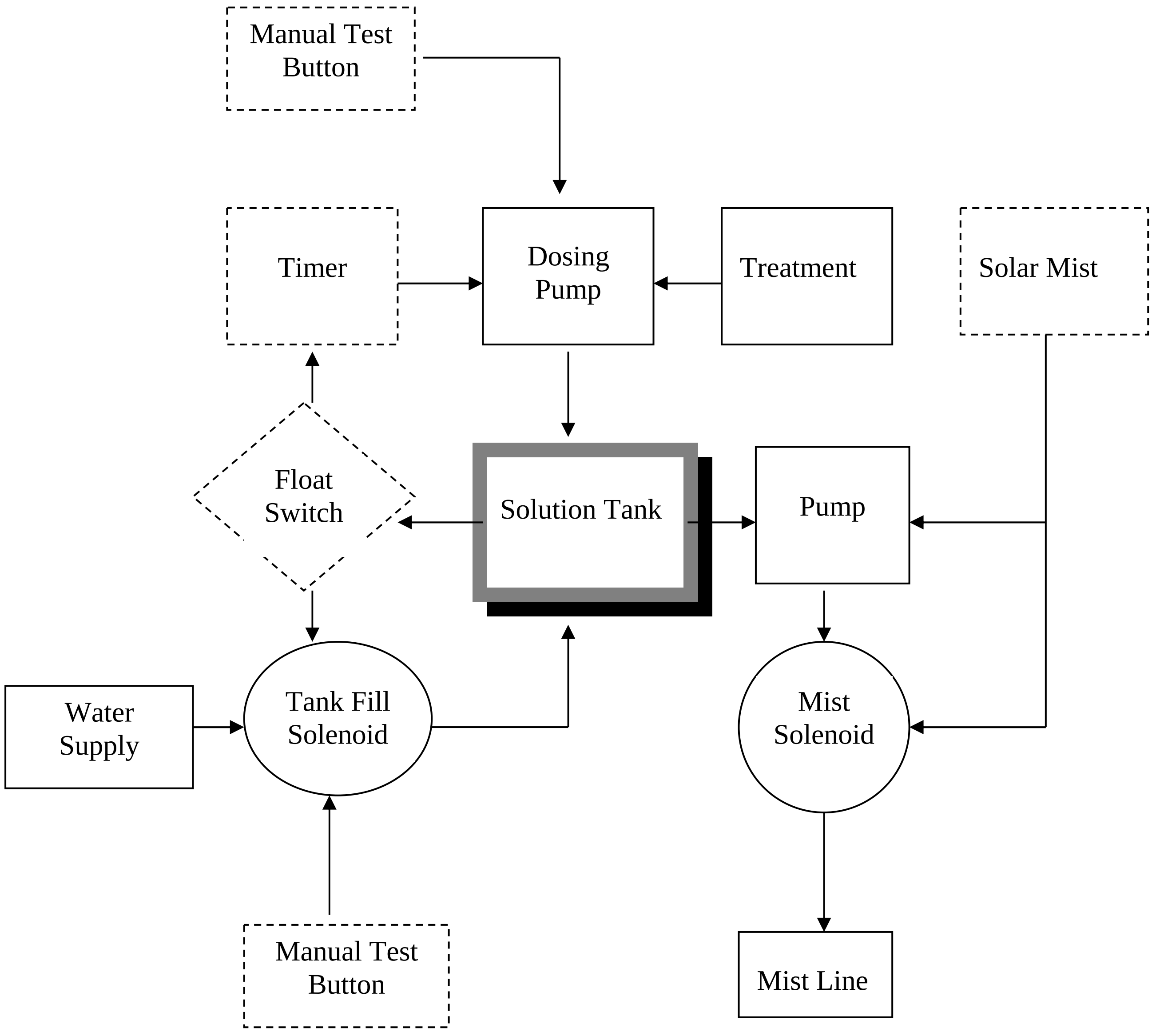
Mogeton spray over cuttings @ 1.4 g/m^2 in 250 mls water every 6 weeks

Treatments were planned to begin at the first signs of slime, moss or liverwort presence.

Method of treatment application

Five independently controlled beds were used for the trial, each with a small tank system supplying the mist line. A dedicated control panel was designed and built by the facilities manager at Efford, Paul Newnham, for the mist line dosing treatments, which also incorporated a number of monitoring stations for daily checking that the dosing was being applied at the correct concentration once calibrated. (see diagram below).

Water Dosing System



Trial Design : Split plot design with unreplicated main plots of disinfectant treatments within which species, with 3 replicates, formed the sub plots, each a modular tray.

Results

This part of the work had been primarily set up to look at the potential of mist line disinfection treatments for control of slime.

However, despite the problems seen with slime build up on cuttings in previous seasons, this year no problems were seen until cuttings were well rooted and due for weaning, when the first signs of slime presence were seen on a few *Euonymus* cuttings. Consequently, there was no opportunity to test treatments 'during propagation', since they were not due to start until the problem occurred. A short test on safety of use of the disinfected water was done by delaying weaning off the mist beds for a month, and no phytotoxicity symptoms were seen with any of the treatments, applied by now over well rooted cuttings.

No moss or liverwort occurred during propagation and therefore Mogeton was not applied

It was originally planned to take the weaned modules through into the plug holding stage with other moss and liverwort control treatments being applied factorially in combination with propagation treatments. However, in the absence of the detailed propagation treatments, this would have just duplicated the second trial looking at plug treatments following rooting, and the decision to stop this trial after the rooting phase was taken.

A further observation was made in August 1999, after sterilisation of the cold water storage tanks was undertaken to conform to the requirements of HS(G)70 – 1993. This was a sterilisation treatment using sodium hypochlorite solution at a minimum level of 50 ppm free chlorine for more than one hour. After this the residual chlorine was neutralised by the addition of Aquatreat TH40 (sodium thiosulphate), and the solution run to waste, before refilling the tank and re-testing for chlorine until levels were comparable to those in the mains water.

A range of late summer species were again struck and rooted under mist following this sterilisation treatment, and no slime (moss or liverwort) were seen on any of this material during propagation.

Discussion

Control of the slime problem could not be effectively assessed in this work due to the previously serious problem suddenly disappearing! Similarly, the safety of use of the various disinfectants for cleaning the mist lines in the presence of cuttings was not addressed, as treatments were not due to start until the slime developed. This would need following up in further work. The requirements for sterilisation of associated water storage tanks under the requirements of the HS(G)70–1993 legislation could also offer another method of general hygiene for control. However, work still needs to be done on its biology and the source(s) of contamination.

B. CONTROL OF MOSS AND LIVERWORT IN PLUGS AFTER PROPAGATION

Objective

To monitor efficacy and safety of a range of chemicals / herbicides and a non chemical treatment for eradication of any moss or liverwort which had developed during propagation under mist, and prevent their colonisation during the plug holding phase pre-potting.

Materials and methods

Cuttings late early September 1998, and rooted in QP modular trays (cell size dependant on species), in a double skinned polythene tunnel, following a rooting hormone treatment of 1000 ppm Synergol ‘quick dip’. Initially rooting was under mist, but converted to low polythene covers in mid November.

Rooting media was a 50% peat : 50% fine pine bark mix with 0.5 kg/m^3 Osmocote 3-4 month mini granules incorporated.

A minimum base temperature of 18ºC was set with mist, 15ºC under the low polythene covers, but the double clad tunnel was unheated.

A routine fungicide programme was applied every 14 days, comprising a rotation of Rovral (iprodione), Octave (prochloraz), Elvaron (dichlofluanid) and Benlate (benomyl).

Following weaning, plug trays were held under cold glass on benching with capillary matting. All watering was by hand.

A weekly liquid feed programme comprising 50:25:50 $N:P_2O_5:K_2O$ was applied following weaning.

Treatments commenced 28 April 1999, with the final record taken 3 September 1999

Treatments

Chemical/herbicide treatments during plug holding stage

a. Untreated control

b. Panacide M (dichlorophen) @ 2.5 mls/m^2 every 6 weeks

c. Mogeton @ 1.4 g/m^2 every 6 weeks

d. Diuron @ 0.025 g/m^2 every 6 weeks

e. Ronstar 2G (oxadiazon) @ 20.0 g/m^2

f. Bravo (chlorothalonil) @ 0.75 g/m^2 every 3 weeks (industry standard)

g. 0.5 cm pine bark mulch (Cambark 100) to *Cytisus* only

h. Enigma ‘Anolyte’* water spray every 6 weeks to *Azalea* and *Euonymus* only

i. Jet 5 @ 25 ppm every 6 weeks to *Azalea* and *Euonymus* only

(Water treatment in which an electrical current is passed through an anode, across which water with small amounts of concentrated saline solution added, is passed to produce an ‘anolyte’ solution. This has a powerful disinfectant property, and by adjusting the electrical current can be produced over a range of pH values. The Company, Enigma (UK) Ltd., have loaned the Neptune equipment necessary to produce the anolyte for the trial).*

All sprays were applied overall in 250 mls water/m^2. Granules were applied in an equal volume of fine sand and knocked off foliage after application.

Species	Evergreen *Azalea* ‘Blue Danube’	QP 96 (cell volume 40 mls)
	Cytisus 'Burkwoodii'	QP 150 (cell volume 30 mls)
	Euonymus fortunei ‘Silver Queen’	QP 77 (cell volume 55 mls)

Trial Design : Randomised block design with 3 replicates. 69 plots in total.

Plot = QP tray.

Records

1. Percentage moss and liverwort cover per plot (tray) at 6 week intervals prior to application of each treatment.

2. Cutting growth by end of the trial

   i. Size score on a scale of 1-5, with 5 the largest, based on cutting length. Cuttings visually scored against selected standards. Actual height of the material used for the visual scoring :

		Azalea	*Cytisus*
Score	1	9.5 cm	19.0 cm
	2	11.0 cm	22.5 cm
	3	12.5 cm	29.0 cm
	4	15.0 cm	34.5 cm
	5	17.0 cm	44.5 cm

ii. Colour score of foliage on a scale of 1-5, with 5 the darkest

iii. Assessment of whether any root damage had occurred.

iv. Photographs as appropriate

Statistical analysis

Results were analysed using the Standard Analysis of variance (ANOVA).

Least significant difference to 5%, on which the significance tests were based, are presented in the tables to aid interpretation of the results.

Results

Moss and Liverwort control (Tables 1 and 2)

Both moss and liverwort occurred in similar quantities in this trial, with greatest colonisation on *Cytisus* where foliage canopy was less. Overall, around 50% of tray cover occurred with both moss and liverwort on *Cytisus*, against 20-30% cover on *Azalea* and *Euonymus.*

Both Panacide M and Mogeton had prevented all but a trace (<5%) of liverwort establishing, as had Diuron. Bravo was less effective, for while giving an initial check to colonisation, it had increased by August with around 15% cover present in the *Azalea* and *Euonymus* and approaching 30% in the *Cytisus.*

In this work Bravo appeared more effective against moss than liverwort, giving as good a result as Panacide M and Mogeton with *Azalea* and *Euonymus*, and while moss appeared to be establishing in *Cytisus* in the early part of the trial it had virtually disappeared by August.

The Enigma 'Anolyte' and Jet 5 treatments had only been applied to the *Azalea* and *Euonymus*, and neither appeared effective in controlling moss or liverwort compared to the untreated control.

The bark mulch applied to *Cytisus* proved most effective against moss, but liverwort was starting to appear mid way through the trial.

Phytotoxicity

Some paling of *Cytisus* foliage was noticeable after the application of Mogeton, and this effect intensified as number of applications increased. With *Azalea* some foliage scorch occurred after the second application of Diuron and *Cytisus* were showing less vigour.

The white deposits from Bravo and orange deposits from Mogeton applications were noticeable.

Growth by the end of the trial (3 September 1999) (Table3 and 4)

With both *Azalea* and *Cytisus* Diuron had reduced cutting growth, and some *Cytisus* deaths had occurred. This reduction in growth was not only observed as a smaller size score, but also a significant reduction in dry weight.

Use of Jet 5 and Enigma 'Anolyte' on *Azalea* also appeared to have reduced cutting size to some extent, though this was not reflected in the dry weight data, suggesting smaller, but stockier, cuttings were produced.

Root growth did not appear to have been affected by treatments.

However, Mogeton treated foliage was paler than the other treatments, significantly so on *Cytisus.*

The bark mulch treatment was also significantly paler on *Cytisus*, possible due to a nitrogen draw down effect from the matured pine bark.

While the trial completed in early September 1999, cuttings were held until November for demonstration purposes at various events, by which time treatment effects had become more pronounced. By November Diuron was still providing almost full control of moss and liverwort from the final treatment application in late July, but by now all the cuttings of *Cytisus* and *Azalea* were also dead ! The paling of the foliage as a result of Mogeton application was also more evident.

Results with *Euonymus* were extremely variable, with a proportion of the cuttings failing to develop new growth. Consequently a record of proportion of cuttings in different quality categories was taken, ranging from dead, through poor, to satisfactory and excellent (Table 4), to see if this was the result of treatment. As with both *Azalea* and *Cytisus* there was a trend of poorer cuttings in the Diuron treatment, where there was the highest proportion of dead–poor cuttings and thus lowest in the satisfactory–excellent categories

Table 1 **Plugs - Percentage Moss cover per tray (1999)**

	Azalea			***Cytisus***			***Euonymus***		
	3 Jun	**9 Jul**	**13 Aug**	**3 Jun**	**9 Jul**	**13 Aug**	**3 Jun**	**9 Jul**	**13 Aug**
Untreated	23	25	32	50	47	53	13	17	32
Panacide M	4	4	3	17	11	0	4	6	1
Mogeton	4	4	1	17	0	0	9	2	1
Diuron	6	7	2	1	13	15	1	1	0
Ronstar 2G	8	6	3	8	3	0	7	7	2
Bravo	1	3	2	18	17	1	1	1	1
Jet 5	13	18	27	-	-	-	3	10	27
Enigma Anolyte	10	22	37	-	-	-	2	13	42
Bark Mulch	-	-	-	1	1	1	-	-	-
LSD 5%	*15.2*	*18.8*	*19.9*	*28.3*	*23.2*	*20.8*	*6.8*	*3.9*	*18.3*

Table 2 **Plugs - Percentage Liverwort cover per tray (1999)**

	Azalea			*Cytisus*			*Euonymus*		
	3 Jun	**9 Jul**	**13 Aug**	**3 Jun**	**9 Jul**	**13 Aug**	**3 Jun**	**9 Jul**	**13 Aug**
Untreated	8	18	23	23	30	45	7	10	27
Panacide M	2	2	1	5	8	2	3	5	1
Mogeton	4	3	1	1	0	0	1	2	1
Diuron	2	2	1	0	2	2	1	0	0
Ronstar 2G	2	1	0	5	5	1	6	8	15
Bravo	5	6	14	8	13	28	7	10	14
Jet 5	2	4	10	-	-	-	2	4	11
Enigma Anolyte	2	4	11	-	-	-	2	4	13
Bark Mulch	-	-	-	3	13	20	-	-	-
LSD 5%	*3.5*	*12.3*	*16.6*	*11.6*	*17.0*	*24.3*	*5.8*	*5.1*	*11.1*

Table 3 **Plugs - Cutting growth by end of trial (3 September 1999)**

	Size score (1-5)*	Colour score (1-5)**	% Root cover over plug	Cutting top dry weight (g)
Azalea				
Untreated	3.7	2.9	87	0.808
Panacide M	3.6	3.5	85	0.803
Mogeton	3.3	2.5	84	0.749
Diuron	2.7	3.7	83	0.401
Ronstar 2G	3.2	3.1	83	0.930
Bravo	3.8	2.9	86	0.829
Jet 5	3.1	2.6	87	0.746
Enigma Anolyte	2.7	3.4	88	0.688
LSD 5%	*0.58*	*0.68*	*5.9*	*0.178*
Cytisus				
Untreated	3.2	4.2	72	0.362
Panacide M	3.5	3.8	72	0.379
Mogeton	2.3	2.7	70	0.343
Diuron	3.1	4.3	61	0.266 (9 dead)
Ronstar 2G	3.1	3.3	71	0.357
Bravo	3.4	4.5	72	0.396
Bark Mulch	3.0	3.0	64	0.429
LSD 5%	*0.69*	*0.92*	*9.0*	*0.0951*

Size score = 1-5, with 5 the largest, based on cutting length, visually scored against selected standards

** Colour Score: 1-5, with 5 the darkest, scored visually against selected standards

Table 4 Euonymus plugs: Quality of cutting growth by 3 September 1999

Key: 0 = Dead
1 = Poor (no new growth)
3 = Satisfactory (some new growth occurring)
5 = Excellent (mass of new growth occurring)

	% cuttings in each category			
	0	**1**	**3**	**5**
Untreated	3	8	86	3
Panacide M	6	9	75	10
Mogeton	5	13	80	2
Diuron	27	21	52	0
Ronstar 2G	10	13	77	0
Bravo	6	10	69	15
Jet 5	1	9	70	20
Enigma Anolyte	0	14	66	20

Discussion

Overall, Panacide M proved one of the more effective and safest treatments to use in the plug holding stage for control of both moss and liverwort across a range of species. Diuron, while proving the best treatment for controlling the moss and liverwort was too phytotoxic, even at the half rate used compared with the rate used on 3 litre containers. Mogeton, while providing effective control, had an adverse effect on the colour of *Cytisus*, and further screening across a wider range of species is required to check its safety of use at this stage of growth. It must also be remembered that Mogeton does not yet have a label approval for use over plants, only for cleaning hard surfaces such as pathways. The other treatments, while giving some check to establishment of moss and liverwort were not as effective as Panacide M.

Originally, this trial had been designed to pot on the plug treatments and follow them through the liner stage in combination with a number of specific liner herbicide treatments, since while moss and liverwort were still serious problems in this stage, control of weeds also needed attention. However, it was felt that with the variability in cutting material from the plug stage, adverse effects of some treatments, and subsequent continued deterioration of some of the material following the end of the trial, there could be difficulties in sorting out and interpreting results from the liner stage itself. Consequently it was decided to terminate the plug trial pre-potting and start a separate liner trial using the untreated cuttings from the plug trial, as well as buying in plugs of other species to extend the range for phytotoxicity testing.

The possible interaction of plug treatments on subsequent liner growth, and any interaction with treatments applied at this stage, was considered in more detail in the later commercial trialling.

C. CONTROL OF MOSS, LIVERWORT AND WEEDS IN THE LINER STAGE

Objective

To examine the efficacy and safety of a range of chemical/herbicide treatments for aiding the development of weed control strategies for liners grown under protection, particularly over the autumn/winter period when moss and liverwort problems increase.

Materials and methods

Rooted plugs of a range of species, which had been potted into 90 mm pots at various times during the year in a peat based mix incorporating Osmocote Plus 12-14 months Autumn formulation, were cleaned of any weeds and grown on under a polythene roof/netting sided twin span tunnel on drained Efford Sandbeds.

Treatments

Species

Evergreen *Azalea* ‘Blue Danube’
Cistus ‘Silver Pink’
Cotoneaster conspicuus
Cytisus 'Burkwoodii'
Euonymus fortunei ‘Silver Queen’
Magnolia soulangeana ‘Rustica Rubra’
Prunus lusitanica
Chamaecyparis lawsoniana ‘Columnaris Glauca’

Chemical/herbicide treatments

a. Untreated control

b. Panacide M (dichlorophen) @ 2.5 mls/m^2

c. Mogeton @ 1.4 g/m^2

d. Ronstar 2G (oxadiazon) @ 20.0 g/m^2

e. Axit GR (isoxaben + trifluralin) @ 10.0 g/m^2

f Lenacil 80 W @ 0.15 g/m^2

f. Diuron @ 0.025 ml/m^2

All sprays applied in 250 mls water/m^2. Granules wereapplied in an equal volume of fine sand to aid distribution.

Treatments were applied every 12 weeks, except Panacide M, which was applied at 6 week intervals. The first treatments were applied 3 October 2000, the final on 12 April 2001.

In all 5 sprays of Panacide M were applied, 3 for those with a 12 week interval between applications.

Trial Design : Randomised block design with 3 replicates, and 10 plants/plot (5 for *Magnolia*).

Records

1. Percentage of pots with moss present and severity of infestation after the winter (February/March 2001).

2. Percentage of pots with liverwort present and severity of infestation after the winter (February/March 2001).

3. Percentage of pots with moss present and severity of infestation after the growing season (August 2001)

4. Percentage of pots with liverwort present and severity of infestation after the growing season (August 2001).

5. Plant growth at the end of the trial (August 2001)

   a. Plant height (cm)
   b. Plant dry weight (g)

6. Photographs as appropriate

Statistical analysis

Results were analysed using the Standard Analysis of variance (ANOVA).

Least significant difference to 5%, on which the significance tests were based, are presented in the tables to aid interpretation of the results.

Results

Moss control (Table 5-6)

Effects of season : Despite the fact that plants in this trial were on a drained sand bed, which would have helped maintain the pot drier, there was a gradual build up of moss over the winter period, and by March 2001, a large proportion of some species had over 50% of the pot covered. However, over the subsequent growing season amount of moss present actually reduced with the majority of species having less than 30% cover by the following August. This in part would be due to maintaining an irrigation regime on the drier, rather than wetter side, as well as the interaction with the drained sand bed standing base, and rapid plant growth at this time of year, reducing the conditions favouring moss establishment.

Effects of species : As was to be expected, species with the least foliage canopy over the pot surface had the greatest incidence of moss present. These included *Cytisus*, *Magnolia* and the conifer. In fact the build up of moss on the dormant *Magnolia* over the winter was the only case where there was no reduction of moss over the growing season.

Effects of treatment : Panacide M provided a somewhat better control of moss in this trial than Mogeton, along with Diuron and Lenacil 80 W. Panacide M, though, was applied every 6 weeks compared to the 12 week intervals between Mogeton applications. There was also evidence of an initial check to moss colonisation where Axit GR and Ronstar 2G were used, though its presence had begun to build up in these treatments by March.

Liverwort control (Table 7)

Moss was the main problem in this trial, with little or no liverwort establishing. Consequently, treatments could not be assessed for its control. However, based on previous experience, the most effective moss treatments should also prevent liverwort, and of the two, liverwort has generally proved the easier to control.

Plant growth at end of trial (August 2001) (Table 8)

A sample of 5 plants/plot were taken to assess growth and any phytotoxicity at the end of the trial in August 2001, this being considered the end of the effective control period from the final application of treatments in April 2001. Both extension growth (height of the plant) and dry weight were measured.

Cytisus, Euonymus and *Chamaecyparis lawsoniana* ‘Columnaris Glauca’ appeared sensitive to Diuron, with height significantly reduced compared with the untreated control. With most of these species there was also a trend for dry weight reduction where Diuron had been applied, though this did not prove to be statistically significant.

There was an indication that *Euonymus* could be sensitive to Lenacil 80 W.

Overall both Panacide M and Mogeton appeared safe over the majority of species in the trial as did the two granular herbicides, but this will need confirmation with further work and across a wider range of species.

Table 5 **Liners - Overall efficacy of treatments against moss**

(figures are averaged across species, with 10 plants/plot (5 for *Magnolia*) x 3 reps)

Key: Severity of infestation
0 = None present
1 = < 10% pot cover
3 = 10-30% pot cover
5 = > 50% pot cover

	Number of pots infested by:			**Severity of infestation by:**		
Treatment	**2 Feb**	**29 Mar**	**20 Aug 2001**	**2 Feb**	**29 Mar**	**20 Aug 2001**
Untreated	6.8	8.3	4.9	2.34	3.50	2.13
Panacide M	1.4	2.5	1.0	2.34	0.75	0.46
Mogeton	1.3	5.7	1.8	2.34	1.38	0.79
Diuron	2.6	2.8	0.1	2.34	0.96	0.17
Lenacil 80 W	1.0	1.4	0.5	2.34	0.50	0.21
Axit GR	2.6	5.3	2.0	2.33	1.33	0.63
Ronstar 2G	3.4	6.9	1.6	2.34	2.00	0.75
LSD 5%	*0.96*	*1.03*	*0.85*	*0.011*	*0.312*	*0.407*

Table 6 Liners - Percentage of pots with Moss present and severity of infestation

(figures are based on 30 plants/treatment, 15 for *Magnolia*)

Key: Severity of infestation
0 = None present
1 = < 10% pot cover
3 = 10-30% pot cover
5 = > 50% pot cover

	By 2 Feb 2001				29 Mar 2001				By 20 Aug 2001			
	0	1	3	5	0	1	3	5	0	1	3	5
Untreated												
Azalea	30	70	0	0	13	27	60	0	87	3	10	0
Cistus	87	13	0	0	60	13	27	0	97	3	0	0
Cotoneaster	23	57	17	3	3	0	97	0	43	27	30	0
Cytisus	7	23	37	33	3	0	0	97	17	0	83	0
Euonymus	30	57	0	13	10	0	33	57	63	10	27	0
Magnolia	0	27	47	26	0	0	0	100	0	0	0	100
Prunus	77	23	0	0	60	40	0	0	90	10	0	0
***C. l.* 'Glauca'**	3	20	27	0	0	0	0	100	10	0	90	0
Mean	32.1	36.3	16.0	50.0	18.6	10.0	27.1	44.3	50.9	6.6	30.0	12.5
Panacide M												
Azalea	87	13	0	0	80	20	0	0	100	0	0	0
Cistus	100	0	0	0	97	3	0	0	100	0	0	0
Cotoneaster	67	33	0	0	57	43	0	0	93	7	0	0
Cytisus	70	30	0	0	67	33	0	0	100	0	0	0
Euonymus	100	0	0	0	67	33	0	0	70	23	7	0
Magnolia	80	20	0	0	67	33	0	0	66	7	27	0
Prunus	100	0	0	0	93	7	0	0	100	0	0	0
***C. l.* 'Glauca'**	83	17	0	0	70	30	0	0	93	7	0	0
Mean	85.9	14.1	0	0	74.8	25.2	0	0	90.3	5.5	4.2	0
Mogeton												
Azalea	87	13	0	0	30	70	0	0	100	0	0	0
Cistus	80	17	3	0	53	47	0	0	97	3	0	0
Cotoneaster	77	23	0	0	53	47	0	0	93	7	0	0
Cytisus	97	3	0	0	36	47	17	0	100	0	0	0
Euonymus	90	10	0	0	26	7	67	0	67	0	33	0
Magnolia	100	0	0	0	27	73	0	0	40	40	20	0
Prunus	100	0	0	0	73	27	0	0	100	0	0	0
***C. l.* 'Glauca'**	63	37	0	0	20	0	80	0	53	47	0	0
Mean	86.7	12.9	0.4	0	39.8	39.7	20.5	0	81.3	12.1	6.6	0
Diuron												
Azalea	67	33	0	0	77	23	0	0	100	0	0	0
Cistus	87	10	3	0	67	33	0	0	100	0	0	0
Cotoneaster	73	20	7	0	77	23	0	0	100	0	0	0
Cytisus	57	43	0	0	57	43	0	0	100	0	0	0
Euonymus	83	17	0	0	67	33	0	0	90	3	7	0
Magnolia	40	53	7	0	67	33	0	0	100	0	0	0
Prunus	100	0	0	0	80	20	0	0	100	0	0	0
***C. l.* 'Glauca'**	83	17	0	0	87	13	0	0	100	0	0	0
Mean	73.8	24.1	2.1	0	72.4	27.6	0	0	98.7	0.4	0.9	0

Table 6 Cont'd. Liners - Percentage of pots with Moss present and severity of infestation
(figures are based on 30 plants/treatment)

	By 2 Feb 2001				29 Mar 2001				By 20 Aug 2001			
	0	**1**	**3**	**5**	**0**	**1**	**3**	**5**	**0**	**1**	**3**	**5**
Lenacil 80 W												
Azalea	80	20	0	0	67	33	0	0	100	0	0	0
Cistus	93	7	0	0	80	20	0	0	100	0	0	0
Cotoneaster	93	7	0	0	93	7	0	0	100	0	0	0
Cytisus	93	7	0	0	87	13	0	0	100	0	0	0
Euonymus	87	13	0	0	77	23	0	0	77	13	10	0
Magnolia	100	0	0	0	87	13	0	0	87	13	0	0
Prunus	100	0	0	0	100	0	0	0	100	0	0	0
***C. l.* 'Glauca'**	100	0	0	0	100	0	0	0	100	0	0	0
Mean	93.3	6.7	0	0	77.4	13.6	0	0	95.5	3.3	1.2	0
Axit GR												
Azalea	73	27	0	0	43	57	0	0	100	0	0	0
Cistus	90	7	3	0	77	23	0	0	100	0	0	0
Cotoneaster	90	10	0	0	30	40	30	0	93	7	0	0
Cytisus	43	57	0	0	40	60	0	0	93	0	7	0
Euonymus	97	3	0	0	54	23	23	0	77	13	10	0
Magnolia	67	27	6	0	70	30	0	0	13	87	0	0
Prunus	100	0	0	0	83	17	0	0	97	3	0	0
***C. l.* 'Glauca'**	33	54	13	0	6	27	67	0	67	33	0	0
Mean	74.1	23.1	2.8	0	50.4	34.6	15.0	0	80.0	17.9	2.1	0
Ronstar 2G												
Azalea	60	40	0	0	27	73	0	0	100	0	0	0
Cistus	93	7	0	0	77	23	0	0	100	0	0	0
Cotoneaster	50	47	3	0	23	0	77	0	87	13	0	0
Cytisus	47	37	16	0	17	0	83	0	77	23	0	0
Euonymus	87	13	0	0	23	27	50	0	73	7	20	0
Magnolia	73	27	0	0	13	87	0	0	53	0	47	0
Prunus	93	7	0	0	67	33	0	0	100	0	0	0
***C. l.* 'Glauca'**	27	57	16	0	0	0	67	0	80	20	0	0
Mean	66.2	29.4	4.4	0	30.9	30.4	34.6	33.0	83.7	7.9	8.4	0
Overall Summary												
Untreated	32	36	16	15	19	10	27	44	51	7	30	12
Panacide M	86	14	0	0	75	25	0	0	90	6	4	0
Mogeton	87	13	0	0	40	40	20	0	81	12	7	0
Diuron	74	24	2	0	72	28	0	0	99	0	1	0
Lenacil 80 W	93	7	0	0	77	23	0	0	96	3	1	0
Axit GR	74	23	3	0	50	35	15	0	80	18	2	0
Ronstar 2G	66	29	4	0	31	30	35	4	84	8	8	0

Table 7 Liners - Percentage of pots with liverwort present and severity of infestation
(figures are averaged across species, based on 225 plants/treatment)

Key: Severity of infestation 0 = None present
1 = < 10% pot cover
3 = 10-30% pot cover
5 = > 50% pot cover

	By 2 Feb 2001				29 Mar 2001				By 20 Aug 2001			
	0	**1**	**3**	**5**	**0**	**1**	**3**	**5**	**0**	**1**	**3**	**5**
Overall Summary												
Untreated	99	1	0	0	84	11	4	1	92	3	3	2
Panacide M	98	1	0	1	99	1	0	0	100	0	0	0
Mogeton	99	1	0	0	100	0	0	0	99	1	1	0
Diuron	100	0	0	0	99	1	0	0	100	0	0	0
Lenacil 80 W	100	0	0	0	100	0	0	0	100	0	0	0
Axit GR	99	1	0	0	99	1	0	0	98	1	1	0
Ronstar 2G	98	2	0	0	96	3	1	0	95	2	2	1

Table 8 **Liners - Plant growth at end of trial (20 August 2001)**

(figures are a mean of 5 plants/plot x 3 replicates)

	Azalea	*Cistus*	*Cotoneaster*	*Cytisus*	*Euonymus*	*Magnolia*	*Prunus*	*C. l.* **Glauca**
Plant Height (cm)								
Untreated	27.2	35.7	54.3	98.4	18.8	61.8	43.7	42.5
Panacide M	34.4	36.7	46.3	91.8	17.4	71.3	43.7	38.0
Mogeton	30.8	40.7	54.2	99.3	18.2	66.3	45.5	39.4
Diuron	34.6	38.0	29.4	86.2	15.2	62.2	51.8	29.7
Lenacil 80 W	32.9	37.4	54.7	93.7	15.0	66.6	45.6	32.4
Axit GR	31.9	35.1	49.4	97.7	18.2	68.6	46.0	37.3
Ronstar 2G	32.0	40.1	52.9	95.0	17.9	74.9	48.3	35.5
LSD 5% = 10.43								
Plant Dry Weight (g)								
Untreated	7.77	9.58	15.26	12.25	6.34	12.38	15.91	14.41
Panacide M	7.30	10.72	16.46	10.68	5.42	14.00	14.69	11.88
Mogeton	7.19	10.93	15.05	13.64	4.95	13.10	18.51	13.05
Diuron	9.44	12.21	14.32	9.86	3.64	11.52	17.05	10.87
Lenacil 80 W	7.81	10.34	18.96	13.22	3.41	13.76	18.28	12.57
Axit GR	7.88	10.60	17.54	12.72	6.80	13.96	18.08	13.06
Ronstar 2G	7.64	14.11	14.09	13.23	6.05	13.95	17.07	12.50
LSD 5% = 3.893								

Discussion

While levels of moss developing in the trial were not excessive there was no doubt of the increased build up over the winter, particularly in the deciduous species (*Magnolia*) where the growing media would remain wetter than the evergreens or conifers. While Panacide M and Mogeton gave satisfactory control of the moss problem, they would not provide weed control, and it was, therefore, encouraging that the herbicide Lenacil 80 W also gave excellent control of moss. There was concern over its safety of use, *Euonymus* appearing sensitive to it in this work, and further screening is required to gauge its potential for this purpose. It has no label approval for use on any crops under protection, so could not be used under the ‘off label approval scheme’. As expected the granules were less effective, overall, in preventing establishment of moss and would need using as part of a weed control strategy in conjunction with other chemicals.

Summary of Efford work

The best results from the Efford programme were taken forward for commercial trialling on three nurseries. While not all the work in the Efford programme was completed before the start of the commercial trialling, the potential of various treatments was obvious, enabling selection of the more promising treatments for moss, liverwort and weed control at both the plug holding and liner stages of growth. These included :

Plug holding stage :	Panacide M Mogeton Ronstar 2G Diuron (at half the rate used in the Efford work to see if it would still give adequate control with improved safety).
Liner stage	Panacide M Mogeton Lenacil 80 W Axit GR Ronstar 2G

The frequency of application was every 6 weeks for Panacide M and Mogeton, every 12 weeks for Lenacil 80 W, Axit GR and Ronstar 2G.

PART 2

Year 2: COMMERCIAL TRIALS

PART 2: 2nd YEAR TRIALS ON COMMERCIAL NURSERIES

Materials and methods

Three members of the ALP Group agreed to host the commercial trials, namely

- Hewton Nursery, Devon
- New Place Nurseries, Sussex
- Northern Liners, Lancashire

These sites offered the opportunity to see if geographical location and different nursery practices would influence results. All sites produce liners under glass with overhead irrigation. Results from these nurseries have been presented under code as Site A, Site B and Site C.

The main cultural practices on these nurseries are presented in the following tables :

a. Nursery irrigation and water application systems

APPLICATION SYSTEM	NURSERIES		
	A	**B**	**C**
Water Supply			
Mains	3	3	3
Re-cycled		3	
Sand filtered		3	
Overhead Irrigation			
Type			
Blue Pin Jet	3	3	
Browning 500			3
Spin Jets		3	3
Automatic Application approx.			
Summer - Rate per m^2/week	6.0	6.0	
Autumn - Rate per m^2/week	3.0		
Winter - Rate per m^2/week	2.0		
Spring - Rate per m^2/week	5.0		

Note: Nursery A had an automated fixed application regime dependant on season.

Nursery B hand watered in winter only.

Nursery C managed a dry regime by regular manipulation of control equipment.

All nurseries watered by hand as necessary. However, Nursery C allowed their pots to dry out further before watering than either Nursery A or B.

b. Growing media

APPLICATION SYSTEM	**NURSERIES**		
	A	**B**	**C**
Peat			
Vapo	60		60
Irish			20
Bulrush		75	
Humex	40		
Composted Bark			
Pine (Singleton)			20
Melcourt			
SHL		25	
Nutrition 'Dibble' method	3	3	3
CRF Used			
Osmocote		3	3
Ficote			
Wetting Agent	3		3

c. Standing base

SYSTEM	NURSERIES		
	A	B	C
Standing Base - Plugs			
Sand bed with Mypex cover	3	3	3
Standing Base - Liners			
Sand bed with Mypex cover		3	
Mypex over soil	3		3
Moss and Liverwort			
Hygiene - Between batches of plugs and liners			
Brushed Mypex	3	3	3
Surface sterilised with:			
Panacide M	3		3
Jet 5		3	
Jeyes Fluid		3	

d. General hygiene husbandry

APPLICATION SYSTEM	NURSERIES		
	A	B	C
Herbicide applications to Liner standing base			
Jeyes Fluid		3	3
Panacide M	3		
Gramoxone, PDQ, Parable	3		
Flexidor 125	3		3
Axit GR on edges	3		
Ronstar 2G on edges			
Ronstar Liquid at edges		3	
Crop grouping			
Group 'dry' plants		3	3
As space is available	3	3	
Cleaning of plugs at potting			
All plugs cleaned by hand at potting		3	3
Rely on herbicide treatment	3		

Note: Elements of moss left behind in fabric sides of plugs.
Because of the scale of the trial (5 plug treatments x 6 liner treatments x 2 replicate blocks), considerable numbers of cuttings were required, and this limited choice within each nursery. Consequently, only one species was common to 2 nurseries (*Hypericum tricolor).* However, this did mean that between the 3 nurseries, each with 5 species in the trial, 14 species were included overall.

The commercial trials were managed jointly by ADAS (David Hutchinson), HRI Efford (Margaret Scott/Sarah Williams), and liaison / trial management staff on each nursery (Steve Watson, Hewton Nursery, Mark Pearce, New Place Nurseries and Chris Connah, Northern Liners). Plant selection, setting up the plug work, potting on and liner layout, plus assessments included the whole team, with trial management and treatment applications looked after by the nursery staff (sites A and B) or a local ex ADAS consultant (Site C).

The final samples for destructive analysis were brought back to Efford for recording.

Treatments

Species	***Site A***	*Berberis thunbergii* 'Aurea'
		Euonymus fortunei 'Harlequin'
		Forsythia intermedia 'Golden Times'
		Hypericum moserianum 'Tricolor'
		Pyracantha coccinea 'Red Column'
	Site B	*Camellia japonica* 'Brushfields Yellow'
		Choisya ternata 'Sundance'
		Elaeagnus pungens 'Maculata'
		Ilex aquifolium 'Ferrox Argentea'
		Magnolia stellata
	Site C	*Ceanothus* 'Yankee Point'
		Cotoneaster horizontalis
		Hebe albicans 'Red Edge'
		Hypericum moserianum 'Tricolor'
		Pernettya mucronatum

Chemical/herbicide treatments

Plug stage

1. Untreated control
2. Panacide M (dichlorophen) @ 2.5 mls/m^2
3. Mogeton @ 1.4 g/m^2
4. Ronstar 2G (oxadiazon) @ 20.0 g/m^2
5. Diuron @ 0.0125 g/m^2

Liner Stage

1. Untreated control
2. Panacide M @ 2.5 mls/m^2
3. Mogeton @ 1.4 g/m^2
4. Lenacil 80 W @ 0.15 g/m^2
5. Axit GR (isoxaben + trifluralin) @ 10.0 g/m^2
6. Ronstar 2G @ 20.0 g/m^2

These were combined factorially to give 30 treatments initially (5 plug x 6 liner treatments), reducing to 25 when Diuron was dropped at the end of the plug stage.

Panacide M and Mogeton were applied every 6 weeks, Lenacil 80 W, Axit GR and Ronstar 2G every 12 weeks.

The trial was set up in early May 2000, with plug treatments assessed and potted on for the liner phase in early July 2000. Potting media were each nurseries standard mix. Prior to potting each plug was cleaned as best it could be of existing moss and liverwort growth, but inevitably some debris was carried over into the liners, especially where it had grown into the plug wrapping.

The trial completed June 2001, during which time 4 assessments of trial progress on each nursery were made. The Gantt chart in Figure 1 summarises the trial schedule, including treatment applications and plant assessments.

Trial design : Randomised block design with two replicates.

Plot : Plugs – 104 modular tray (84 with a few species)
Liners – Empot tray with 20 plants

Assessments

Plug stage (Assessment 1, July 2000)

1. Percentage moss and liverwort cover over tray prior to potting.
2. Note any phytotoxicity symptoms
3. Sample of 5 plugs / plot to be taken back to Efford for assessment
   i. Size score1-5, with 5 the largest. Visually assessed against selected samples for each score.
   ii. Percentage root development over surface of plug
   iii. Number of weeds present / plot by species
   iv. Note of any phytotoxicity
   v. Photographs as appropriate

Assessment 2 (November 2001)

1. Number of pots / plot (20) with moss and liverwort present, plus severity of infestation on a scale of 0-5, (0=Nil, 1~10%, 3~30%, 5~50%).
2. Number of weeds present / plot (20) by species
3. Note of any phytotoxicity symptoms
4. Photographs as appropriate

Assessment 3 (March 2001)

1. Number of pots / plot (20) with moss and liverwort present, plus severity of infestation on a scale of 0-5, (0=Nil, 1~10%, 3~30%, 5~50%).
2. Number of weeds present / plot (20) by species
3. Note of any phytotoxicity symptoms
4. Photographs as appropriate

Assessment 4 (June 2001)

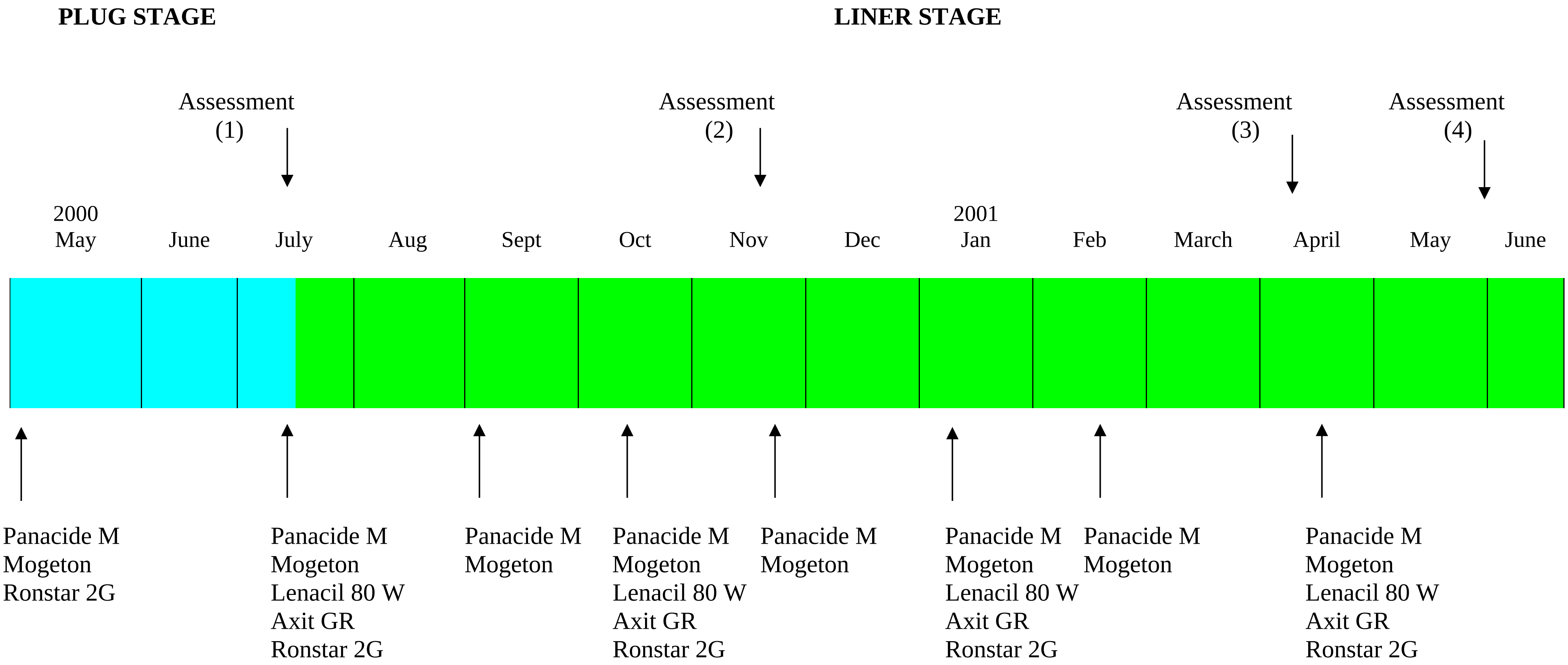
1. Number of pots / plot (20) with moss and liverwort present, plus severity of infestation on a scale of 0-5, (0=Nil, 1~10%, 3~30%, 5~50%).
2. Number of weeds present / plot (20) by species
3. Note of any phytotoxicity symptoms
4. Sample of 5 plants / plot taken back to Efford for destructive assessment
   i. Size score on a scale of 1-5, 5 being the largest
   ii. Root assessment - % cover over pot ball
   iii. Bulk dry weight of plants (g)
5. Photographs as appropriate

Statistical analysis

Results were analysed using the Standard Analysis of Variance (ANOVA).

Least significant difference to 5%, on which the significance tests were based, are presented in the tables to aid interpretation of the results.

Figure 1 **Commercial Trials: Year 2 - Schedule**



Results

General nursery weed pressure

This was obtained from plots left untreated at both the plug and liner stages (UU). This is not the standard for the nurseries, since each had its own weed control programme applied routinely. It did, however, provide an estimate of the background weed pressure on each site, and gave a revealing insight as to how the different cultural practices on each nursery was influencing the severity of weed problems.

Figure 2 shows that Site A had a much higher background weed pressure than Site C, and while it appeared that Site B had the highest number of pots with moss and liverwort present, the actual levels of each were considerably lower than Site A.

Similarly the number of weeds occurring over the period of the trial was considerably lower on Site B and C than on Site A.

The main difference between the nurseries appeared to be their irrigation management, with Site A maintaining a much wetter regime than Site C, with Site B in-between. Although all the nurseries had overhead irrigation, different management regimes were in place on each.

Site A was fully automated for both the growing season and winter, though level of water applied in the winter was reduced. The irrigation was managed to ensure that the crops did not run the risk of drying out.

Site B also had automated control for the growing season, backed up by additional hand watering as necessary, particularly to the sides and ends of the beds, with spot watering by hand during the winter.

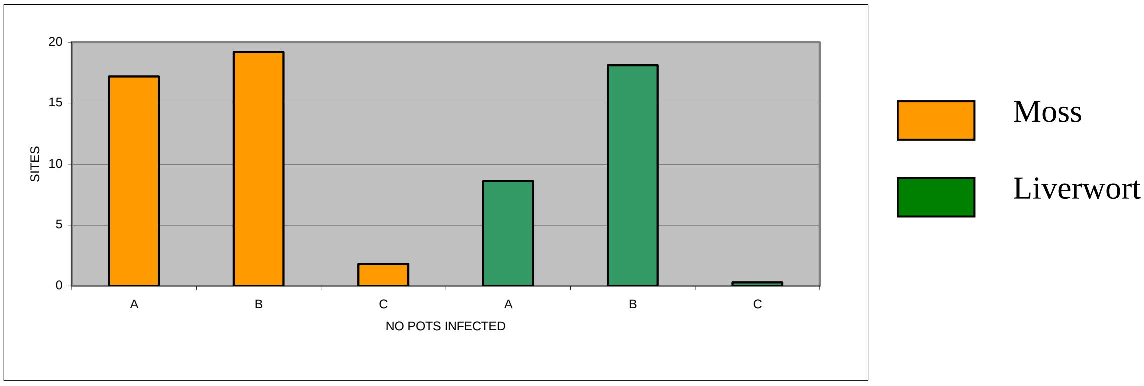
Site C, on the other hand, deliberately managed a ‘dry’ regime, allowing plants to dry back between irrigation cycles, more so than on Sites A and B. This was achieved by detailed monitoring of the crop(s) and regular manipulation of the control equipment to produce the regime required, In some cases plants could be showing signs of early wilting before irrigation was applied.

Another contributing factor to the wetter conditions on Site A was the use of an all peat mix, which would have had a greater water holding capacity than Site B and C mixes which had a proportion of bark included.

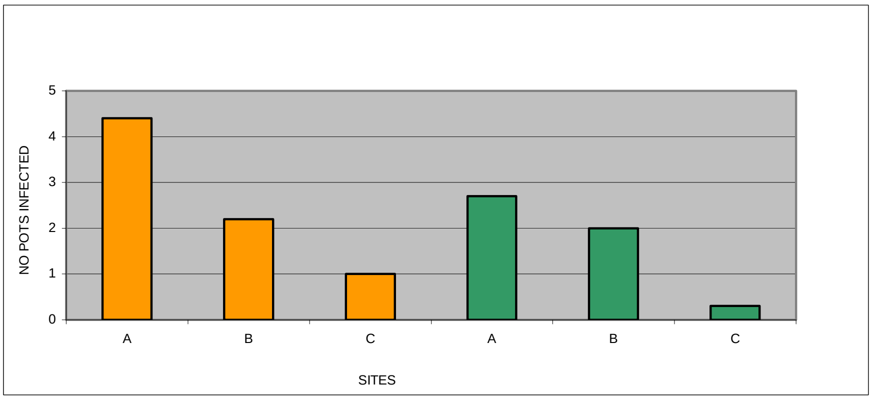
The fact that wetter conditions increased the presence of moss, liverwort and weeds was to be expected. However, the work provided a first hand opportunity to monitor and quantify the degree to which irrigation management, under large scale commercial situations, could be used as a tool to reduce moss, liverwort and weed pressure, and thus reduce dependence on herbicides, and make their use more effective. This whole area is explored further in the Discussion section.

Figure 2 Influence of irrigation management on background weed pressure (UU)

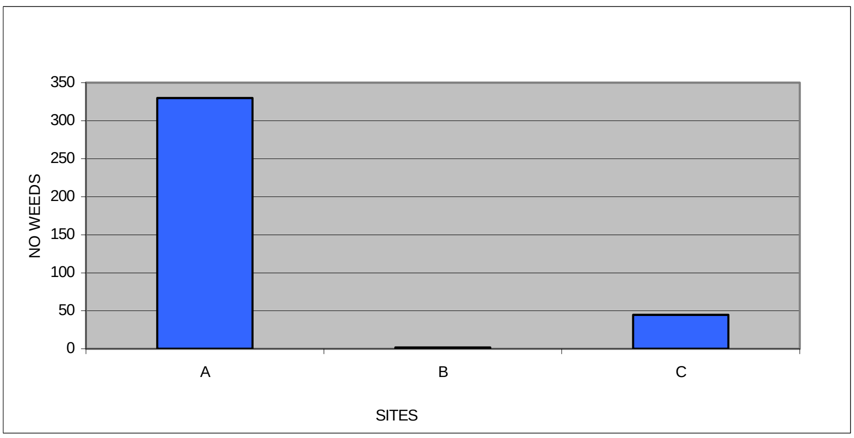
Number of pots infected **Moss and Liverwort**



Severity of Infection **Moss and Liverwort**



Total Number **Weeds**



Efficacy of treatments against moss and liverwort

A. During plug stage (Assessment 1)

Results are presented in Table 9.

Whether moss or liverwort were the greater problem depended on site and species. Overall Site A had a greater moss problem than liverwort, apart from *Hypericum*, and Site C, although having a much lower inoculum, also had a higher proportion of Moss than liverwort. On nursery B, however, *Magnolia* had a severe liverwort problem, while the other species developed more moss.

In looking at the effectiveness of treatments in controlling the problems, liverwort, where it had developed appeared easier to control than moss.

No treatment proved more effective than others at this stage, each appearing to give some check to development of either moss or liverwort, compared with the untreated control, with some species.

Where there was a particularly heavy infestation of moss on Site A *(Forsythia*), no control was achieved with chemicals, whereas with liverwort on Site B (*Magnolia*) a marked check was given by Mogeton. In contrast to the Efford work, Ronstar 2G appeared to be providing a better control than either Panacide M or Mogeton.

A number of factors need to be considered in the interpretation of these results. Firstly, plugs used in the trial had been held under general nursery conditions for variable periods of time before the trial was set up. Consequently some plugs were already contaminated, and treatments set up to prevent colonisation were having to cope with eradication. Treatments have always been more effective in prevention rather than eradication, which could help explain why they were less effective than in the Efford trial where plugs started out clean.

Secondly, only a single application of treatments were possible in the plug stage due to limited time, and this was less than ideal for the treatments to get on top of the problem, especially with colonisation already present. It has been observed in other work that it is the cumulative effect of several applications that reduces or prevents development of serious problems.

Diuron was included in the plug stage treatments due to its effectiveness in controlling moss and liverwort in the Efford trial, despite its phytotoxicity at the 0.025 g/m^2. Consequently its rate in the commercial trialling was again halved to 0.0125 g/m^2 to see if efficacy could be maintained without phytotoxicity. Unfortunately, at this lower rate, while plant damage was reduced, control of moss and liverwort was lost. This treatment was, therefore, not taken on into the liner stage of the trial, and was replaced with Axit GR, at the request of growers, for a direct comparison with Ronstar 2G.

Phytotoxicity: From the sample of 5 plugs taken for destructive assessments, *Berberis* clearly showed its sensitivity to Diuron, even at this very low rate, with both top and root growth reductions, (Table 10). There was also a significant reduction in the growth of the young plug *Pyracantha* where Mogeton had been used (Site A). There were no signs of any phytotoxicity with the other 12 species.

Table 9 **Influence of treatment on presence of moss and liverwort over plug tray prior to potting (July 2000)**

(figures are based on 2 replicates with 84-104 cuttings/tray)

	Nursery A					Nursery B					Nursery C					
	Berberis	**Euonymus**	**Forsythia**	**Hypericum**	**Pyracantha**	**Camellia**	**Choisya**	**Elaeagnus**	**Ilex**	**Magnolia**	**Ceanothus**	**Cotoneaster**	**Hebe**	**Hypericum**	**Pernettia**	**Mean**
% Moss																
Untreated	27	30	100	0	30	11	32	53	34	2	24	16	0	24	14	26.5
Panacide M	9	15	93	2	18	10	15	41	33	0	12	5	0	25	0	18.5
Mogeton	17	19	94	4	13	5	22	61	44	1	12	21	0	20	2	22.3
Ronstar 2G	8	14	86	4	5	3	10	16	12	0	15	32	0	9	0	14.3
Diuron	48	18	87	12	6	5	3	49	14	2	11	6	0	14	1	18.4
	LSD 5% = 14.2					*LSD 5% = 19.8*					*LSD 5% = 22.5*					
% Liverwort																
Untreated	2	19	22	27	1	0	6	0	0	74	7	3	0	3	0	10.9
Panacide M	11	4	4	9	2	0	13	0	1	69	2	0	0	3	0	7.9
Mogeton	3	11	3	31	3	0	8	0	2	23	1	0	0	2	0	5.8
Ronstar 2G	9	14	15	24	3	0	3	0	0	12	1	0	0	2	0	5.5
Diuron	6	12	4	12	3	0	1	0	0	49	1	1	1	2	0	6.1
	LSD 5% = 13.6					*LSD 5% = 15.2*					*LSD 5% = 5.3*					

Table 10 **Influence of treatment on cutting size and dry weight by potting (July 2000)**

(figures are a mean of 2 replicates x 5 cuttings/plot)

	Nursery A					Nursery B					Nursery C					
	Berberis	**Euonymus**	**Forsythia**	**Hypericum**	**Pyracantha**	**Camellia**	**Choisya**	**Elaeagnus**	**Ilex**	**Magnolia**	**Ceanothus**	**Cotoneaster**	**Hebe**	**Hypericum**	**Pernettia**	**Mean**
Size Score (1-5, 5 = largest)																
Untreated	3.3	4.2	4.0	5.0	3.8	3.7	5.0	4.8	5.0	5.0	3.7	4.0	4.7	4.0	4.5	4.3
Panacide M	4.0	4.4	4.0	5.0	3.8	4.5	4.3	4.8	4.8	5.0	3.3	3.0	4.3	4.3	4.0	4.2
Mogeton	3.7	4.2	4.0	5.0	4.0	3.5	4.3	5.0	5.0	4.8	3.7	3.7	4.3	5.0	4.0	4.3
Ronstar 2G	3.3	3.8	4.0	5.0	4.0	3.8	4.3	5.0	5.0	4.8	4.7	4.3	4.3	4.3	4.0	4.3
Diuron	1.0	4.4	3.8	4.0	4.0	4.2	4.3	4.8	3.0	3.8	4.3	4.3	4.0	4.0	4.0	3.9
	LSD 5% = 0.72					*LSD 5% = 0.87*					*LSD 5% = 1.64*					
Dry weight (g)																
Untreated	1.10	1.89	1.31	1.09	4.87	7.65	1.44	6.37	7.30	6.21	1.62	1.42	1.54	1.41	1.97	3.17
Panacide M	0.90	2.00	1.12	0.96	5.19	6.89	1.20	3.67	7.02	6.00	1.67	1.19	1.87	1.22	1.70	2.84
Mogeton	1.06	1.55	1.30	1.39	3.74	9.65	1.29	4.95	7.39	6.46	1.86	1.19	1.67	1.85	1.34	3.11
Ronstar 2G	1.02	1.11	1.38	0.90	4.49	8.00	1.44	4.95	6.82	6.31	2.11	1.46	1.69	1.61	1.97	3.01
Diuron	0.38	1.78	1.23	0.92	4.75	7.95	1.51	5.00	6.74	5.56	1.90	1.31	1.67	1.38	1.77	2.92
	LSD 5% = 0.985					*LSD 5% = 1.762*					*LSD 5% = 0.874*					

B. During liner stage

Assessment 2 (November 2000)

This record addressed the question of whether there were any carry over effects of plug treatments into the liner phase of growth, or any interaction between plug and liner treatment.

These results are presented in Figure 3a (moss) and 3b (liverwort). These are presented graphically and show all 25 treatments colour coded and blocked together by the treatment being received in the liner stage, but individual bars within each colour representing the plug stage treatments. Thus in the blue bars, representing the Mogeton liner treatment, MU was untreated in the plug stage, MM had received Mogeton, MP, Panacide M and MR, Ronstar 2G. An example plant has been selected from each nursery to show the main effects.

While there was some variability in results within nurseries and species, depending on plug treatment, these differences did not prove to be statistically significant, suggesting that plug treatments were not having any lasting carry over effects into the liner phase. This is not surprising given the 6-12 week application requirements of treatments, which by the time the plugs were potted in this work were at the stage of needing re-application.

At this assessment, degree of control of moss was site specific. At Site A, where there was a heavy infestation in the untreated pots, the significant check to moss by application of Panacide M, Mogeton and Lenacil 80 ~W can clearly be seen, both in the number of pots infected and severity of infestation. At Site B, only Lenacil 80 W had an influence in reducing the number of pots with moss present, though overall, severity of infestation was considerably less than Site A. The low level of moss present on Site C was also highlighted. In contrast to the plug stage, Ronstar 2G appeared less effective in checking moss establishment in liners. Neither did Axit GR provide any control.

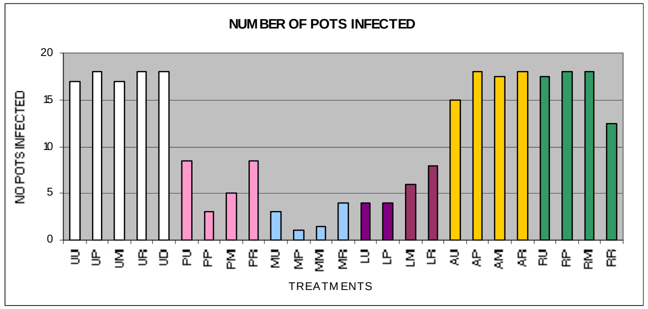
With Liverwort, *Magnolia* at Site B was the species most affected, and here the ability of Mogeton and Lenacil 80 W in reducing the number of pots colonised can be seen. Panacide M appeared less effective at this stage.

Effects of treatments on Moss control by November 2000

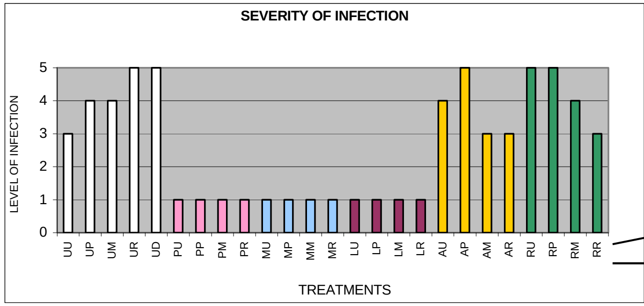
(Figures are averaged over 2 replicates, with 20 plants/plot)

Figure 3a

Nursery A: *Forsythia*



LSD 5% = 7.56

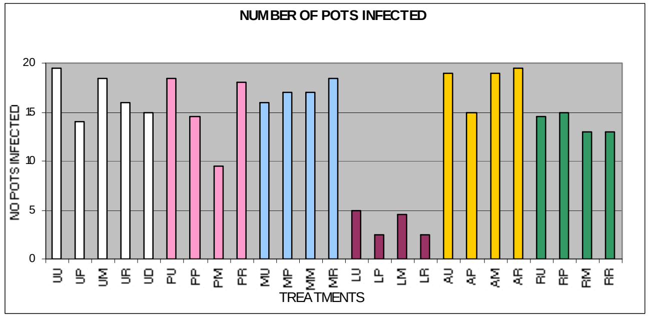


Plug trt

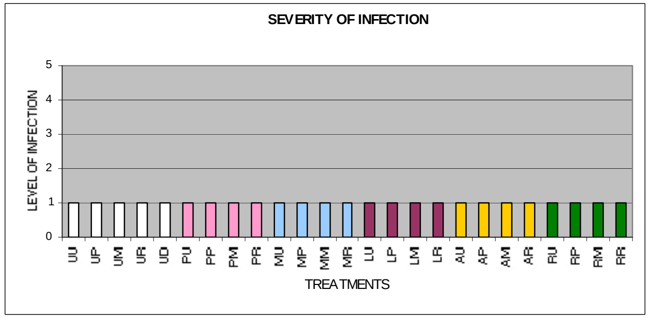
Liner trt

LSD 5% =2.01

Nursery B: *Magnolia*



LSD 5% = 6.37



LSD 5% = 0.46

Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

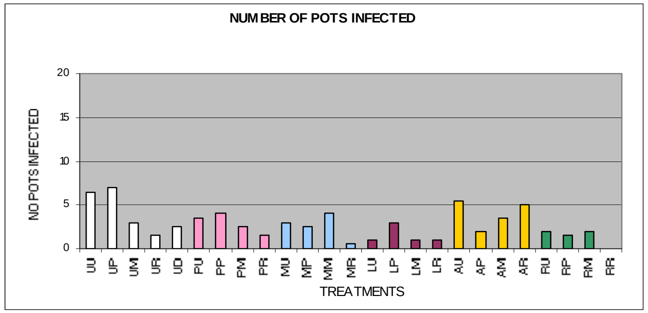
M = Mogeton

L = Lenacil 80 W

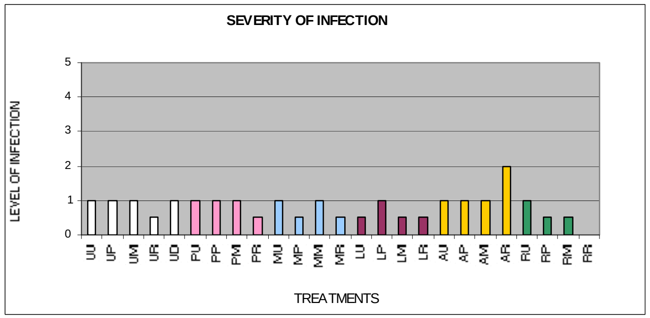
A = Axit GR

R = Ronstar 2G

Nursery C: *Ceanothus*



LSD 5% =4.46

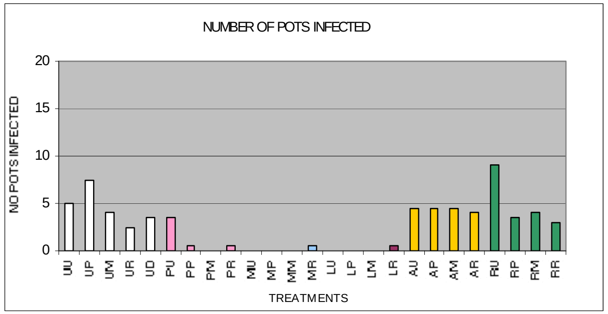


LSD 5% = 1.10

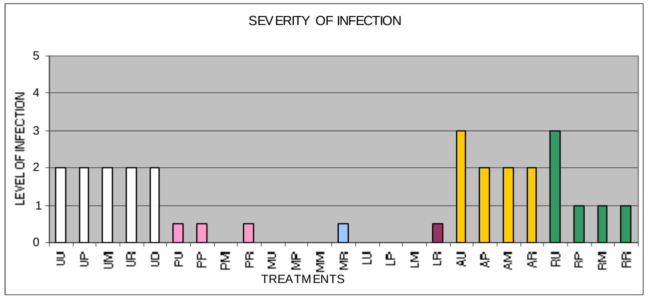
Effects of treatments on Liverwort control by November 2000

Figure 3b

Nursery A: *Forsythia*



LSD 5% = 5.48

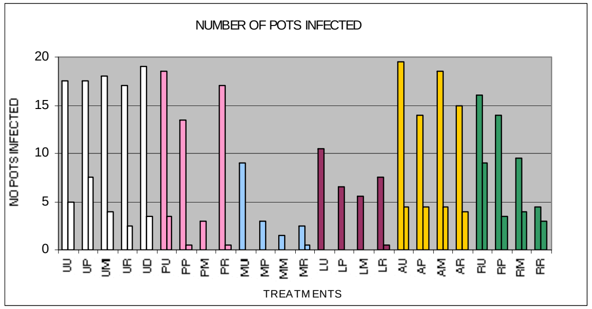


LSD 5% = 2.21

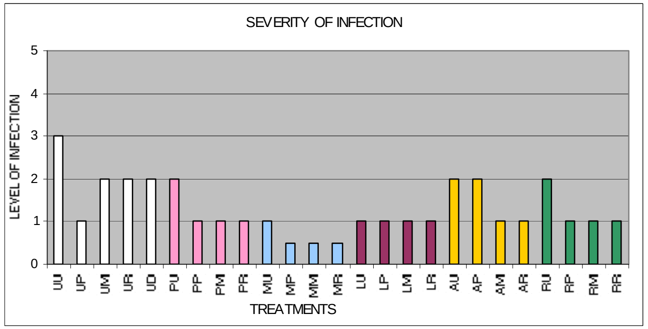
Plug trt

Liner trt

Nursery B: *Magnolia*



LSD 5% = 7.30



LSD 5% = 0.94

Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

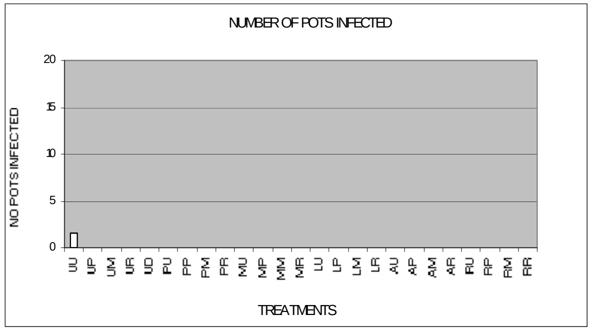
M = Mogeton

L = Lenacil 80 W

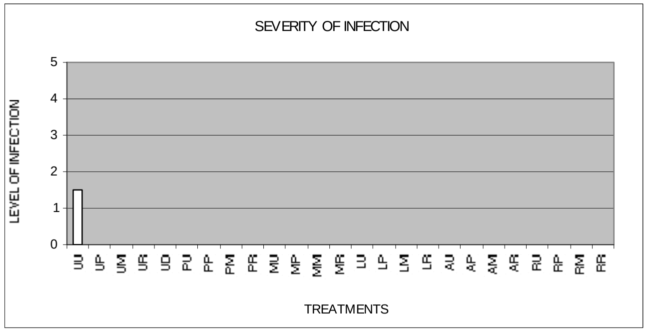
A = AXit GR GR

R = Ronstar 2G

Nursery C: *Ceanothus*



LSD 5% = 1.01



LSD 5% = 0.65

Assessment 3 (April 2001)

Since there was no significant carry over of plug treatment into the subsequent liner phase, these results have been presented as a mean of the liner treatment averaged across the plug treatments. This has made it much easier to see main effects of treatments.

This assessment relates to the point of anticipated sale of plants, with all nurseries having their major sales period starting in March/April. Consequently, this 3rd assessment shows the overall efficacy of treatments in the control of moss and liverwort. In Figure 4 main effects of treatments averaged across species on each nursery is given for moss (Figure 4a) and liverwort (Figure 4b).

Again moss was shown to be more difficult to control than liverwort, but good control was achieved on Site A by this point with Lenacil 80 W and Mogeton, closely followed by Panacide M.

As already discussed, Site B appeared to have a high proportion of pots infested, but severity of infection was low. Only Lenacil 80 W had any influence in reducing the number of pots affected. The value of having only low levels of inoculum to control is demonstrated by Site C, where eradication of the moss and liverwort was achieved with Panacide M, Mogeton and Lenacil 80 W.

A similar pattern emerged for liverwort control, with Lenacil 80 W and Mogeton giving good control, closely followed by Panacide M.

The overall control of moss and liverwort averaged across site and species is shown in Figure 5. Here the potential of Lenacil 80 W for controlling moss and liverwort stands out, though it has no registration for use under protection. Mogeton also gave reasonable control of both moss and liverwort, though again has no registration in the UK for use over plants. Panacide M also gave reasonable control overall.

Comparison of treatment effects within a species on two of the nurseries

The only common species across tow of the nurseries was *Hypericum* (Sites A and C)., with results presented in Figure 6a (moss) and 6b (liverwort).

Overall, the pattern of results seen was similar to those already discussed, with Lenacil 80 W providing excellent control of both moss and liverwort, and Mogeton outperforming Panacide M in the control of liverwort.

Levels of Liverwort were much reduced in the drier growing environment of Site C.

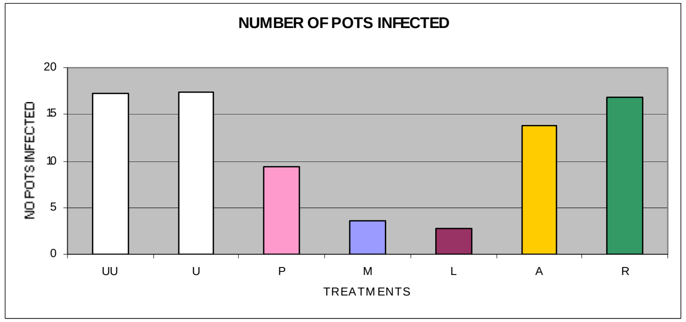
Control of moss or liverwort was not achieved with Ronstar 2G or Axit GR.

Effects of treatments on Moss control by April 2001

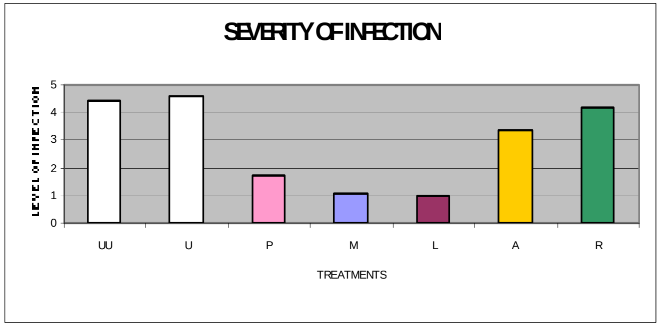
(data averaged across plug treatments and 5 species on each nursery)

Figure 4a

Nursery A

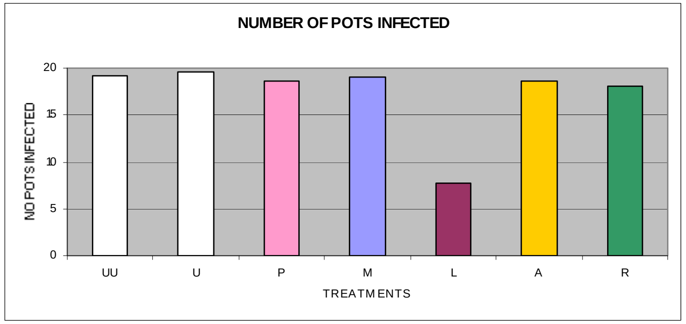


LSD 5% = 1.61

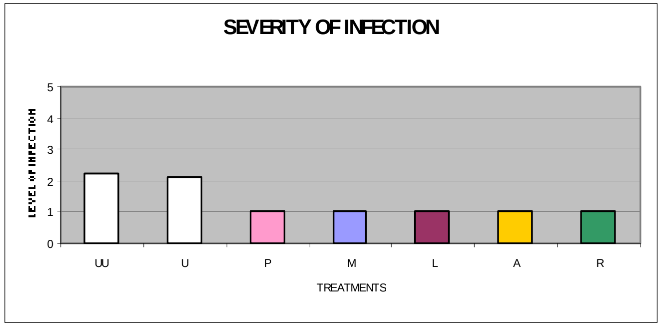


LSD 5% = 0.43

Nursery B

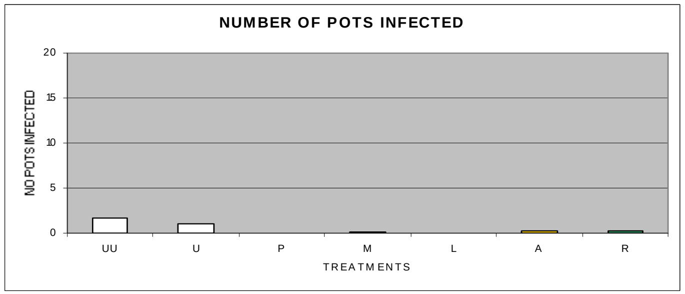


LSD 5% = 1.23

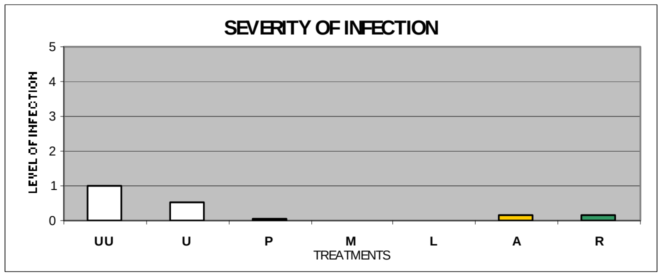


LSD 5% = 0.15

Nursery C



LSD 5% = 0.35



LSD 5% = 0.20

Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

A = AXit GR GR

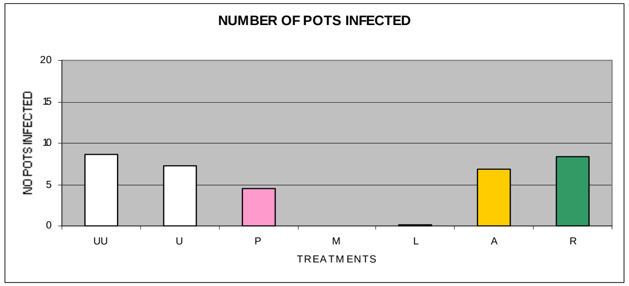
R = Ronstar 2G

Effects of treatments on Liverwort control by April 2001

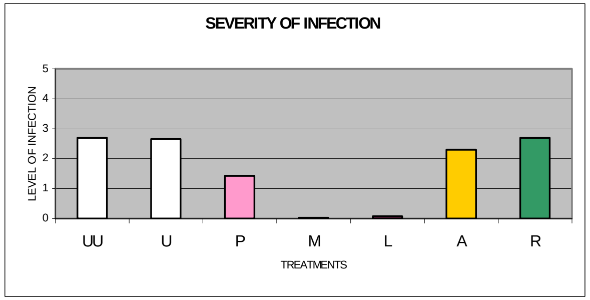
(data averaged across plug treatments and 5 species on each nursery)

Figure 4b

Nursery A

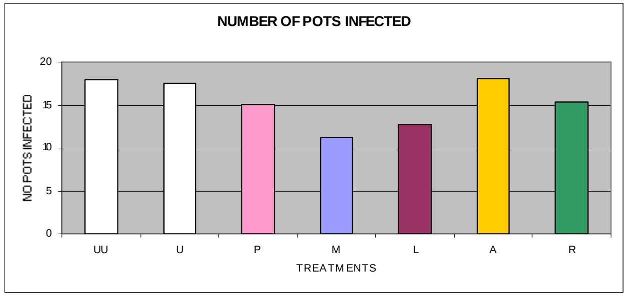


LSD 5% = 1.67

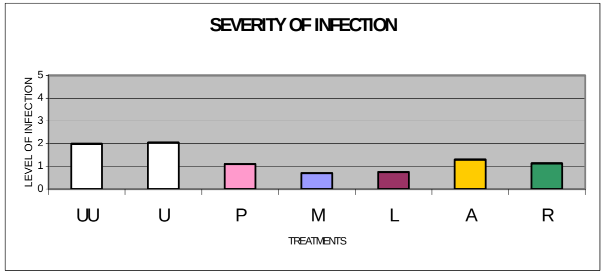


LSD 5% = 0.47

Nursery B

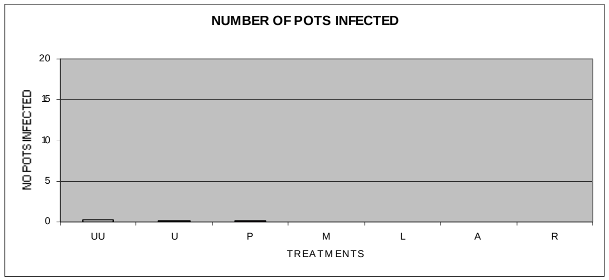


LSD 5% = 2.22

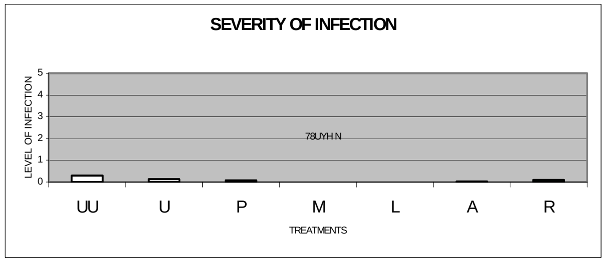


LSD 5% = 0.22

Nursery C



LSD 5% = 0.09



LSD 5% = 0.12

Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

A = AXit GR GR

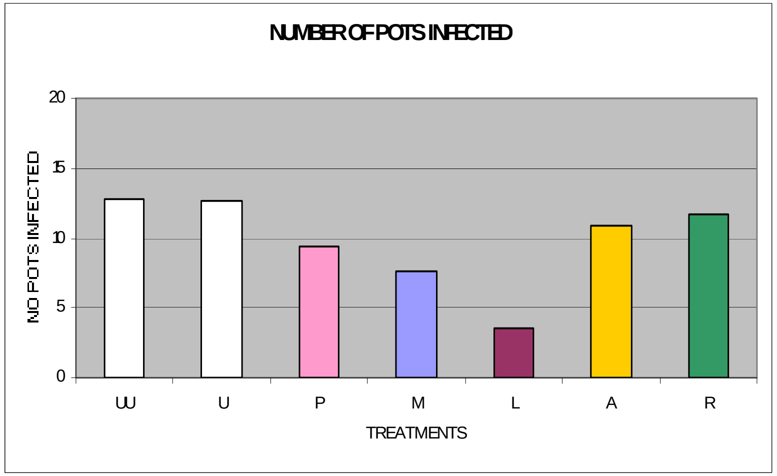
R = Ronstar 2G

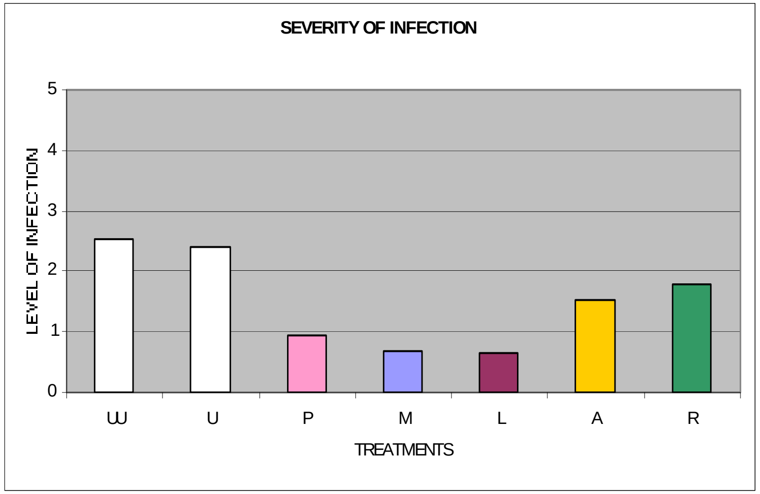
Figure 5

Overall control of Moss and Liverwort by April 2001

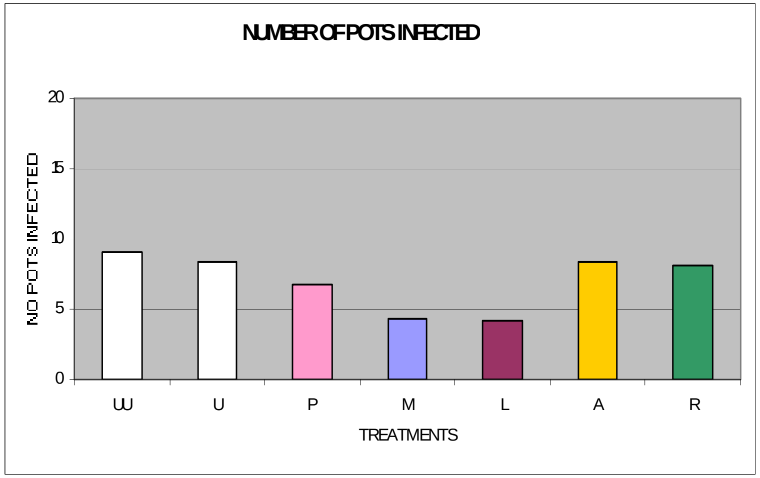
(data averaged across plug treatments, species and nurseries)

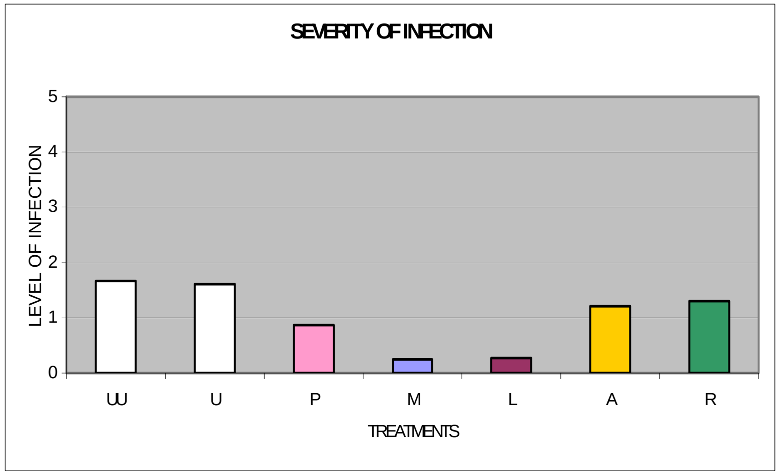
Moss





Liverwort





Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

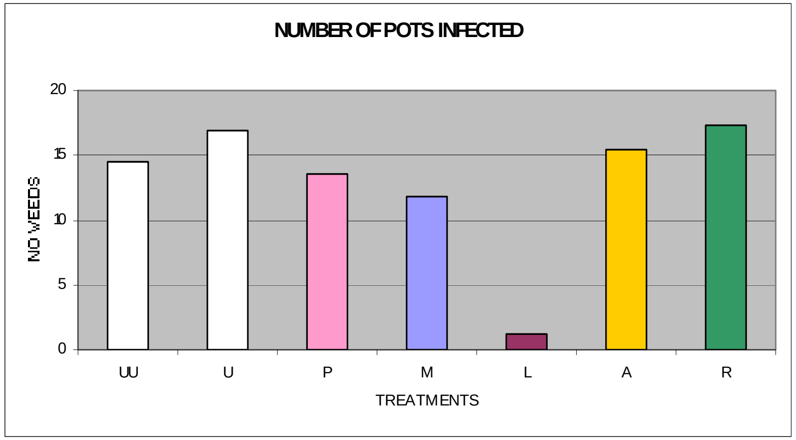
A = AXit GR GR

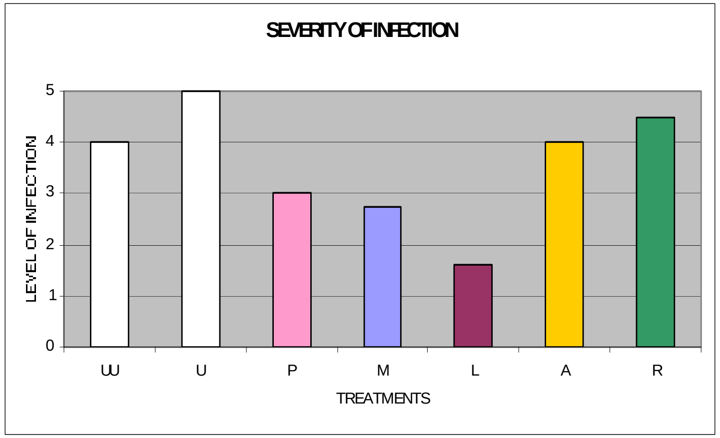
R = Ronstar 2G

Figure 6a **Comparison of Moss control in *Hypericum* across two sites**

(data averaged across plug treatments)

Nursery A

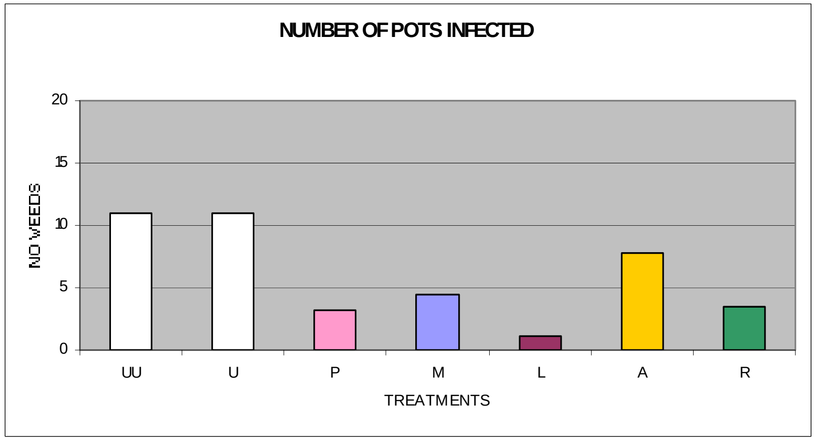


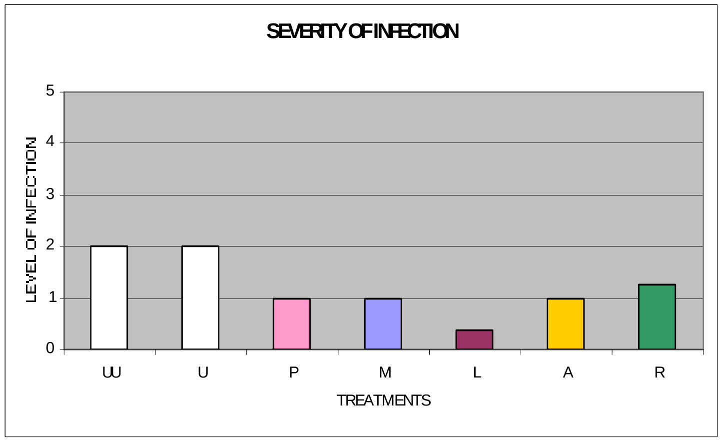


LSD 5% = 2.09

LSD 5% = 0.69

Nursery C





Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

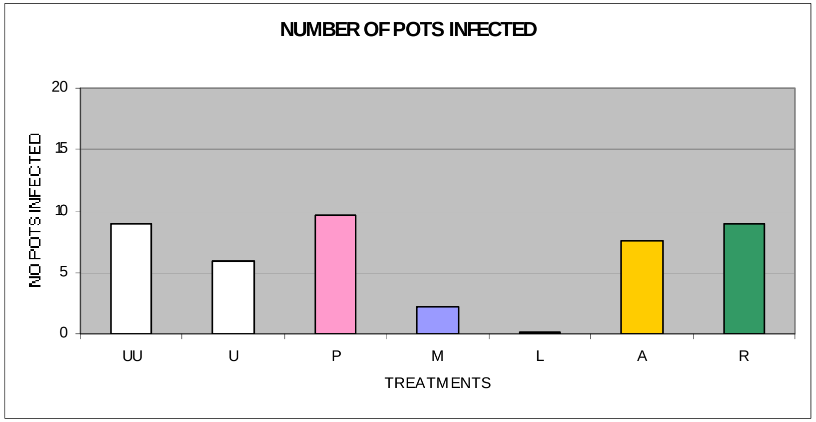
A = AXit GR GR

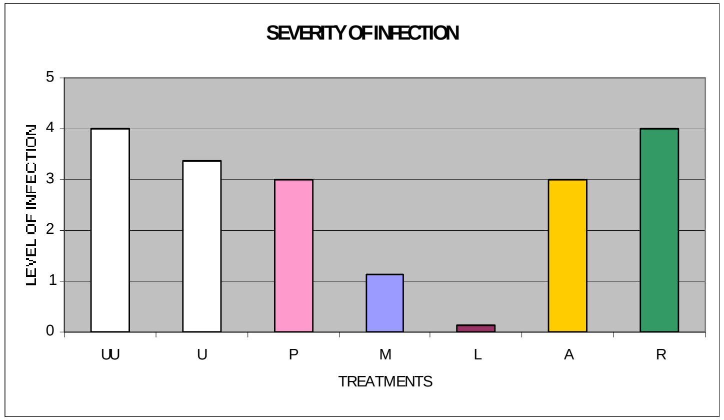
R = Ronstar 2G

Figure 6b **Comparison of Liverwort control in *Hypericum* across two sites**

(data averaged across plug treatments)

Nursery A

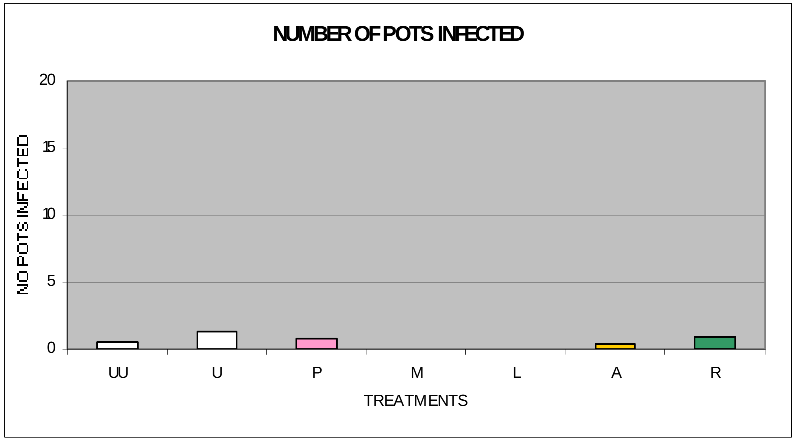


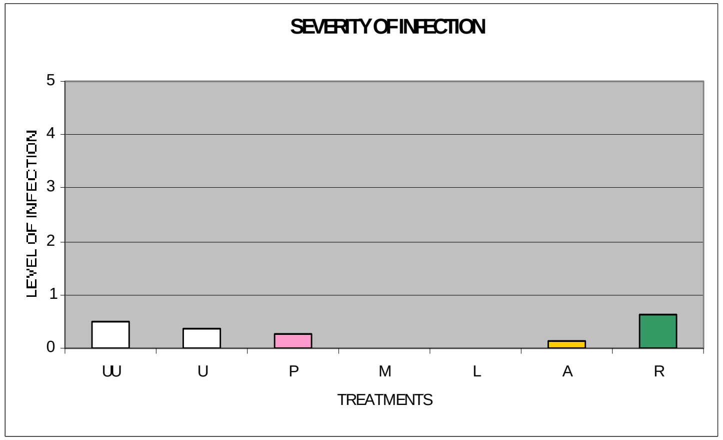


LSD 5% = 2.63

LSD 5% = 0.82

Nursery C





Key

UU = Untreate plug & liner

U = Untreated liner

P = Panacide M

M = Mogeton

L = Lenacil 80 W

A = AXit GR GR

R = Ronstar 2G

Weed Control

The number of weeds present at each assessment and a cumulative total number of weeds occurring over the period of the trial was obtained.

Three main weeds were present : Annual Meadow Grass *(Poa annua)*
Hairy Bittercress *(Cardamine hirsuta)*
Pearlwort *(Sagina procumbens)*

The level of importance of the weeds varied between the three nurseries , with Annual Meadow Grass a particular problem for Site C, and Hairy Bittercress and Pearlwort for Site A. Site B was remarkably clear of weeds.

The Annual Meadow Grass problem at Site C was the result of an infestation coming in with the plugs, and necessitated a great deal of hand weeding in the early stages of liner growth. Effective, though not total, control was achieved with the herbicides Lenacil 80 W, Axit GR and Ronstar 2G. (Figure 7).

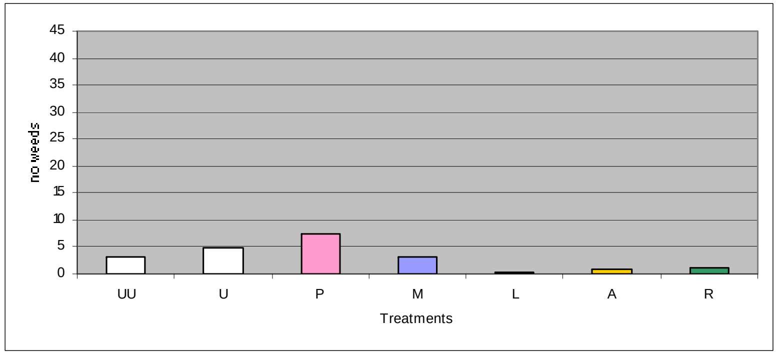
The Hairy Bittercress problem on Site A was not completely solved by herbicides, though there was a reduction in level of infestation achieved with Lenacil 80 W and Ronstar 2G, followed by Axit GR. Back-up hand weeding would have been essential with this weed to prevent its spread. (Figure 8).

Pearlwort was also a problem for Site A, and here the only significant control was achieved with Axit GR. (Figure 9)

Figure 7 **Weed control - Effects of treatments on control of Annual Meadow Grass (*Poa annua*)**

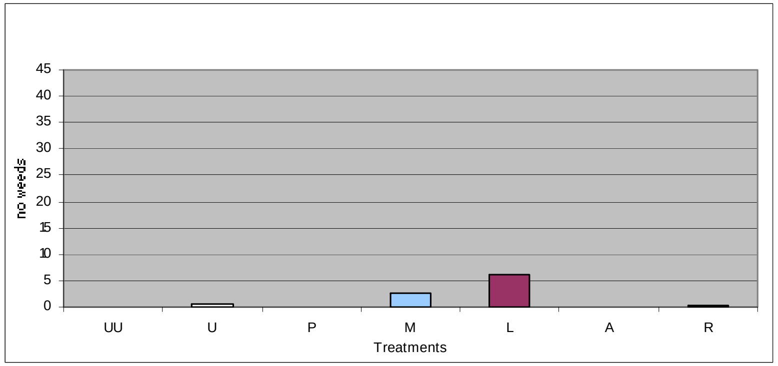
(data is cumulative, giving the total number over the period of the trial)

Nursery A



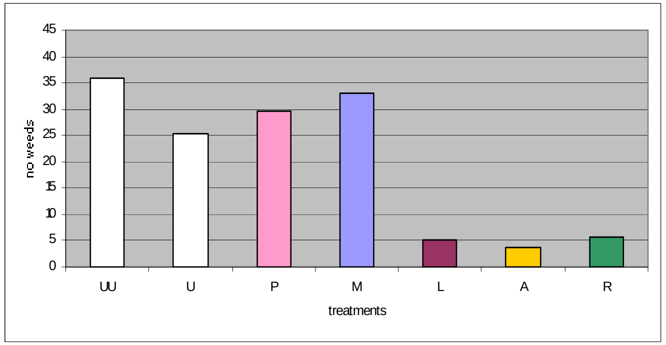
LSD 5% = 3.59

Nursery B



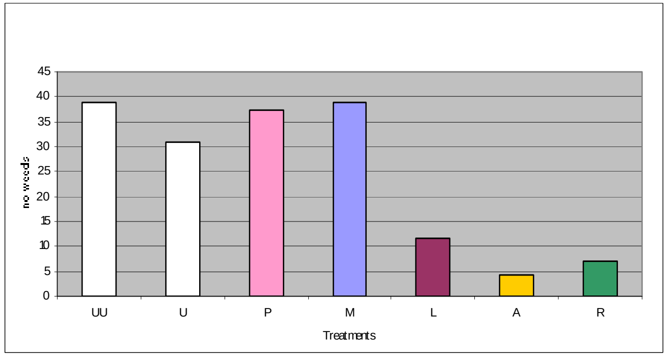
LSD 5% = 4.84

Nursery C



LSD 5% = 10.93

Total across all three sites



Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

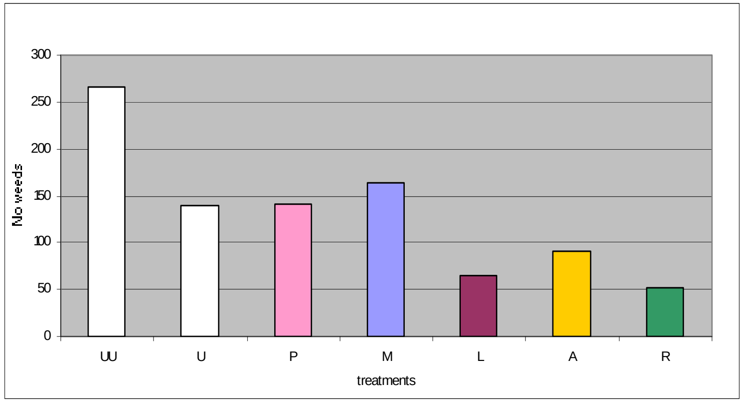
A = AXit GR GR

R = Ronstar 2G

Figure 8 **Weed control - Effects of treatments on control of Hairy Bittercress (*Cardamine hirsuta*)**

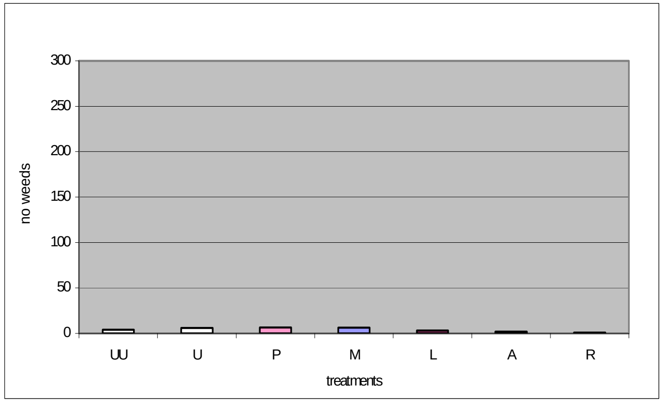
(data is cumulative, giving the total number over the period of the trial)

Nursery A



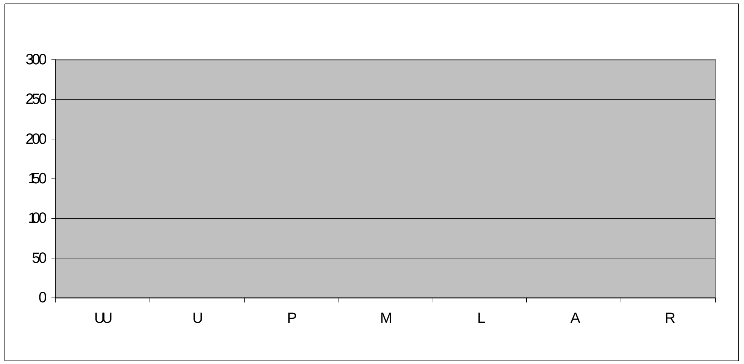
LSD 5% = 62.25

Nursery C



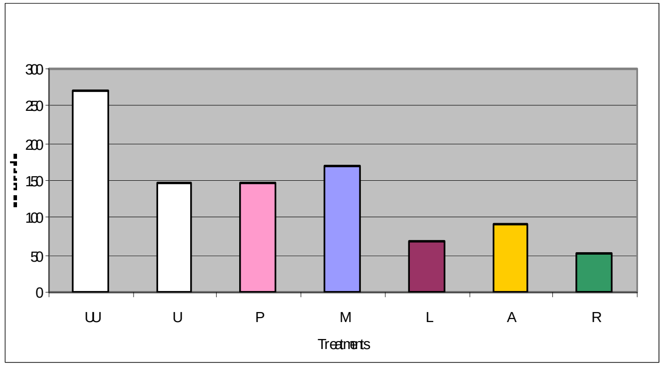
LSD 5% = 5.24

Nursery B



LSD 5% = 0.14

Total across all three sites



Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

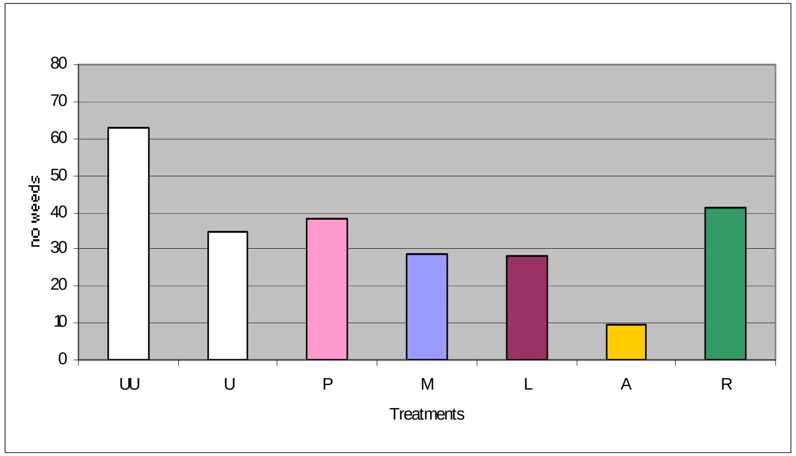
A = AXit GR GR

R = Ronstar 2G

Figure 9 **Weed control - Effects of treatments on control of Pearlwort (Sagina procumbens)**

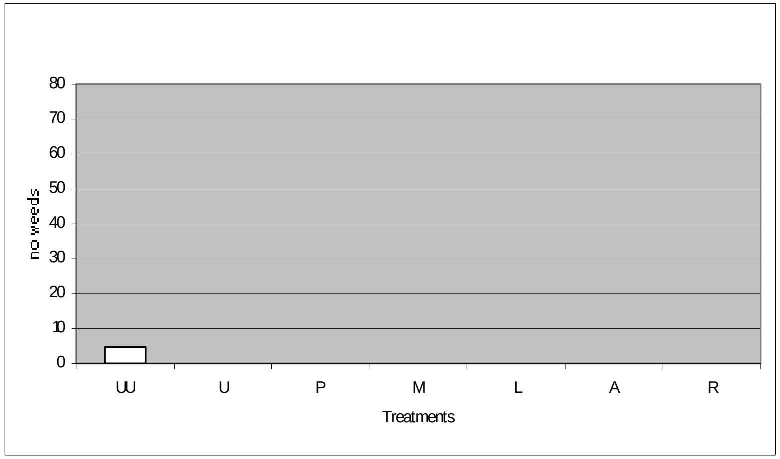
(data is cumulative, giving the total number over the period of the trial)

Nursery A



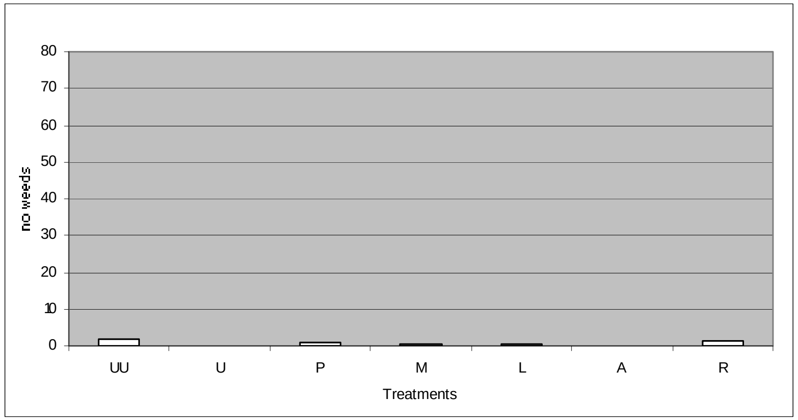
LSD 5% = 21.76

Nursery C



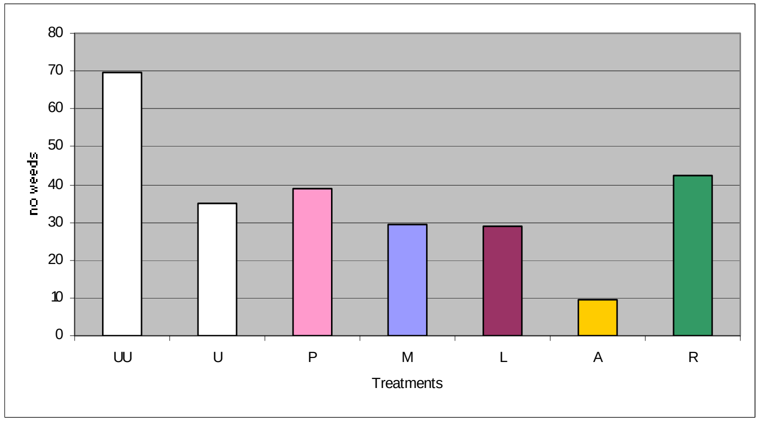
LSD 5% = 1.16

Nursery B



LSD 5% = 1.40

Total across all three nurseries



Key

UU = Untreated plug & liner

U = Untreated

P = Panacide M

M = Mogeton

L = Lenacil 80 W

A = AXit GR GR

R = Ronstar 2G

Phytotoxicity

Phytotoxicity was assessed in two ways. First by direct visual observations of any foliage symptoms, and secondly by a destructive sample of plant dry weight to obtain a robust record of plant growth.

Plug stage

At Site A the golden *Berberis* proved sensitive to Diuron, with increased leaf spotting apparent, reduced root and top growth, and 20% cutting deaths. A significant loss of cuttings also occurred where Ronstar 2G had been applied (8%), compared to only 1.5% in the untreated control. *Hypericum* also proved somewhat sensitive to Diuron and to a lesser extent Ronstar 2G, where increased leaf spotting was observed. An increase in leaf spotting of *Berberis* was also apparent where Mogeton had been applied. These symptoms, in the main, proved short lived, with little or no symptoms observed in the liner stage as a result of these treatments.

At Site B a similar pattern emerged, with Diuron reducing growth of *Magnolia* and *Ilex*, and increasing leaf spotting on *Choisya*, together with Panacide M and Ronstar 2G. There was also an indication of some foliage necrosis on *Camellia* where Mogeton had been applied.

No such phytotoxic symptoms were seen at Site C at the plug stage.

Due to the sensitivity of a number of species to Diuron, even at such a low rate as used in the commercial trialling (0.0125 g/m^2), together with its lack of control of moss and liverwort at this rate, it was dropped from the liner stage, and as already discussed, replaced with Axit GR.

Liner stage

No obvious signs of phytotoxicity were observed at any of the three sites at Assessment 2 (November 2000) or Assessment 3 (April 2001). Treatments up until this point had been to plants with more mature growth, or which had slowed down or was deciduous over the winter. What effect treatments might have on material in full flush of soft growth was monitored in the trial extension, where a further set of treatments were applied in mid-April 2001, and final growth records taken in June 2001, (Assessment 4). (Figures 10a, 10b, 10c)

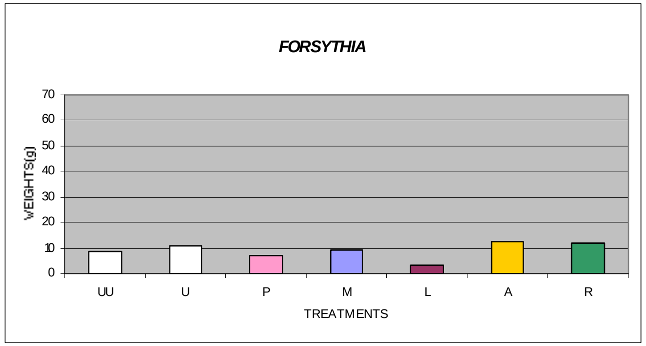
The softer growth stage of the golden *Forsythia* and *Euonymus* 'Harlequin on Site A proved sensitive to Lenacil 80 W, with severe foliage necrosis occurring, which in the case of *Forsythia* was accompanied by a significant reduction in plant growth.

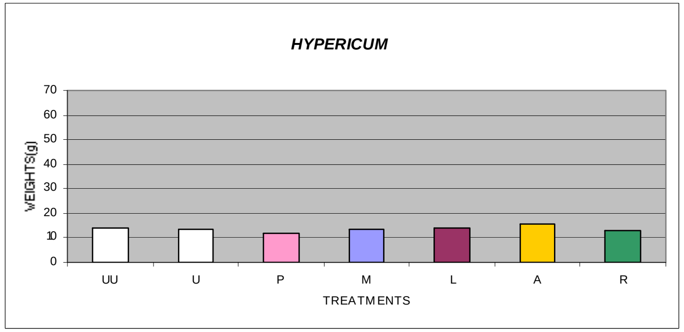
No signs of any phytotoxicity was observed at Site B on the 5 species included there, apart from a suggestion of a small decrease in growth of *Elaeagnus pungens* 'Maculata' as a result of Lenacil 80 W.

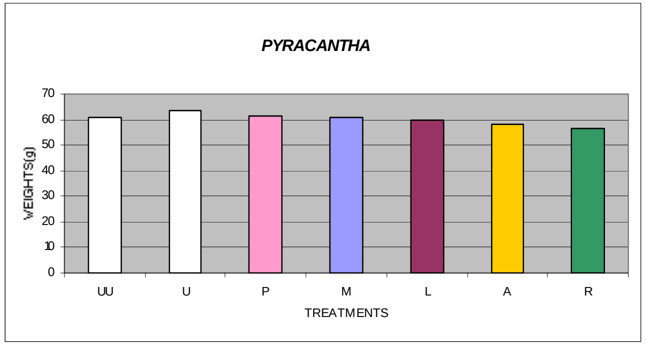
At Site C, Ceanothus 'Yankee Point' proved sensitive to Lenacil 80 W, with a small reduction in growth, but a striking veinal chlorosis of the foliage (see photograph, page 14). A sample of treated and untreated plants were brought back to Efford, potted into 3 litre containers, and held until the Open Days on the 25 and 26 October 2001. By this time, although symptoms were less marked they were still obvious. No problems were seen with the other 4 species.

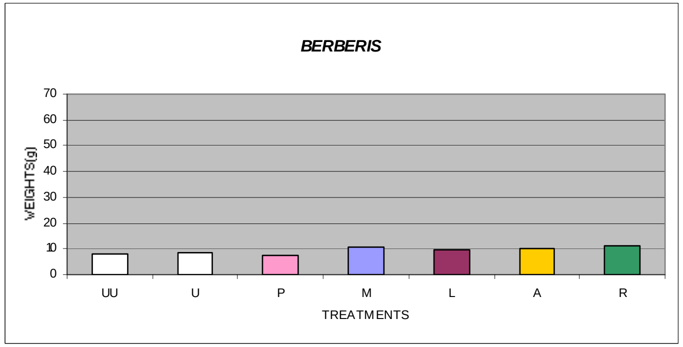
Figure 10a **Plant growth by end of trial (June 2001) - dry weight (g): Nursery A**

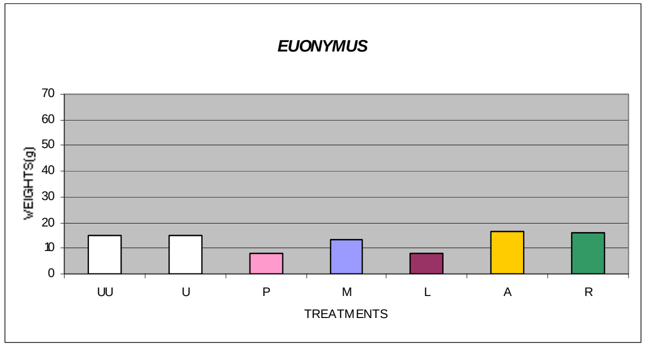
(data averaged across plug treatments)











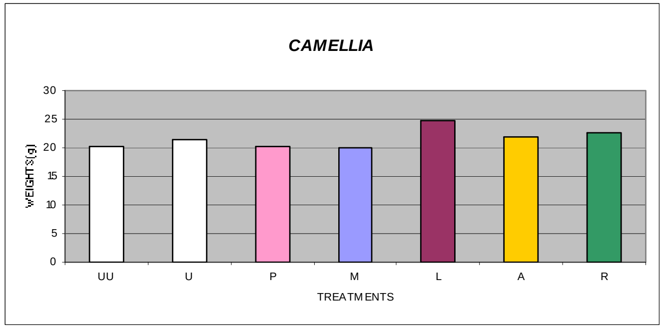
Key

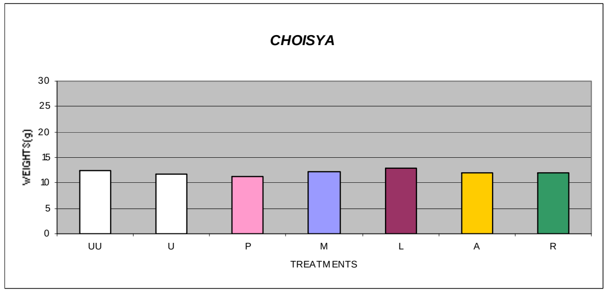
UU = Untreated plug & liner
U = Untreated
P = Panacide M
M = Mogeton
L = Lenacil 80 W
A =AXit GR GR
R = Ronstar 2G

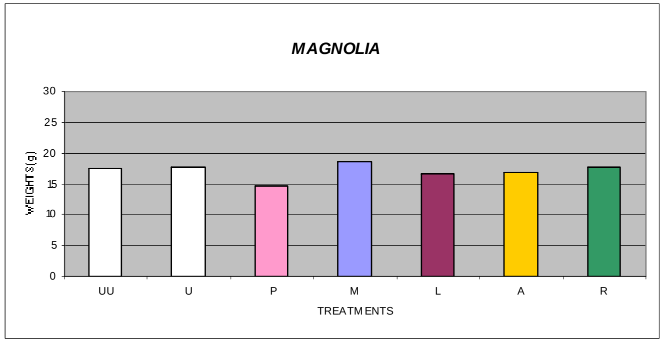
LSD 5% = 4.77

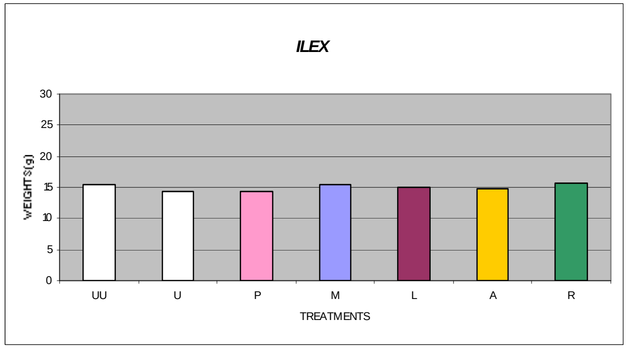
Figure 10b **Plant growth by end of trial (June 2001) - dry weight (g): Nursery B**

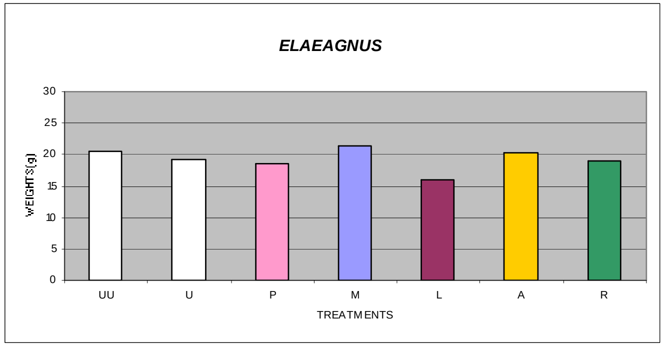
(data averaged across plug treatments)











Key

UU = Untreated plug & liner

U = Untreated P = Panacide M

M = Mogeton

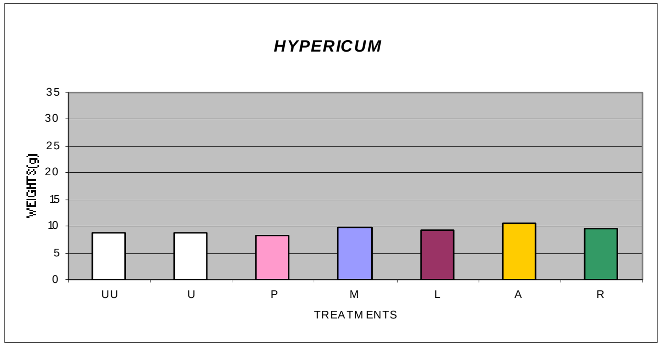
L = Lenacil 80 W

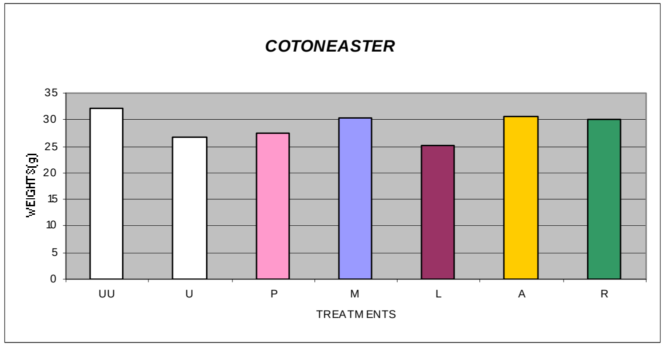
A = AXit GR GR

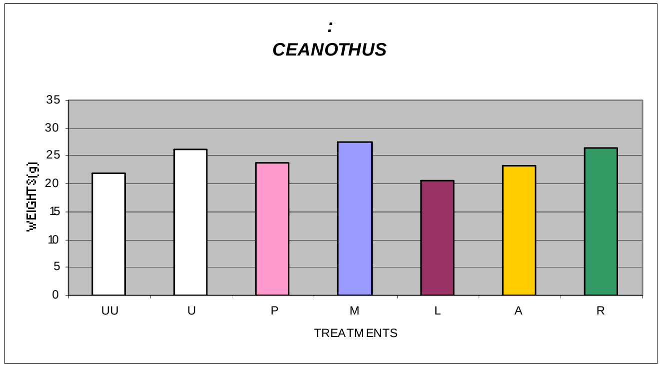
R = Ronstar 2G

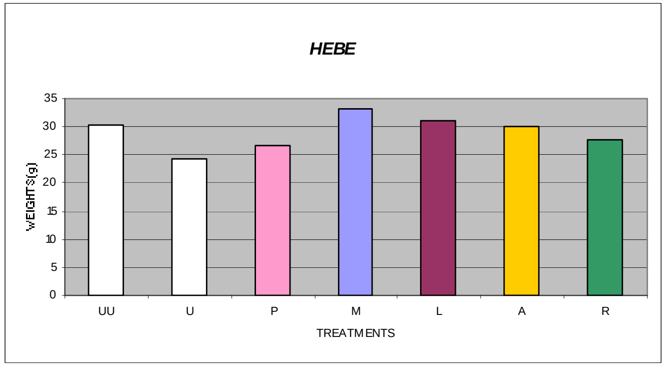
LSD 5% = 2.26

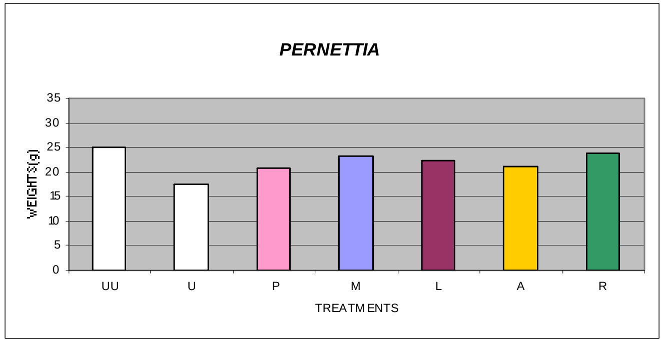
Figure 10c **Plant growth by end of trial (June 2001) - dry weight (g): Nursery C**
(data averaged across plug treatments)











Key

UU = Untreated plug & liner
U = Untreated
P = Panacide M
M = Mogeton
L = Lenacil 80 W
A = AXit GR GR
R = Ronstar 2G

LSD 5% = 5.01

Discussion

Moss and liverwort biology

The moss species generally associated with container HNS production has been *Funaria hygrometrica*, but over the past few years other species have been observed. These need identifying and checking that treatments capable of controlling *Funaria hygrometrica* also take out other species.

Germinating spores first produce a filamentous type growth, which then develops buds that grow into the leafy plant anchored to the media by rhizomes. Spore producing bodies (sporophytes), following fertilization, are borne above the vegetative growth on slender stems, which with *Funaria hygrometrica* are bright orange in colour. The sporophyte is a complex structure, protected during development by an outer sheath, which sheds when mature, exposing thread like filaments ('teeth'), which form a ring around the mouth of the capsule. These are sensitive to changes in humidity, and under low humidity dry out and move away from the mouth of the capsule allowing the spores to escape. Each capsule can contain more than 50,000 spores.

The liverwort species mainly encountered is *Marchantia polymorpha*, which has dichotomous branched vegetative growth (thallus) capable of forming new plants when this growth fragments.

This species has a vegetative spore phase from 'cups' (gemma) which are formed on the surface of the thallus. These contain the vegetative spores (gemmae), which are released as the cups fill with water, each capable of forming a new pair of young plants.

In the sexual reproductive phase separate male and female organs are formed, with fertilization taking place under wet conditions, before the typical umbrella shaped sporophytes are borne aloft on sturdy stems. These contain spores with hygroscopic threads (elaters), which twist and coil as they dry and propel the spores into the air. Literature suggests that 7 million spores may be formed on each plant !!

Thus the presence of water helps spread the vegetative phases of growth, and germination of spores, while low humidity can help the dispersal of the fertilized spore stage. A better understanding of the life cycles of the moss and liverwort within container media , and conditions required for the different stages, could help provide guidelines for interrupting their 'ideal conditions', and help limit their spread, as the preliminary information on controlled irrigation has indicated in this work.

Trial programme

This programme of work was set up to help develop guidelines for weed control strategies for moss, liverwort and weed control HNS in the plug and liner stages of growth under protection. This against a background of reducing availability of chemicals, as active ingredients are withdrawn, and an increase in accreditation schemes, which demand the production of quality, weed free plants for sale.

Some work has already been done with liners (HNS 35b), but not with the potentially more sensitive plug holding stage. However, rooted plugs can be held for varying periods before potting, and during this time uneven watering and variability in vigour of cuttings within the tray, together with empty cells from cutting failure, can hasten and encourage development of moss and liverwort. Once established, it becomes difficult to eradicate and/or achieve 100% hand cleaning of the plugs pre-potting. This is especially so with the increased use of wrapped plugs (Fertiss, Elle), where both moss and liverwort growth can anchor itself to the bandage. Thus inoculum gets carried over to the liner pot and can develop rapidly.

Hand cleaning is also time consuming, with a number of nurseries approached indicating that one third of costs at dispatch relate to cleaning pots of moss liverwort and weeds, and topping pots with fresh mix as necessary. Consequently, even if completely clean pots are not yet able to be produced, a reduction in weed presence can make them easier to remove. Addressing this problem has major implications for reducing labour input, costs and being better able to meet the standards required of the accreditation schemes.

The work was in two phases, the first at HRI Efford encompassing detailed work to identify potential treatments for both plugs and liners, which then in phase two were trialled on three commercial nurseries in the ALP Group**.** A great deal of data was generated, which has been focussed down to answer specific questions at each stage of assessment, with an overview emerging of the most effective treatments, but still requiring further information to ensure that best use is made of them in terms of application and safety.

Some of the treatments were already in use in the Industry, including Bravo, which has the benefit of fungicidal properties, reducing leaf spotting, as well as suppressing moss and liverwort. It does need applying every three weeks, though, and there was interest in finding treatments requiring less frequent applications, as well as seeing which could be used with safety in the plug as well as liner stage. The highest label recommendation for use of Bravo is now 0.6 g/m^2.

The preliminary Efford work identified Panacide M, Mogeton, Diuron and Ronstar 2G as having potential for checking moss and liverwort in the plug stage. Some phytotoxicity was seen with Mogeton in yellowing of *Cytisus* foliage, and Diuron, at the rate used proved too phytotoxic, symptoms worsening with time. Because it is so effective against moss and liverwort it was decided to take it forward into the commercial trials at an even lower rate. For the liner phase the herbicides Lenacil 80 W and Axit GR were included along with those applied in the plug stage. Lenacil 80 W had proved effective against moss and liverwort as well as weeds in previous trials, but there was a question over its safety, hence its use only in the liners. Axit GR, though not effective against moss or liverwort was included for its potential to control pearlwort.

Irrigation management

The major result from the commercial trialling, however, was the potential of using controlled water stress as a means of significantly reducing the background inoculum of moss, liverwort and weeds. All nurseries had overhead irrigation lines, but managed very different regimes. Nursery A opted for a wetter regime, with automated control over both the growing season and during the winter. Automated control over the growing season on Nursery B was backed up by hand watering over the winter, while Nursery C managed a much drier regime, letting plants dry back, sometimes to wilting starting to occur, before applying the next cycle of irrigation. This required constant monitoring of the crops and attention to detail in adjusting the irrigation controllers, but demonstrated just how much this strategy was contributing to the reduction in moss, liverwort and weed problems.

This result has also been confirmed in the HortLINK programme looking at improving the efficiency of water use (HL0132LHN / HNS 97), with weed presence reduced as less water, compared to the ‘normal’ standard, was applied. In addition there are implications for manipulation of plant growth under drier regimes, the HortLINK programme demonstrating more compact, quality growth under a regime applying only 60% of the normal standard.

There is also the benefit of reduced disease pressure under the drier regimes.

There is no doubt that too much water is being used on some nurseries, but developing and implementing a ‘drier’ irrigation regime requires constant crop monitoring, attention to detail and confidence in the application of such regimes, since pots must still be capable of rewetting. This is where the use of wetting agents could become more important in the future, a topic currently under trial (HNS 107a).

At the moment many irrigation regimes build in a safety or comfort factor, to ensure that plants don’t dry out. However, the benefits that have been, or are beginning to be demonstrated, from controlled irrigation techniques are showing the way forward to be able to achieve cleaner, improved quality crops with reduced use of chemicals. An important concept as environmental pressures for reduced use of chemicals increase, and an ever increasing number of chemical active ingredients are withdrawn from the market.

Further work is required on methods of attaining the drying cycles to reduce the moss, liverwort and weed inoculum. The monitoring equipment being developed in the HortLINK programme, (HNS 97), will help in identifying and controlling how dry containers become before irrigation is needed, as well as plant requirements. There is also scope to consider allowing pots to dry back, especially the surface, before bringing the standard irrigation back in line for a period. What sort of periods of wetting / drying are required to prevent germination of spores or weed seed will need detailed investigation.

Chemical / herbicide treatments

These appeared more effective under the drier irrigation environment, since there was only a limited amount of inoculum to start with.

Both Panacide M and Mogeton gave reasonable control of moss and liverwort in plugs and liners, with Mogeton out performing Panacide M on occasion, especially for moss. However, the orange deposit on the foliage was unsightly, and needed time to wear off before sale. It must also be remembered that Mogeton still does not have registration for use in the UK, except for cleaning hard surfaces such as pathways.

There were indications that some species might, on occasion, be sensitive to Panacide M (or Mogeton), and testing for safety of use over the range of species to be treated is important prior to general nursery use. Potential efficacy and safety of Panacide M over plugs was encouraging, since the plug stage is one of the main areas for moss and liverwort establishment.

Ronstar 2G, apart from some leaf spotting in the early stages of plug growth, appeared reasonably safe over the limited range of species used in the trial, though again screening for safety of use over the range of species being grown is important. It only gave a small check to growth of moss and liverwort. Nor does this herbicide have label approval for use under protection.

Diuron had been included since it had proved so effective in controlling moss and liverwort. However, even at a quarter of the rate normally used on larger containers, it still proved too phytotoxic, and at this lower rate, (0.0125 g/m^2), was no longer providing effective control of moss or liverwort.

With the plugs it will be important to start the programme against moss and liverwort shortly after weaning, otherwise inoculum could build up unawares, and eradication is more difficult to achieve than prevention. This was highlighted in this work, where an unavoidable delay in starting the trial on the commercial nurseries meant that plugs were already ‘dirty’, and consequently treatments were less effective than they might have been.

The problems of bringing in dirty plugs was also demonstrated with Nursery C, where a massive influx of Annual Meadow Grass in the early stages of liner growth was the result of contaminated plugs. This necessitated several hand weedings to get on top of the problem, though it was significantly reduced by the herbicides Lenacil 80 W, Axit GR and Ronstar 2G.

As far as weed control goes, identification is the important first step in choice of herbicide programme. For example, Axit GR proved effective, though did not give total control, of Pearlwort, while Ronstar 2G, Lenacil 80 W and Axit GR gave a good check to Annual Meadow Grass and Hairy Bittercress. The granular herbicides become more effective under damper conditions, which aids distribution of the active ingredient over the media surface. This needs balancing, however, with drier regimes reducing the presence of inoculum in the first place.

Lenacil 80 W proved the most striking herbicide for the liner stage, providing as effective moss and liverwort control to Panacide M and Mogeton, plus weed control. However, there were concerns as to its safety of use, and while it appeared 'relatively safe' on mature and dormant crops overwinter, it did cause damage when applied to a spring flush of soft growth. The golden and variegated species proved particularly sensitive (*Forsythia*, *Euonymus*), as did *Ceanothus.* It will, therefore be important to test this herbicide for safety of use over a wider range of species to determine its potential. At the moment Lenacil 80 W does not have registration for use under protection, which will need addressing if it is to be considered for this application.

The fact that Lenacil 80 W appeared relatively safe for overwintering liners was encouraging, since this is the period when there can be a serious build up of moss and liverwort, as well as some weeds such as Annual Meadow Grass and Hairy Bittercress. It also raises the question as to whether other herbicides with activity against moss and liverwort, but considered less safe for use over the growing season, might also be able to be used over this period. This requires further investigation to identify promising candidate herbicides that will still be available in the future, and test them for safety of use under protection over crops at different stages of growth. This would strengthen the options for developing guidelines and strategies for moss, liverwort and weed control for plugs and liners under protection, linked to specific problems. Programmes will then be able to be developed incorporating a number of chemicals/herbicides to match individual nursery requirements, the effectiveness of which will be improved by controlled irrigation to achieve 'drier' regimes.

The best treatments from the work at present would be Panacide M, (or Mogeton when registered), for the plug stage, which basically has a moss and liverwort problem. For the liners there is the option to use one of the granular herbicides at potting, following up with Panacide M or Mogeton later on for moss and liverwort if a problem, possibly in combination with Flexidor for weed control, linking with a late winter application of Lenacil 80 W. However we must stress that few of these chemicals/herbicides have registration for use under protection, nor are they always safe, and manufacturers labels should be followed. There is more work to be done before they can be widely used, except under experimental permit. In addition, consideration also needs to be given as to their interaction with IPM programmes.

Table. 11 summarises the overall effectiveness of the chemicals/herbicides against moss, liverwort and weeds, with Tables 12-13 outlining details of any phytotoxicity observed.

**Table 11	Overall summary of efficacy of treatments against moss, liverwort and weeds**

Key: **x** Nil	• slight	• • moderate	• • • good control

Treatment	Rate/m^2	Moss	Liverwort	Annual M. Grass	Hairy Bittercress	Pearlwort	Deposit
Plugs							
Panacide M	**2.5 mls**	• • •	• •	-	-	-	x
Mogeton	**1.4 g**	• • •	• •	-	-	-	4
Diuron @	**0.025 g**	• • •	• • •	-	-	-	x
Diuron @	**0.0125 g**	x	•	-	-	-	x
Ronstar 2 G	**20.0 g**	• •	• •	-	-	-	x
Bravo	**0.75 g**	• •	• •	-	-	-	4
Jet 5	**25 ppm**	•	•	-	-	-	x
Enigma Anolyte	**pH 6.0**	x	•	-	-	-	x
Bark mulch	**5 mm**	• • •	• •	-	-	-	x
Liners							
Controlled irrigation		• • •	• • •				
Panacide M	**2.5 mls**	• •	• • •	x	x	x	x
Mogeton	**1.4 g**	• • •	• • •	x	x	x	4
Diuron	**0.025 g**	• • •	• • •	-	-	-	x
Lenacil 80 W	**0.15 g**	• • •	• • •	• • •	• •	•	x
Axit GR	**10.0 g**	•	•	• • •	•	• • •	x
Ronstar 2G	**20.0 g**	•	•	• • •	• •	•	x

Notes :

- While controlled irrigation reduced weed presence, direct comparison of effects on individual weed species was not possible in this trial since their presence varied between nurseries.

- Plugs – Poor control of moss where plugs were already contaminated at the start of the trial, since treatments were designed for prevention rather than eradication of existing infestations.

- Always consult the manufacturers literature to check that the product has approval for use under the conditions for which it is required. Where a product has clearance for use on another crop **grown under similar conditions**, then it may be used on ornamentals at the growers' own commercial risk under the off-label arrangements for 'Long Term Arrangements for Extension of Use (2000).

Table 12 **Overall summary of safety of use of a range of chemicals investigated during the course of the Efford and commercial trials - PLUGS**

Key for phytotoxicity: 4 nil • some • • moderate • • • severe

Chemical Rate/m^2	Panacide M 2.5 ml	Mogeton 1.4 g	Diuron 0.025 g	Diuron 0.0125 g	Ronstar 2G 20.0 g	Bravo 0.75 g	Jet 5 25 ppm	Anolyte
Efford								
***Azalea* 'Blue Danube'**	4	4	• • •	-	4	4	4	4
***Cytisus* 'Burkwoodii'**	4	• •	• • •	-	4	4	4	4
***Euonymus fortuneir* 'Silver Queen'**	4	4	4	-	4	4	4	4
Commercial								
***Berberis thunbergii* 'Aurea'**	4	•	-	• • •	•	-	-	-
***Euonymus fortunei* 'Harlequin'**	4	4	-	4	4	-	-	-
***Forsythia intermedia* 'Golden Times'**	4	4	-	4	4	-	-	-
***Hypericum moserianum* 'Tricolor'**	4	4	-	•	4	-	-	-
***Pyracantha coccinea* 'Red Column'**	4	4	-	4	4	-	-	-
***Camellia japonica* 'Brushfields Yellow'**	4	•	-	4	4	-	-	-
***Choisya ternata* 'Sundance'**	•	4	-	•	•	-	-	-
***Elaeagnus pungens* 'Maculata'**	4	4	-	4	4	-	-	-
***Ilex aquifolium* 'Ferrox Argentea'**	4	4	-	•	4	-	-	-
Magnolia stellata	4	4	-	•	4	-	-	-
***Ceanothus* 'Yankee Point'**	4	4	-	4	4	-	-	-
Cotoneaster horizontalis	4	4	-	4	4	-	-	-
***Hebe albicans* 'Red Edge'**	4	4	-	4	4	-	-	-
***Hypericum moserianum* 'Tricolor'**	4	4	-	4	4	-	-	-
Pernettia mucronatum	4	4	-	4	4	-	-	-

Table 13 **Overall summary of safety of use of a range of chemicals investigated during the course of the Efford and commercial trials - LINERS**

Key for phytotoxicity 4 nil • some • • moderate • • • severe

Chemical **Rate/m²** ***Type of growth***	**Panacide M** **4.0 ml**	**Mogeton** **1.4 g**	**Diuron** **0.025 g**	**Lenacil 80 W** **0.15 g** ***Soft***	**Lenacil 80 W** **0.15 g** ***Mature***	**Axit GR** **10.0 g**	**Ronstar 2G** **20.0 g**
Efford							
Azalea **'Blue Danube'**	4	4	4	-	4	4	4
Cistus **'Silver Pink'**	4	4	4	-	4	4	4
Cotoneaster conspicuus	4	4	4	-	4	4	4
Cytisus **'Burkwoodii'**	4	4	• •	-	4	4	4
Euonymus fortunei **'Silver Queen'**	4	4	• •	-	*	4	4
Mag. soulangeana **'Rustica Rubra'**	4	4	4	-	4	4	4
Prunus lusitania	4	4	4	-	4	4	4
C. law. **'Columnaris Glauca'**	4	4	•	-	4	4	4
Commercial							
Berberis thunbergii **'Aurea'**	4	4	-	4	4	4	4
Euonymus fortunei **'Harlequin'**	4	4	-	• • •	4	4	4
Forsythia x intermedia **'Golden Times'**	4	4	-	• • •	4	4	4
Hypericum moserianum **'Tricolor'**	4	4	-	4	4	4	4
Pyracantha coccinea **'Red Column'**	4	4	-	4	4	4	4
Camellia japonica **'Brushfields Yellow'**	4	4	-	4	4	4	4
Choisya ternata **'Sundance'**	4	4	-	4	4	4	4
Elaeagnus pungens **'Maculata'**	4	4	-	•	4	4	4
Ilex aquifolium **'Ferrox Argentea'**	4	4	-	4	4	4	4
Magnolia stellata	4	4	-	4	4	4	4
Ceanothus **'Yankee Point'**	4	4	-	• • •	4	4	4
Cotoneaster horizontalis	4	4	-	4	4	4	4
Hebe albicans **'Red Edge'**	4	4	-	4	4	4	4
Hypericum moserianum **'Tricolor'**	4	4	-	4	4	4	4
Pernettia mucronatum	4	4	-	4	4	4	4

The cost of the various chemicals/herbicides is presented in Table 14, where it can be seen that the price of the granular herbicides are over 10 times that of Lenacil 80 W, and Mogeton almost 6 times that of Panacide M.

Table 14 **Chemicals/Herbicides used and costs/m^2@ 16 November 2001**

Product	Supplier of product used in trial	Active Ingredient	Product Rate/m^2	Product Cost/m^2 - pence
Bravo	Syngenta	chlorthalonil	0.75 g	0.65
Panacide M	Coalite	dichlorphen	2.5 ml	1.3
Mogeton	Hortichem	quinoclamine	1.4 g	6.1
Lenacil 80	Fargro	lenacil 80 W	0.15 g	0.84
Axit GR	Fargro	trifluarialin+ isoxaben	10.0 g	9.3
Ronstar 2G	Hortichem	oxadiazon	20.0 g	10.7

Addresses:

Coalite Chemicals
PO Box 152, Buttermilk Lane, Bolsover, Chesterfield, Derbyshire, S44 6AZ
Tel: 01246 826816 Fax: 01246 240309
e-mail: sales@coalitechemicals.com

Fargro Ltd
Toddington Lane, Littlehampton, Sussex BN17 7PP
Tel: 01903 721591 Fax: 01903 730737
e-mail: promos-fargro@btinternet.com

Hortichem Ltd
A division of Certis Europe BV
16 Mills Way, Boscombe Down Business Park
Amesbury, Wiltshire SP4 7RX
Tel: 01980 676500 Fax: 01980 626555
e-mail: certis@certiseurope.co.uk

Syngenta Crop Protection UK Ltd Whittlesford, Cambridge CB2 4QT
Tel: 0800 169 6058 Fax: 01223 493700

Conclusions

Detailed trial work at HRI Efford between 1998-2000 identified a range of chemicals / herbicides which had potential for control of moss, liverwort and/or weeds. These were taken on into commercial trialling between 2000-2001 on three nurseries in the ALP Group in different parts of the country. The main findings can be summarised as follows :

- Moss and liverwort proved the main problems in the **plug** stage, with Panacide M and Mogeton proving the most effective treatments

- In the **liner** stage, management of dryer watering regimes produced a marked reduction in moss, liverwort and weed presence, and was seen as a major step forward in weed control strategies, with reduced reliance on chemicals/herbicides

- Herbicide programmes were more effective where weed inoculum was reduced

- Liverwort was easier to control than moss

- Effective control depended on matching treatment to weed species present

➢ Panacide M, and particularly Mogeton, gave reasonable control of moss and liverwort, but not weeds

➢ Lenacil 80 W proved the most effective herbicide, controlling moss, liverwort and weeds (except Pearlwort), but proved phytotoxic to some species when applied to softer growth (Golden *Forsythia*, *Euonymus* 'Harlequin', *Ceanothus*). It proved much safer to use overwinter.

➢ Ronstar 2G gave effective control of Hairy Bittercress (*Cardamine hirsuta*) and Annual Meadow Grass (*Poa annua*), but not Pearlwort (*Sagina procumbens*), nor in this trial moss or liverwort

➢ Axit GR controlled Annual Meadow Grass and Pearlwort, but appeared less effective against Hairy Bittercress, and gave little control of moss or liverwort

The results from this project will enable guidelines to be developed for herbicide programmes to control moss, liverwort or weeds at different times of the year. However, few have approval for use under protection at the moment, necessitating further action when their potential is determined.

Technology Transfer

Results presented at the following HDC events :

- ***Propagation Workshop – Theory into practice***

  22-23 September 1999, at HRI East Malling

- ***Propagation Workshops during 2000***

  Hewton Nursery, 22 August 2000

  New Place Nurseries, 13 September 2000

  Northern Liners, 21 September 2000

- ***Weed Control Workshops***

  Northern Liners, 29 November 2000

  Hilliers nurseries, 1 December 2000

- ***Four Oaks Trade Show Exhibit***

  4-5 September 2001

- ***HNS Open Day, HRI Efford***

  25-26 September 2001