

<b>Project title:</b>	Container Grown HNS: Further crop safety screening of Dual Gold (s-metolachlor) and Sumimax (flumioxazine)
<b>Project number:</b>	HNS 139a
<b>Project leader:</b>	John Atwood, ADAS
<b>Report:</b>	Final report, June 2012
<b>Previous report:</b>	N/A
<b>Key staff:</b>	John Atwood – ADAS Project Leader Harriet Roberts – ADAS Site Manager
<b>Location of project:</b>	Darby Nursery Stock , Methwold, Thetford, Norfolk, IP26 4PW
<b>Industry Representative:</b>	Ian Nelson, Johnsons of Whixley Ltd. Whixley, York, YO26 8AQ
<b>Date project commenced:</b>	1 <sup>st</sup> April 2011
<b>Date project completed (or expected completion date):</b>	30 <sup>th</sup> June 2012

## **DISCLAIMER**

*AHDB, operating through its HDC division seeks to ensure that the information contained within this document is accurate at the time of printing. No warranty is given in respect thereof and, to the maximum extent permitted by law the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.*

*Copyright, Agriculture and Horticulture Development Board 2012. All rights reserved.*

*No part of this publication may be reproduced in any material form (including by photocopy or storage in any medium by electronic means) or any copy or adaptation stored, published or distributed (by physical, electronic or other means) without the prior permission in writing of the Agriculture and Horticulture Development Board, other than by reproduction in an unmodified form for the sole purpose of use as an information resource when the Agriculture and Horticulture Development Board or HDC is clearly acknowledged as the source, or in accordance with the provisions of the Copyright, Designs and Patents Act 1988. All rights reserved.*

*AHDB (logo) is a registered trademark of the Agriculture and Horticulture Development Board. HDC is a registered trademark of the Agriculture and Horticulture Development Board, for use by its HDC division. All other trademarks, logos and brand names contained in this publication are the trademarks of their respective holders. No rights are granted without the prior written permission of the relevant owners.*

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

## AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

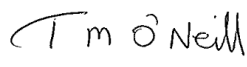
John Atwood  
Principal Horticultural Consultant  
ADAS

Signature .  .

Date. 27 June 2012

## Report authorised by:

Tim O'Neill  
Horticulture Research Manager  
ADAS

Signature  .

Date 27 June 2012

# CONTENTS

<b>Grower Summary .....</b>	<b>1</b>
Headline.....	1
Background.....	1
Summary .....	2
Financial Benefits .....	7
Action Points.....	7
<b>Science Section .....</b>	<b>8</b>
Introduction .....	8
Materials and methods .....	9
Results and discussion .....	10
Conclusions .....	21
Knowledge and Technology Transfer .....	23
References .....	24
Appendices .....	25

## **GROWER SUMMARY**

### **Headline**

Over 100 cultivars of nursery stock have been assessed for tolerance to two new herbicides: Dual Gold (s-metolachlor) and Sumimax (flumioxazine). A large number of species have been identified as tolerant to summer applications of Dual Gold and winter applications of Sumimax, increasing herbicide options available to the hardy nursery stock (HNS) industry.

### **Background**

At present the HNS industry is dependant on relatively few herbicides and consequently resistant weeds can be a problem. There are limited options for summer treatments to enable control of a full range of weeds. Ronstar 2G (oxadiazon) can be applied after potting and is typically followed with Flexidor 125 (isoxaben). Flexidor 125 however does not control groundsel, willowherb or grasses and has sometimes failed to control pearlwort. Results from HNS 139 showed that Dual Gold could contribute improved control of all of these weeds. Because of the wide range of stock grown in the UK it was suggested that a broader range of crop safety information would be desirable to enable growers to take advantage of this herbicide. Dual Gold can be used on outdoor ornamentals under an Extension of Authorisation for Minor Use (EAMU) 2012/0501, however applications may only be made during the period 1-31 May.

For winter herbicide treatments growers have been largely dependant on Butisan S and Flexidor 125 to clean up and maintain control into the spring. New label restrictions mean that metazachlor products (such as Butisan S or Sultan 50SC) can only be used up to a maximum of 1000 g a.i./ha metazachlor over a three year period on the same site, reducing to around 25% the amount previously used each year and therefore making it less useful as a nursery herbicide. Sumimax has a broad weed control spectrum and could be a potential replacement for winter use but, as with Dual Gold, a broader range of crop safety information would be desirable particularly for evergreens.

This project aimed to provide further crop safety information on a wide variety of container-grown stock treated with Dual Gold and Sumimax, by spraying un-replicated treatment strips across a very broad range of container-grown shrubs. Treatments were applied in addition to the normal nursery herbicide programme then closely monitored for phytotoxicity and any effects scored. Recommendations for treatment are based on these findings.

## Summary

Two trials were carried out on a commercial nursery (Darby Nursery Stock, Norfolk). The aim was to cover example cultivars of all of the main range of hardy nursery stock subjects normally grown on commercial nurseries in the UK and assess their susceptibility or tolerance to applications of Dual Gold and Sumimax.

Experiment one was carried out in summer 2011, with one application of Dual Gold applied at 1.4 L/ha (at 1000 L water/ha) to plots of 1 m<sup>2</sup>. Eighty-nine HNS subjects were sprayed in all between 28<sup>th</sup> June and 11<sup>th</sup> July. These were assessed for any damage or growth effects 2, 6 and 12 weeks after treatment application. Note that the rate of use approved under the EAMU is now 0.78 L/ha, lower than the rate used in this trial. At the time of the experimental application Dual Gold was approved at 1.4 L/ha (label recommendation for Maize) under the Long Term Arrangements for Extension of Use. The EAMU was subsequently granted at a lower rate.

Experiment two was carried out in winter 2011/12, with one application of Sumimax (flumioxazine) being applied at 0.1 L/ha (at 1000 L water/ha) to plots of ~1 m<sup>2</sup>. Ninety-five HNS subjects were sprayed in all on the 17<sup>th</sup> January. These were assessed for any damage or growth effects 2, 6 and 12 weeks after treatment application.

Table 1 provides a summary of all the subjects assessed showing which are tolerant to herbicide applications and which are likely to be damaged by such treatments. With both treatments and timings, the majority of subjects tested showed little or no damage or growth defects as a result of the treatment applications. The exceptions are detailed below

### **Dual Gold**

*Berberis* varieties showed some stunting and leaf cupping initially after treatment but this was short lived with no differences being obvious after 6 weeks. *Buddleja* varieties, 'Lochinch' in particular showed some significant yellowing to foliage still obvious 12 weeks after application. *Cotinus* 'Grace', *Forsythia x intermedia* 'Lynwood Variety', *Hebe* 'Sapphire' and *Jasminum officinale* 'Clotted cream' all showed puckering and distortion of young leaves and tips soon after treatment but subsequently grew away and new leaves were unaffected by week 12. *Kerria japonica* 'Golden Guinea', *Philadelphus* 'Manteau d'Hermine' and *Sambucus nigra* f. *porphyrophylla* 'Eva' showed varying levels of leaf scorch with the *Sambucus* being the worst affected, again all grew away from damage by week 12.

*Lonicera japonica* 'Halliana' showed leaf blistering to sprayed leaves but new leaves were unaffected. *Rhus typhina* 'Laciniata' showed some severe stunting initially but recovered well.

## Sumimax

Sumimax was applied when many of the subjects were dormant such that phytotoxic affects in many cases were only observed at the final assessment. Several species showed delayed development and bud break including; *Euonymus fortunei* 'Emerald Gaiety' and 'Silver Queen', *Kerria* 'Golden Guinea', *Pachysandra terminalis* 'Variegata', *Philadelphus* 'Belle Etoile' and *Spiraea* cultivars. *Cytisus* 'Porlock' and *Lonicera nitida* 'Baggesen's Gold' showed some obvious stunting. *Cornus sericea* 'Hedgerows Gold' (v) and *Pelargonium* Angeleyes Bicolor 'Pabicolor' were stunted but also showed leaf purpling and browning. Other species including *Abelia*, *Cistus*, *Euryops*, *Hedera*, *Hypericum*, *Leycesteria*, *Ligustrum*, *Pittosporum*, *Pyracantha*, *Sorbaria* and *Viburnum* showed bronzing, brown flecking and patching to young leaves. Damage was very slight in the case of *Abelia*, *Cistus*, *Hypericum* and *Sorbaria* but was more significant and persistent on *Hedera helix* 'Glacier', *Pittosporum tenuifolium* 'Tom Thumb', *Pyracantha* and evergreen *Viburnum*.

**Table 1.** Tolerance to applications of Dual Gold and Sumimax. (S = Susceptible – unacceptable crop damage can occur - do not treat, MS = Moderately Susceptible – some crop damage may occur but plants normally grow away, T = Tolerant, any damage considered insignificant, - = not tested)

Varieties	Dual Gold (applied summer 2011)	Sumimax (applied winter 2012)
<i>Abelia x grandiflora</i> 'Gold Spot'	T	T
<i>Amelanchier canadensis</i>	T	T
<i>Aucuba japonica</i> 'Crotonoides'	T	-
<i>Aucuba japonica</i> 'Variegata'	-	T
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Admiration'	MS	-
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Atropurpurea Nana'	T	-
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Aurea'	-	T
<i>Berberis darwinii</i>	MS	T
<i>Berberis x ottawensis</i> f. <i>purpurea</i>	T	-
<i>Berberis x stenophylla</i>	-	T
<i>Buddleja alternifolia</i>	MS	-
<i>Buddleja davidii</i> 'Buzz Magenta'	-	T
<i>Buddleja</i> 'Lochinch'	S	-
<i>Caryopteris x clandonensis</i> 'Heavenly Blue'	T	T
<i>Caryopteris x clandonensis</i>	T	-

Varieties	Dual Gold (applied summer 2011)	Sumimax (applied winter 2012)
'Worcester Gold'		
<i>Ceanothus</i> 'Blue mound'	-	T
<i>Ceanothus</i> 'Concha'	T	-
<i>Ceanothus x delileanus</i> 'Gloire de Versailles'	T	T
<i>Ceratostigma willmottianum</i> 'Forest Blue'	T	-
<i>Ceratostigma plumbaginoides</i>	T	T
<i>Chaenomeles x superba</i> 'Crimson and Gold'	T	-
<i>Chaenomeles x superba</i> 'Pink Lady'	T	-
<i>Cistus x pulverulentus</i> 'Sunset'	-	T
<i>Clematis alpina</i> 'Constance'	T	-
<i>Clematis x cartmanii hort.</i> 'Avalanche'	T	-
<i>Clematis interfolia</i> 'Petit foucon'	T	-
<i>Clematis macropeta</i> 'Markham's Pink'	T	-
<i>Clematis macropetala</i>	T	-
<i>Clematis montana</i> 'Rubens'	T	-
<i>Clematis</i> 'Piilu'	-	T
<i>Clematis</i> 'Polish Spirit'	-	T
<i>Convolvulus cneorum</i>	-	T
<i>Cornus alba</i> 'Baton Rouge'	-	T
<i>Cornus sericea</i> 'Flaviramea'	T	T
<i>Cornus sericea</i> 'Hedgerows Gold' (v)	T	S
<i>Cornus sanguinea</i> 'Midwinter Fire'	T	-
<i>Cornus alba</i> 'Sibirica Variegata'	T	T
<i>Coronilla valentina subsp. glauca</i> 'Citrina'	-	T
<i>Continus coggygria</i> 'Royal Purple'	T	T
<i>Cytisus</i> 'Lena'	T	T
<i>Cytisus</i> 'Porlock'	-	MS
<i>Cytisus x praecox</i>	T	-
<i>Cytisus x praecox</i> 'Allgold'	-	T
<i>Deutzia gracilis</i> 'Nikko'	T	-
<i>Elaeagnus pungens</i> 'Maculata'	T	T
<i>Escallonia</i> 'Peach Blossom'	-	T
<i>Escallonia</i> 'Red Dream'	T	T
<i>Euonymus fortunei</i> 'Emerald Gaiety'	-	MS
<i>Euonymus fortunei</i> 'Emerald'n gold'	-	T
<i>Euonymus japonicas</i> 'Ovatus Albus'	-	T
<i>Euonymus fortunei</i> 'Silver Queen'	-	MS
<i>Euphorbia</i> 'Despina'	-	T
<i>Euryops pectinatus</i>	-	MS
<i>Exochorda x macrantha</i> 'The Bride'	T	T
<i>Forsythia x intermedia</i> 'Lynwood Variety'	T	T



Varieties	Dual Gold (applied summer 2011)	Sumimax (applied winter 2012)
<i>Fuchsia</i> 'Delta's Sarah'	T	-
<i>Genista lydia</i>	T	T
<i>Hebe</i> 'Silver Queen'	T	-
<i>Hebe</i> 'Margaret'	T	-
<i>Hebe</i> 'Sapphire'	MS	-
<i>Hedera colchica</i> 'Dentata Variegata'	T	T
<i>Hedera helix</i> 'Glacier'	T	S
<i>Helichrysum</i> 'Icicles'	-	T
<i>Helichrysum italicum</i> 'Korma'	T	T
<i>Hydrangea macrophylla</i> 'Madame Emile Mouillere'	T	-
<i>Hydrangea paniculata</i> 'Phantom'	-	T
<i>Hydrangea petiolaris</i>	T	T
<i>Hydrangea aspera</i> Villosa Group	T	-
<i>Hypericum</i> 'Hidcote variegata'	T	T
<i>Hypericum</i> x <i>moserianum</i>	-	T
<i>Hypericum</i> x <i>moserianum</i> 'Tricolor'	-	T
<i>Ilex</i> x <i>altaclerensis</i> 'Golden King'	T	T
<i>Jasminum humile</i> 'Revolution'	T	-
<i>Jasminum nudiflorum</i>	-	T
<i>Jasminum officinale</i> 'Clotted Cream'	S	-
<i>Kerria</i> 'Golden Guinea'	T	MS
<i>Kolkwitzia</i> 'Pink Cloud'	T	T
<i>Lavatera</i> x <i>clementii</i> 'Burgundy Wine'	-	T
<i>Lavatera</i> x <i>clementii</i> 'Rosea'	T	-
<i>Lavendula angustifolia</i> 'Vera'	-	T
<i>Lavendula angustifolia</i> 'Hidcote'	T	-
<i>Lavender stoechas</i> 'Regal Splendour'	T	T
<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'	T	S
<i>Ligustrum japonicum</i> 'Aureum'	T	T
<i>Ligustrum ovalifolium</i>	-	MS
<i>Lonicera nitida</i> 'Baggesen's Gold'	T	MS
<i>Lonicera japonica</i> 'Cream Cascade'	-	T
<i>Lonicera fragrantissim</i> '	MS	T
<i>Lonicera japonica</i> 'Halliana'	MS	-
<i>Mahonia</i> x <i>media</i> 'Charity'	-	T
<i>Mahonia</i> x <i>media</i> 'Lionel Fortescue'	T	-
<i>Osmanthus</i> x <i>burkwoodii</i>	T	T
<i>Pachysandra terminalis</i> 'Green Carpet'	-	T
<i>Pachysandra terminalis</i> 'Variegata'	-	T
<i>Pelargonium Angeleyes</i> Bicolor 'Pabicolor'	-	S
<i>Perovskia</i> 'Blue Spire'	T	-

Varieties	Dual Gold (applied summer 2011)	Sumimax (applied winter 2012)
<i>Philadelphus</i> 'Belle Etoile'	-	T
<i>Philadelphus</i> 'Manteau d'Hermine'	T	T
<i>Philadelphus</i> 'Starbright'	-	T
<i>Photinia fraseri</i> 'Red Robin'	T	-
<i>Photinia</i> 'Scarlet Blaze'	-	MS
<i>Physocarpus opulifolius</i> 'Angel Gold'	T	T
<i>Physocarpus opulifolius</i> 'Diabolo'	-	T
<i>Physocarpus opulifolius</i> 'Lady in Red'	T	T
<i>Pittosporum garnettii</i>	-	T
<i>Pittosporum tenuifolium</i> 'Tom Thumb'	-	S
<i>Potentilla fruticosa</i> 'Abbotswood'	T	-
<i>Potentilla fruticosa</i> 'Gold Star'	T	-
<i>Prunus incisa</i> 'Kojo-no-Mai'	T	T
<i>Prunus laurocerasus</i> 'Cherry Brandy'	T	T
<i>Pyracantha</i> 'Mohave'	-	S
<i>Pyracantha</i> 'Orange Glow'	T	-
<i>Pyracantha coccinea</i> 'Red Column'	T	S
<i>Rhus typhina</i> 'Laciniata'	S	-
<i>Rosa</i> 'Iceberg' = 'Korbin'	T	T
<i>Rosmarinus</i> 'Miss Jessopp's Upright'	T	-
<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	S	T
<i>Santolina chamaecyparissus</i>	-	T
<i>Santolina rosmarinifolia</i> 'Primrose Gem'	-	T
<i>Brachyglottis</i> (Dunedin Group) 'Drysdale'	-	T
<i>Sorbaria sorbifolia</i> 'Sem'	T	T
<i>Spiraea</i> 'Arguta'	T	T
<i>Spiraea japonica</i> 'Firelight'	T	T
<i>Spiraea japonica</i> 'Golden Princess'	-	T
<i>Spiraea japonica</i> 'Goldflame'	T	T
<i>Spiraea japonica</i> 'Little Princess'	-	MS
<i>Spiraea japonica</i> 'Shirobana'	T	T
<i>Syringa</i> x <i>josiflexa</i> 'Bellicent'	T	T
<i>Syringa meyeri</i> 'Palibin'	-	T
<i>Viburnum davidii</i>	T	S
<i>Vinca major</i> 'Maculata'	T	-
<i>Vinca minor</i> 'Ralph Shugert'	T	-
<i>Weigela</i> 'Kosteriana variegata'	T	T
<i>Weigela florida</i> 'Foliis Purpureis'	T	T
<i>Wisteria floribunda</i> 'Domino' = 'Issai'	T	-

## Financial Benefits

The use of Dual Gold should give improved summer weed control particularly for willowherb, groundsel and grasses although the rate of use approved is lower than that used in trials so efficacy could be reduced. Sumimax is a possible replacement for Butisan S or Sultan 50 SC as a winter clean-up and residual treatment for weed control in established stock.

Virtually all container nursery stock growers could benefit from this work as weed control is a common problem across the industry. Willowherb and groundsel are particular problems and restrictions on the use of metazachlor containing products such as Butisan S or Sultan 50 SC imposed this year will make control more difficult to achieve. The costs of Dual Gold and Sumimax are relatively low at £14/ha and £17/ha respectively. It is anticipated that saving one round of hand weeding at a cost of 2.5p per pot (187,500 pots/ha) equates to a saving of £4687/ha

## Action Points

- Dual Gold can be used as an addition to the normal herbicide programme on a wide range of HNS subjects for improved control of groundsel, grasses and willowherb
- Dual Gold is only authorised for application during May at 0.78 L/ha under EAMU 20120501
- Sumimax (or similar products Guillotine and Digital) can be used on a range of HNS subjects (see list of susceptibility in Table 1) during the dormant season for control of existing seedling weeds and residual weed control
- Sumimax, Digital and Guillotine are authorised for use on outdoor ornamentals under EAMUs 20082844, 20082897 and 20082881
- Although a number of dormant evergreen species were tolerant of Sumimax it caused damage to some species such as *Pyracantha*. Some caution should therefore be exercised before treating species for the first time.

## SCIENCE SECTION

### Introduction

At present, the hardy nursery stock industry is dependant on relatively few herbicides and consequently resistant weeds can be a problem. There are limited options for summer treatments to enable control of a full range of weeds. Ronstar 2G (oxadiazon) can be applied after potting and is typically followed with Flexidor 125 (isoxaben). Flexidor 125, however, does not control groundsel, willowherb or grasses and has sometimes failed to control pearlwort. Results from HNS 139 (Atwood 2009) showed that Dual Gold (s-metolachlor) could contribute improved control of all of these weeds and was tested on a limited range of 20 shrub species with only minor adverse effects noted. Some further information is available from the use of similar product Pennant Magnum (s-metolachlor) in the US but most research has been on herbaceous crops (Palmer, Vea and Lightbourne, 2006). Because of the wide range of stock grown in the UK it was considered that a broader range of crop safety information would be desirable to enable growers to take advantage of this herbicide. Further screening on herbaceous crops was completed in HNS 166 (Atwood 2010). Dual Gold can be used on outdoor ornamentals under an Extension of Authorisation for Minor Use (EAMU) 20120501.

For winter herbicide treatments, growers have been largely dependant on Butisan S (metazachlor) and Flexidor 125 to clean up and maintain control into the spring. New label restrictions mean that metazachlor products (such as Butisan S) can only be used up to a maximum of 1000 g a.i./ha metazachlor over a three year period on the same site, reducing to around 25% the amount previously used each year. Sumimax (flumioxazine) has a broad weed control spectrum as identified in HNS 139 and could be a potential replacement for winter use but, as with Dual Gold, a broader range of crop safety information would be desirable particularly for evergreens. Although the active flumioxazine is used on ornamentals in the US, the main product used for container grown stock is Broadstar (flumioxazine), a granular product which would have much reduced contact activity compared with a sprayable formulation. The sprayable formulation in the US is Sureguard (flumioxazine), but is used mainly on field grown deciduous crops. A number of trials have been carried out in the US under the IR4 programme using both Broadstar and Sureguard (Palmer and Vea, 2007) on container grown crops including a limited range of conifers, but the formulations and rates of use are different to those available in the UK. Nursery trials have indicated some potential for the use of sprayable formulations of flumioxazine as autumn or winter treatments for deciduous container grown stock (Barolli and Ahrens, 2009). However, there is little information on the use of sprayable flumioxazine formulations

such as Sumimax and Sureguard on container grown crops evergreens during the dormant season. Sumimax (and similar products Digital and Guillotine) can be used on outdoor ornamentals under EAMUs 20082844, 20082897 and 20082881.

The aim of the project was to test both herbicides over cultivars of all of the main hardy nursery stock subjects normally grown on commercial nurseries in the UK. The species were selected in discussion with the project co-ordinator and technical manager of the host nursery, taking into account existing information from HNS 139 and US data on Pennant Magnum and Sureguard when selecting species for testing. The specific objectives were:

- To test Dual Gold for crop safety on a wide range of container-grown shrubs when applied as a summer treatment over crop foliage
- To test Sumimax for crop safety on a wide range of container-grown shrubs, including evergreens, when applied as a mid-winter, dormant season treatment.

## **Materials and methods**

The trials were carried out on a commercial hardy nursery stock holding (Darby Nursery Stock, Methwold, Norfolk). The species/cultivars selected for testing were chosen by the study director in discussion with the project's industry representative and Darby's nursery technical manager. Most of the plants were from Darby Nursery Stock commercial stock but three species; *Rosa*, *Prunus* and *Viburnum* were sourced from Robin Tacchi Plants, Garboldisham, Norfolk as they were not available on the nursery. Full details of the potting mix, standard herbicide applications, irrigation and meteorological records are displayed in the appendices along with an image of each subject on the day of application. Outdoor species were stood out on outdoor sandbeds. Indoor species (as indicated in Appendix 6) were raised in polytunnels or glasshouses.

### **Experiment 1**

Un-replicated 1 m<sup>2</sup> treatment plots were marked out alongside an untreated plot within each commercial species block. The number of plants in each plot varied according to the pot size and spacing but generally consisted of 4x4 or 5x5 pots. Dual Gold was applied at 1.4 L/ha in 1000 L water/ha to newly potted plants on Airfield site on 29<sup>th</sup> June and on the Broad fen site on 11<sup>th</sup> July 2011 (table 1). The Dual Gold application went on in addition to the standard herbicide programme being used on site, and in most cases these plants had already received Ronstar 2G after potting (full details Appendix 6).

Plants were monitored for phytotoxicity and quality for 3 months following treatment taking 3 assessments at 2, 6 and 12 weeks after treatment assessing the central pots within each

plot, comparing individual effects with the control and scoring on a 0-9 scale where zero was dead and nine was no effect, photographing observed symptoms.

## Experiment 2

A further trial was carried out in winter 2012 applying an un-replicated treatment of Sumimax to 1 m<sup>2</sup> plots marked out alongside an untreated plot within each commercial species block. The number of plants in each plot varied according to the pot size and spacing but generally consisted of 4x4 or 5x5 pots. Sumimax was applied at 100 ml/ha in 1000 L water/ha on 17<sup>th</sup> January (Table 1). In most cases, these plants also received a standard herbicide programme including Flexidor 125 applied by Darby Nursery Stock staff. Nursery standard treatments were applied to both the experimental treatment plots and the untreated controls. Nursery standard herbicide applications were documented for each species (full details Appendix 7). Plants were monitored for phytotoxicity for 3 months following treatment taking three assessments at 2, 6 and 12 weeks after treatment assessing the central pots within each plot, comparing individual effects with the control and scoring on a 0-9 scale where 0 is dead and 9 is no effect, photographing observed symptoms.

**Table 1.** Treatment list and application timing

Experiment	Treatment	Active and concentration	Rate	Timing
1	1. Untreated	-	-	29 June 2011 or 11 July 2011
	2. Dual Gold	960 g/L s-metolachlor	1.4 L/ha	
2	1. Untreated	-	-	17 Jan 2012
	2. Sumimax	300 g/L flumioxazine	0.1 L/ha	

## Results and discussion

### Dual Gold

*Berberis* varieties showed some stunting and leaf cupping initially after treatment but this was short lived and no differences were obvious after 6 weeks. *Buddleja* varieties, 'Lochin' in particular, showed some significant yellow flecks to foliage still obvious 12 weeks after application. *Cotinus* 'Grace', *Forsythia* x *intermedia* 'Lynwood Variety', *Hebe* 'Sapphire' and *Jasminum officinale* 'Clotted cream' all showed puckering and distortion of young leaves and tips soon after treatment but which all grew away from; new leaves were unaffected by week 12 although some old damage was still visible on the *Cotinus* and *Jasminum*. *Kerria* 'Golden Guinea', *Philadelphus* 'Manteau d'Hermine' and *Sambucus nigra*

f. *porphyrophylla* 'Eva' showed varying levels of leaf scorch with the *Sambucus* being the worst affected and also being stunted; however again, all grew away from damage by week 12. *Lonicera japonica* 'Halliana' showed leaf blistering to sprayed leaves but new leaves were unaffected. *Rhus typhina* 'Laciniata' showed some severe stunting initially but recovered well. See tables 2 and 3 and figures 1-12

**Table 2.** Dual gold quality/phytotoxicity assessments 2, 6 and 12 weeks after treatment (WAT), 0-9 scale 9 = no effect 0 = dead, >7 = commercially acceptable

Varieties	Quality 2 WAT	Quality 6 WAT	Quality 12 WAT	Average score
<i>Abelia x grandiflora</i> 'Gold Spot'	9.0	9.0	9.0	9.0
<i>Amelanchier canadensis</i>	8.0	9.0	9.0	8.7
<i>Aucuba japonica</i> 'Crotonoides'	9.0	9.0	9.0	9.0
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Admiration'	6.0	9.0	9.0	8.0
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Atropurpurea Nana'	9.0	9.0	9.0	9.0
<i>Berberis darwinii</i>	7.0	9.0	9.0	8.3
<i>Berberis x ottawensis</i> f. <i>purpurea</i>	8.0	9.0	9.0	8.7
<i>Buddleja alternifolia</i>	6.0	9.0	9.0	8.0
<i>Buddleja</i> 'Lochinch'	7.0	5.0	5.0	5.7
<i>Caryopteris x clandonensis</i> 'Heavenly Blue'	9.0	*	*	9.0
<i>Caryopteris x clandonensis</i> 'Worcester Gold'	9.0	*	*	9.0
<i>Ceanothus</i> 'Concha'	9.0	9.0	9.0	9.0
<i>Ceanothus x delileanus</i> 'Gloire de Versailles'	7.0	9.0	*	8.0
<i>Ceratostigma willmottianum</i> 'Forest Blue'	9.0	9.0	9.0	9.0
<i>Ceratostigma plumbaginoides</i>	9.0	9.0	9.0	9.0
<i>Chaenomeles x superba</i> 'Crimson and Gold'	9.0	9.0	*	9.0
<i>Chaenomeles x superba</i> 'Pink Lady'	9.0	9.0	9.0	9.0
<i>Clematis alpina</i> 'Constance'	9.0	*	*	9.0
<i>Clematis</i> 'Avalanche'	9.0	8.3	*	8.7
<i>Clematis interfolia</i> 'Petit Foucon'	9.0	9.0	9.0	9.0
<i>Clematis macropetala</i> 'Markham's Pink'	9.0	*	*	9.0
<i>Clematis macropetala</i>	9.0	*	*	9.0
<i>Clematis montana</i> 'Rubens'	9.0	9.0	9.0	9.0
<i>Cornus</i> 'Flaviramea'	9.0	9.0	9.0	9.0
<i>Cornus sericea</i> 'Hedgerows Gold'	9.0	9.0	9.0	9.0
(v)				9.0
<i>Cornus sanguinea</i> 'Midwinter Fire'	9.0	9.0	9.0	9.0
Varieties	Quality 2 WAT	Quality 6 WAT	Quality 12 WAT	Average score
<i>Cornus alba</i> 'Sibirica variegata'	9.0	9.0	9.0	9.0

<i>Cotinus</i> 'Grace'	7.0	8.0	*	7.5
<i>Cytisus</i> 'Lena'	9.0	9.0	*	9.0
<i>Cytisus</i> x <i>praecox</i>	9.0	9.0	9.0	9.0
<i>Deutzia gracilis</i> 'Nikko'	9.0	9.0	9.0	9.0
<i>Elaeagnus pungens</i> 'Maculata'	9.0	9.0	9.0	9.0
<i>Escallonia</i> 'Red Dream'	9.0	9.0	9.0	9.0
<i>Exochorda</i> x <i>macrantha</i> 'The Bride'	9.0	9.0	9.0	9.0
<i>Forsythia</i> x <i>intermedia</i> 'Lynwood Variety'	6.0	9.0	9.0	8.0
<i>Fuchsia</i> 'Delta's Sarah'	9.0	*	*	9.0
<i>Genista lydia</i>	9.0	*	*	9.0
<i>Hebe</i> 'Silver Queen'	9.0	9.0	*	9.0
<i>Hebe</i> 'Margaret'	9.0	9.0	*	9.0
<i>Hebe</i> 'Sapphire'	9.0	8.5	*	8.8
<i>Hedera colchica</i> 'Dentata Variegata'	9.0	9.0	9.0	9.0
<i>Hedera helix</i> 'Glacier'	9.0	9.0	9.0	9.0
<i>Helichrysum italicum</i> 'Korma'	9.0	9.0		9.0
<i>Hydrangea macrophylla</i> 'Madame Emile Mouillere'	9.0	9.0	9.0	9.0
<i>Hydrangea petiolaris</i>	9.0	9.0	9.0	9.0
<i>Hydrangea aspera</i> Villosa Group	9.0	9.0		9.0
<i>Hypericum</i> 'Hidcote'	9.0	9.0	9.0	9.0
<i>Ilex</i> x <i>altaclerensis</i> 'Golden King'	9.0	9.0		9.0
<i>Jasminum humile</i> 'Revolution'	9.0	9.0	9.0	9.0
<i>Jasminum officinale</i> 'Clotted Cream'	5.0	7.0	9.0	7.0
<i>Kerria japonica</i> 'Golden Guinea'	7.0	9.0	9.0	8.3
<i>Kolkwitzia amabilis</i> 'Pink Cloud'	8.0	9.0	9.0	8.7
<i>Lavatera</i> x <i>clementii</i> 'Rosea'	9.0	9.0	*	9.0
<i>Lavandula angustifolia</i> 'Hidcote'	9.0	*	*	9.0
<i>Lavandula</i> 'Regal Splendour'	9.0	9.0	*	9.0
<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'	9.0	*	*	9.0
<i>Ligustrum japonicum</i> 'Aureum'	9.0	9.0	9.0	9.0
<i>Lonicera nitida</i> 'Baggesen's Gold'	9.0	9.0	9.0	9.0
<i>Lonicera fragrantissima</i>	7.0	9.0	9.0	8.3
<i>Lonicera japonica</i> 'Halliana'	5.0	6.8	8.0	6.6
<i>Mahonia</i> x <i>Media</i> 'Lionel Fortescue'	9.0	9.0	9.0	9.0
<i>Osmanthus</i> x <i>burkwoodii</i>	9.0	9.0	*	9.0
<i>Perovskia</i> 'Blue Spire'	9.0	*	9.0	9.0
<i>Philadelphus</i> 'Manteau d'Hermine'	8.5	9.0	9.0	8.8
<i>Photinia fraseri</i> 'Red Robin'	9.0	9.0	9.0	9.0
<i>Physocarpus opulifolius</i> 'Angel Gold'	9.0	9.0	9.0	9.0
<i>Physocarpus opulifolius</i> 'Lady in Red'	9.0		9.0	9.0
Varieties	Quality 2 WAT	Quality 6 WAT	Quality 12 WAT	Average score
<i>Potentilla fruticosa</i> 'Abbotswood'	9.0	9.0	9.0	9.0



<i>Potentilla fruticosa</i> 'Goldstar'	9.0	9.0	9.0	9.0
<i>Prunus laurocerasus</i> 'Cherry Brandy'	9.0	9.0	9.0	9.0
<i>Prunus incisa</i> 'Kojo-no-Mai'	9.0	9.0	9.0	9.0
<i>Pyracantha</i> 'Orange Glow'	9.0	9.0		9.0
<i>Pyracantha coccinea</i> 'Red Column'	9.0	9.0	9.0	9.0
<i>Rhus typhina</i> 'Laciniata'	4.0	9.0	*	6.5
<i>Rosa</i> 'Iceberg' = 'Korbin'	9.0	9.0	9.0	9.0
<i>Rosmarinus</i> 'Miss Jessopp's Upright'	9.0	9.0	9.0	9.0
<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	5.0	9.0	9.0	7.7
<i>Sorbaria sorbifolia</i> 'Sem'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Arguta'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Firelight'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Goldflame'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Shirobana'	9.0	9.0	9.0	9.0
<i>Syringa</i> x <i>josiflexa</i> 'Bellicent'	9.0	9.0	9.0	9.0
<i>Viburnum davidii</i>	9.0	9.0	9.0	9.0
<i>Vinca major</i> 'Maculata'	9.0	*	*	9.0
<i>Vinca minor</i> 'Ralph Shugert'	9.0	8.0	8.0	8.3
<i>Weigela</i> 'Kosteriana variegata'	9.0	9.0	9.0	9.0
<i>Weigela florida</i> 'Foliis Purpureis'	9.0	9.0	9.0	9.0
<i>Wisteria floribunda</i> 'Domino' = 'Issai'	9.0	9.0	9.0	9.0

\* Plants moved or sold, unable to assess

**Table 3.** Varieties which showed phytotoxicity to Dual Gold and comments on observations

Varieties	2 WAT	6 WAT	12 WAT	Comments
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Admiration'	6	9	9	Stunted, leaf up-cupped at first assessment
<i>Berberis darwinii</i>	7	9	9	slightly smaller at first assessment
<i>Berberis</i> x <i>ottawensis</i> f. <i>purpurea</i>	8	9	9	less extension growth at first assessment
<i>Buddleja alternifolia</i>	6	9	9	Leaf yellowing and leaf tip distortion at first assessment
<i>Buddleja</i> 'Lochinch'	7	5	5	Yellow necrotic spots on edge of leaf, persisted, unacceptable
<i>Cotinus</i> 'Grace'	7	8		Slight puckering of young leaf, grew away but some effect still visible on old leaf
<i>Forsythia</i> x <i>intermedia</i> 'Lynwood Variety'	6	9	9	Slight distortion in tip leaf
<i>Hebe</i> 'Sapphire'	9	8.5		Twisted tips
<i>Jasminum officinale</i> 'Clotted Cream'	5	7	9	Severe tip distortion, recovered with new growth unaffected
<i>Kerria japonica</i> 'Golden Guinea'	7	9	9	Scorch on edge of leaf

<i>Ligustrum japonicum</i> 'Aureum'	9	9	9	Slight leaf tip curling noted between assessments
<i>Lonicera fragrantissima</i>	7	9	9	Leaf distortion, temporary
<i>Lonicera japonica</i> 'Halliana'	5	6.8	8	Blistered to sprayed leaf new growth ok
<i>Photinia fraseri</i> 'Red Robin'	9	9	9	Slight leaf curling noted between assessments
<i>Philadelphus</i> 'Manteau d'Hermine'	8.5	9	9	Very slight yellow edge of young leaf at first assessment
<i>Rhus typhina</i> 'Laciniata'	4	9		Very severe stunting initially
<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	5	9	9	Severe, leaf scorched narrowed, unnatural, grew away from damage
<i>Vinca minor</i> 'Ralph Shugard'	9	8	8	Inward curling central leaves slightly reduced vigour



**Figure 1.** *Ligustrum japonicum* 'Aureum' tip curling



**Figure 2.** *Vinca minor* 'Ralph Shugert' leaf curling



**Figure 3.** *Hebe* 'Sapphire' tip distortion



**Figure 4.** *Lonicera japonica* 'Halliana' slight leaf distortion



**Figure 5.** *Sambucus nigra* f. *porphyrophylla* 'Eva', yellowing, distortion



**Figure 6.** *Photinia fraseri* 'Red Robin' treated on right, slight puckering of leaf



**Figure 7.** *Berberis darwinii*, reduced growth



**Figure 8.** *Buddleja* 'Lochin', yellow fleck on edge of young leaf



**Figure 9.** *Cotinus* 'Grace', slight leaf puckering



**Figure 10.** *Jasminum officinale* 'Clotted Cream', tip distortion



**Figure 11.** *Forsythia x intermedia* 'Lynwood Variety', tip distortion



**Figure 12.** *Lonicera fragrantissima*, tip scorch



## Sumimax

Application was made when many of the subjects were dormant, therefore phytotoxicity affects in many cases were only observed at the final assessment once new growth had commenced. Several species showed delayed bud break and development, including; *Euonymus fortunei* 'Emerald Gaiety' and 'Silver Queen', *Kerria japonica* 'Golden Guinea', *Pachysandra* 'Variegata', *Philadelphus* 'Belle Etoile' and *Spiraea japonica* cultivars. *Cytisus* 'Porlock', *Lonicera nitida* 'Baggesen's Gold' showed some obvious stunting. *Cornus sericea* 'Hedgerow Gold' (v) and *Pelargonium* Angel eyes Bicolor 'Pabicolor' were stunted but also showed leaf purpling and scorch. A number of other (mainly evergreen) species showed bronzing, brown flecking and patching to young leaves three months after treatment, including *Abelia*, *Cytisus*, *Euryops*, *Hedera*, *Hypericum*, *Leycesteria*, *Ligustrum*, *Pyracantha*, *Sorbaria* and *Viburnum*. See tables 4 and 5 and figures 13 - 25

**Table 4.** Sumimax phytotoxicity assessments 2, 6 and 12 weeks after treatment (WAT), 0-9 scale 9 = no effect, 0=complete kill

Varieties	Phytotox 2 WAT	Phytotox 6 WAT	Phytotox 12 WAT	Average score
<i>Abelia x grandiflora</i> 'Gold Spot'	9.0	7.0	9.0	8.3
<i>Amelanchier canadensis</i>	9.0	9.0	9.0	9.0
<i>Aucuba japonica</i> 'Variegata'	9.0	9.0	9.0	9.0
<i>Berberis thunbergii</i> 'Aurea'	9.0	9.0	9.0	9.0
<i>Berberis darwinii</i>	9.0	9.0	9.0	9.0
<i>Berberis x stenophylla</i>	9.0	9.0	9.0	9.0
<i>Buddleja davidii</i> 'Buzz Magenta'	9.0	9.0	9.0	9.0
<i>Caryopteris x clandonensis</i> 'Heavenly Blue'	9.0	9.0	9.0	9.0
<i>Ceanothus</i> 'Blue Mound'	9.0	9.0	9.0	9.0
<i>Ceanothus x delileanus</i> 'Gloire de Versailles'	9.0	9.0	9.0	9.0
<i>Ceratostigma plumbaginoides</i>	8.7	9.0	9.0	8.9
<i>Cistus x pulverulentus</i> 'Sunset'	9.0	8.0	9.0	8.7
<i>Clematis</i> 'Piilu'	9.0	9.0	9.0	9.0
<i>Clematis</i> . 'Polish Spirit'	9.0	9.0	9.0	9.0
<i>Convolvulus cneorum</i>	9.0	9.0	9.0	9.0
<i>Cornus</i> 'Baton Rouge'	9.0	9.0	9.0	9.0
<i>Cornus sericea</i> 'Flaviramea'	9.0	9.0	*	9.0
<i>Cornus sericea</i> 'Hedgerows Gold' (v)	9.0	9.0	5.0	7.7
<i>Cornus alba</i> 'Sibirica variegata'	9.0	9.0	9.0	9.0
<i>Coronilla valentina</i> subsp. glauca 'Citrina'	9.0	9.0	9.0	9.0
<i>Cotinus</i> 'Grace'	9.0	9.0	9.0	9.0
<i>Cotinus coggygria</i> 'Royal Purple'	9.0	9.0	9.0	9.0
<i>Cytisus</i> 'Lena'	9.0	9.0	9.0	9.0

<i>Cytisus</i> 'Porlock'	7.0	9.0	7.0	7.7
Varieties	Phytotox 2 WAT	Phytotox 6 WAT	Phytotox 12 WAT	Average score
<i>Cytisus x praecox</i> 'Allgold'	9.0	9.0	9.0	9.0
<i>Elaeagnus pungens</i> 'Maculata'	8.8	9.0	*	8.9
<i>Escallonia</i> 'Peach Blossom'	9.0	9.0	9.0	9.0
<i>Escallonia</i> 'Red Dream'	9.0	9.0	9.0	9.0
<i>Euonymus fortunei</i> 'Emerald Gaiety'	9.0	9.0	7.0	8.3
<i>Euonymus fortunei</i> 'Emerald 'n' Gold'	9.0	9.0	9.0	9.0
<i>Euonymus ovatus</i> 'Albus'	9.0	9.0	9.0	9.0
<i>Euonymus fortunei</i> 'Silver Queen'	9.0	9.0	8.0	8.7
<i>Euphorbia</i> 'Despina'	9.0	9.0	9.0	9.0
<i>Euryops pectinatus</i>	7.0	7.0	9.0	7.7
<i>Exochorda x macrantha</i> 'The Bride'	9.0	8.7	9.0	8.9
<i>Forsythia x intermedia</i> 'Lynwood Variety'	9.0	9.0	9.0	9.0
<i>Genista lydia</i>	9.0	9.0	9.0	9.0
<i>Hedera colchica</i> 'Dentata Variegata'	9.0	9.0	9.0	9.0
<i>Hedera helix</i> 'Glacier'	9.0	6.5	6.0	7.2
<i>Helichrysum</i> 'Icicles'	9.0	9.0	9.0	9.0
<i>Helichrysum italicum</i> 'Korma'	9.0	9.0	9.0	9.0
<i>Hydrangea paniculata</i> 'Phantom'	9.0	9.0	9.0	9.0
<i>Hydrangea petiolaris</i>	9.0	9.0	9.0	9.0
<i>Hypericum</i> 'Hidcote variegata'	9.0	9.0	9.0	9.0
<i>Hypericum x moserianum</i>	9.0	9.0	9.0	9.0
<i>Hypericum x moserianum</i> 'Tricolor'	8.7	7.8	9.0	8.5
<i>Ilex x altaclerensis</i> 'Golden King'	9.0	9.0	9.0	9.0
<i>Jasminum nudiflorum</i>	9.0	9.0	9.0	9.0
<i>Kerria japonica</i> 'Golden Guinea'	9.0	9.0	7.0	8.3
<i>Kolkwitzia amabilis</i> 'Pink Cloud'	8.7	9.0	9.0	8.9
<i>Lavatera x clementii</i> 'Burgundy Wine'	9.0	9.0	*	9.0
<i>Lavendula angustifolia</i> 'Vera'	8.8	9.0	9.0	8.9
<i>Lavendula stoechas</i> 'Regal Splendour'	8.8	9.0	9.0	8.9
<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'	9.0	9.0	6.0	8.0
<i>Ligustrum japonicum</i> 'Aureum'	9.0	9.0	9.0	9.0
<i>Ligustrum ovalifolium</i>	8.0	7.3	6.0	7.1
<i>Lonicera nitida</i> 'Baggesen's Gold'	9.0	8.2	7.0	8.1
<i>Lonicera japonica</i> 'Cream Cascade'	9.0	9.0	9.0	9.0
<i>Lonicera fragrantissima</i>	9.0	9.0	9.0	9.0

<i>Mahonia x media</i> 'Charity'	9.0	8.7	9.0	8.9
<b>Varieties</b>	<b>Phytotox 2 WAT</b>	<b>Phytotox 6 WAT</b>	<b>Phytotox 12 WAT</b>	<b>Average score</b>
<i>Osmanthus x burkwoodii</i>	9.0	8.7	9.0	8.9
<i>Pachysandra terminalis</i> 'Green Carpet'	8.5	9.0	9.0	8.8
<i>Pachysandra</i> 'Variegata'	8.3	9.0	8.0	8.4
<i>Pelargonium</i> Angel eyes Bicolor 'Pabicolor'	9.0	6.2	6.0	7.1
<i>Philadelphus</i> 'Belle Etoile'	9.0	9.0	8.0	8.7
<i>Philadelphus</i> 'Manteau d'Hermine'	9.0	9.0	9.0	9.0
<i>Philadelphus</i> 'Starbright'	9.0	9.0	9.0	9.0
<i>Photinia</i> 'Scarlet Blaze'	6.8	7.8	9.0	7.9
<i>Physocarpus opulifolius</i> 'Angel gold'	9.0	9.0	9.0	9.0
<i>Physocarpus opulifolius</i> 'Diabolo'	9.0	9.0	9.0	9.0
<i>Physocarpus opulifolius</i> 'Lady in Red'	9.0	9.0	*	9.0
<i>Pittosporum garnettii</i>	9.0	9.0	9.0	9.0
<i>Pittosporum tenuifolium</i> 'Tom Thumb'	9.0	7.0	4.0	6.7
<i>Prunus incisa</i> 'Kojo-no-Mai'	9.0	9.0	9.0	9.0
<i>Prunus laurocerasus</i> 'Cherry Brandy'	9.0	9.0	9.0	9.0
<i>Pyracantha</i> 'Mohave'	9.0	9.0	6.0	8.0
<i>Pyracantha coccinea</i> 'Red Column'	9.0	9.0	6.0	8.0
<i>Rosa</i> 'Iceberg' = 'Korbin'	6.5	9.0	9.0	8.2
<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	9.0	9.0	9.0	9.0
<i>Santolina chamaecyparissus</i>	9.0	9.0	9.0	9.0
<i>Santolina rosmarinifolia</i> 'Primrose Gem'	8.7	8.8	9.0	8.8
<i>Brachyglottis</i> (Dunedin Group) 'Drysedale'	9.0	9.0	9.0	9.0
<i>Sorbaria sorbifolia</i> 'Sem'	4.7	9.0	9.0	7.6
<i>Spiraea japonica</i> 'Arguta'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Firelight'	9.0	9.0	*	9.0
<i>Spiraea japonica</i> 'Golden Princess'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Goldflame'	9.0	9.0	9.0	9.0
<i>Spiraea japonica</i> 'Little Princess'	9.0	7.7	7.0	7.9
<i>Spiraea japonica</i> 'Shirobana'	9.0	8.5	8.0	8.5
<i>Syringa x josiflexa</i> 'Bellicent'	9.0	9.0	9.0	9.0
<i>Syringa meyeri</i> 'Palibin'	8.7	9.0	9.0	8.9
<i>Viburnum davidii</i>	8.7	9.0	6.0	7.9
<i>Weigela</i> 'Kosteriana variegata'	9.0	9.0	9.0	9.0
<i>Weigela florida</i> 'Foliis Purpureis'	9.0	9.0	9.0	9.0

\* Plants moved or sold, unable to assess

**Table 5.** Varieties which showed phytotoxicity to Sumimax and comments on observations

Varieties	2 WAT	6 WAT	12 WAT	Comments
<i>Abelia x grandiflora</i> 'Gold Spot'	9.0	7.0	9.0	Black spots on foliage, grew away
<i>Cistus x pulverulentus</i> 'Sunset'	9.0	8.0	9.0	Brown spots on foliage, grew away
<i>Cornus sericea</i> 'Hedgerows Gold' (v)	9.0	9.0	5.0	Stunted, leaf purpled
<i>Cytisus</i> 'Porlock'	7.0	9.0	7.0	Stunted but starting to re-grow
<i>Euonymus fortunei</i> 'Emerald Gaiety'	9.0	9.0	7.0	Delayed new growth
<i>Euonymus fortunei</i> 'Silver Queen'	9.0	9.0	8.0	Slightly delayed new growth
<i>Euryops pectinatus</i>	7.0	7.0	9.0	Brown flecking, necrosis at first two assessments
<i>Hedera helix</i> 'Glacier'	9.0	6.5	6.0	Brown patches on young leaf unacceptable
<i>Hypericum x moserianum</i> 'tricolor'	8.7	7.8	9.0	Browning to leaves
<i>Kerria japonica</i> 'Golden Guinea'	9.0	9.0	7.0	Delayed growth
<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'	9.0	9.0	6.0	Severe bronzing on young leaves
<i>Ligustrum ovalifolium</i>	8.0	7.3	6.0	Browning on edge of leaf
<i>Lonicera nitida</i> 'Baggesen's Gold'	9.0	8.2	7.0	Stunted, less new growth
<i>Pachysandra</i> 'Variegata'	8.3	9.0	8.0	Marginally less growth
<i>Pelargonium</i> Angel eyes Bicolor 'Pabicolor'	9.0	6.2	6.0	Stunted and browned
<i>Philadelphus</i> 'Belle Etoile'	9.0	9.0	8.0	Slightly delayed new growth
<i>Photinia</i> 'Scarlet Blaze'	6.8	7.8	9.0	black marking on stems, twisted leaves at first assessment, grew away
<i>Pittosporum tenuifolium</i> 'Tom Thumb'	9.0	7.0	4.0	Badly scorched/bronzed
<i>Pyracantha</i> 'Mohave'	9.0	9.0	6.0	Browning of young leaf and stunting, marked
<i>Pyracantha coccinea</i> 'Red Column'	9.0	9.0	6.0	Browning of young leaf and stunting, marked
<i>Rosa</i> 'Iceberg' = 'Korbin'	6.5	9.0	9.0	leaf yellowing and spotting first assessment only
<i>Sorbaria sorbifolia</i> 'Sem'	4.7	9.0	9.0	Delayed opening brown necrotic buds first assessment only
<i>Spiraea japonica</i> 'Little Princess'	9.0	7.7	7.0	Slow growth
<i>Spiraea japonica</i> 'Shirobana'	9.0	8.5	8.0	Slightly less vigorous
<i>Viburnum davidii</i>	8.7	9.0	6.0	Bronzed foliage



**Figure 13.** *Sorbaria sorbifolia* 'Sem' necrotic dead tips



**Figure 14.** *Euryops pectinatus* brown flecks on leaves



**Figure 15.** *Photinia* 'Scarlet blaze' black flecking to stems



**Figure 16.** *Hydrangea paniculata* 'Phantom' delayed bud break



**Figure 17.** *Euonymus fortunei* 'Emerald Gaiety' delayed new growth



**Figure 18.** *Pittosporum tenuifolium* 'Tom Thumb' purpling



**Figure 18.** *Leycesteria formosa* 'Golden Lanterns' = 'Notbruce' leaf bronzing



**Figure 19.** *Cornus sericea* 'Hedgerows Gold' (v)





**Figure 20.** *Ligustrum ovalifolium* browning to leaf edges



**Figure 21.** *Pelargonium* Angel eyes Bicolor 'Pabicolor'



**Figure 22.** *Hedera helix* 'Glacier' brown spotting



**Figure 23.** *Pyracantha coccinea* 'Red Column' brown scorched leaves



**Figure 24.** *Spiraea japonica* 'Shirobana' delayed right



**Figure 25.** *Spiraea japonica* 'Little Princess' delayed

## Conclusions

### *Dual Gold*

Treatments were made in mid summer (June-July) when crops were in full leaf and active growth, without washing off, and at a higher rate (1.4 L/ha) than is currently approved (0.78 L/ha). In spite of this, out of over 100 different cultivars treated, only 18 cultivars (14 different species) showed some initial signs of temporary phytotoxicity, mainly tip scorch,

leaf puckering, yellow spotting and stunting and of these only two species (*Buddleja* and *Lonicera*) showed damage that persisted for 12 weeks, enough to downgrade the crop.

For *Berberis*, *Hebe*, *Jasminum*, *Rhus* and *Sambucus*, although the crop subsequently recovered, because of the level of initial damage (which could affect marketability) it is not recommended that these species are treated if they are for marketing in the short term.

### **Sumimax**

Sumimax is known to have a contact action, therefore it was anticipated that it might prove to be a relatively risky treatment when applied over foliage or buds. It was therefore interesting to observe the effect of treatment on dormant or semi-dormant cultivars both evergreen and deciduous. The majority of deciduous subjects were unaffected, including interestingly *Buddleja* which is normally sensitive to herbicides. Similarly, a good range of evergreen subjects were unaffected by treatment.

Out of 100 different cultivars treated phytotoxic effects were noted on 25 cultivars (22 different species). Fifteen of the cultivars affected were evergreens and symptoms ranged from a slight delay to the onset of new growth (e.g. *Euonymus*) to more severe spotting or browning of young foliage (e.g. *Pyracantha*). For evergreens *Hedera*, *Pittosporum*, *Pelargonium*, *Pyracantha*, and *Viburnum* the damage was sufficient to recommend not treating these species. For *Cytisus*, *Euonymus*, *Ligustrum*, and *Lonicera*, damage was short term and these subjects could be considered for treatment depending on the marketing period.

Fewer deciduous subjects showed symptoms, typically a delay to the onset of growth e.g. *Spiraea japonica*. For a few subjects, although deciduous, some leaf was present and this was bronzed e.g. *Cornus* 'Hedgerow Gold' and *Leycesteria*. Of the deciduous subjects only *Cornus sericea* 'Hedgerows Gold' (v), and *Leycesteria* were considered too susceptible to damage to be recommended not to be treated. For *Kerria*, *Spiraea* and *Sorbaria* damage was short term and these subjects could be considered for treatment depending on the marketing period.

Although a good range of evergreen subjects were unaffected by treatment, because of the contact action of Sumimax it is recommended that some caution should be exercised before treating other evergreen subjects for the first time.

## **Knowledge and Technology Transfer**

Results from HNS 139a have been fully incorporated in the updated grower guide 'Practical Weed Control for Nursery Stock' to be published Summer 2012.

A short article was published in HDC News April 2012 to coincide with the new EAMU for Dual Gold to provide growers with further information on its potential uses.

.

## References

Atwood, J. (2009). Control of problem weeds in hardy nursery stock. Horticultural Development Company Final report for project HNS 139.

Atwood, J. (2010). Hardy ornamentals: herbicide screening for herbaceous perennials and grasses. Horticultural Development Company Annual report for project HNS 166.

Barolli, S. and Ahrens, J. R. (2009). Fall applications of flumioxazine on deciduous ornamentals. Proc. North East Weed Science Soc. 63:62.

Palmer, C., Veal, E. and Lightbourne, N. (2006). IR-4 Ornamental horticulture programme s-metolachlor crop safety.  
[http://ir4.rutgers.edu/ir4\\_pdf\\_default.aspx\\_pdf=http://ir4.rutgers.edu/Ornamental\\_SummaryReports\\_FlumioxazinDataSummary2007.pdf](http://ir4.rutgers.edu/ir4_pdf_default.aspx_pdf=http://ir4.rutgers.edu/Ornamental_SummaryReports_FlumioxazinDataSummary2007.pdf)

Palmer, C. and Veal, E. (2007). IR-4 Ornamental horticulture programme flumioxazine crop safety.  
[http://ir4.rutgers.edu/ir4\\_pdf\\_default.aspx\\_pdf=http://ir4.rutgers.edu/Ornamental\\_SummaryReports\\_S-MetolachlorDataSummary2006.pdf](http://ir4.rutgers.edu/ir4_pdf_default.aspx_pdf=http://ir4.rutgers.edu/Ornamental_SummaryReports_S-MetolachlorDataSummary2006.pdf)






























## Appendices

### Appendix 1. Growth stage when Dual Gold was applied for each species










			
<i>Abelia x grandiflora</i> 'Gold Spot'	<i>Amelanchier canadensis</i>	<i>Aucuba japonica</i> 'Crotonoides'	<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Admiration'
		Image not available	
<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Atropurpurea Nana'	<i>Berberis darwinii</i>	<i>Berberis x ottawensis</i> f. <i>purpurea</i>	<i>Buddleja alternifolia</i>
			Image not available
<i>Buddleja</i> 'Lochinch'	<i>Caryopteris x clandonensis</i> 'Heavenly Blue'	<i>Caryopteris x clandonensis</i> 'Worcester Gold'	<i>Ceanothus</i> 'Concha'
			
<i>Ceanothus x delileanus</i> 'Gloire de Versailles'	<i>Ceratostigma willmottianum</i> 'Forest Blue'	<i>Ceratostigma plumbaginoides</i>	<i>Chaenomeles x superba</i> 'Crimson and Gold'
			
<i>Chaenomeles x superba</i> 'Pink Lady'	<i>Clematis alpina</i> 'Constance'	<i>Clematis x cartmanii</i> hort. 'Avalanche'	<i>Clematis interfolia</i> 'Petit Foucon'
			
<i>Clematis macropetala</i> 'Markham's Pink'	<i>Clematis macropetala</i>	<i>Clematis montana</i> 'Rubens'	<i>Cornus</i> 'Flaviramea'



			
<i>Cornus sericea</i> 'Hedgerows Gold' (v)	<i>Cornus sanguinea</i> 'Midwinter Fire'	<i>Cornus alba</i> 'Sibirica variegata'	<i>Cotinus</i> 'Grace'
			
<i>Cytisus</i> 'Lena'	<i>Cytisus x praecox</i>	<i>Deutzia gracilis</i> 'Nikko'	<i>Elaeagnus pungens</i> 'Maculata'
Image not available			
<i>Escallonia</i> 'Red Dream'	<i>Exochorda x macrantha</i> 'The Bride'	<i>Forsythia x intermedia</i> 'Lynwood Variety'	<i>Fuchsia</i> 'Delta's Sarah'
			
<i>Genista lydia</i>	<i>Hebe</i> 'Silver Queen'	<i>Hebe</i> 'Margaret'	<i>Hebe</i> 'Sapphire'
			
<i>Hedera colchica</i> 'Dentata Variegata'	<i>Hedera helix</i> 'Glacier'	<i>Helichrysum italicum</i> 'Korma'	<i>Hydrangea macrophylla</i> 'Madame Emile Mouillere'
			
<i>Hydrangea petiolaris</i>	<i>Hydrangea aspera</i> Villosa Group	<i>Hypericum</i> 'Hidcote'	<i>Ilex x altaclerensis</i> 'Golden King'
			
<i>Jasminum humile</i> 'Revolution'	<i>Jasminum officinale</i> 'Clotted Cream'	<i>Kerria japonica</i> 'Golden Guinea'	<i>Kolkwitzia amabilis</i> 'Pink Cloud'

























			
<i>Lavatera x clementii</i> 'Rosea'	<i>Lavendula angustifolia</i> 'Hidcote'	<i>Lavendula stoechas</i> 'Regal splendour'	<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'
			
<i>Ligustrum japonicum</i> 'Aureum'	<i>Lonicera nitida</i> 'Baggesen's Gold'	<i>Lonicera</i> <i>fragrantissima</i>	<i>Lonicera japonica</i> 'Halliana'
			
<i>Mahonia x media</i> 'Lionel Fortescue'	<i>Osmanthus x burkwoodii</i>	<i>Perovskia</i> 'Blue Spire'	<i>Philadelphus</i> Manteau d'Hermine'
			
<i>Photinia fraseri</i> 'Red Robin'	<i>Physocarpus opulifolius</i> 'Angel Gold'	<i>Physocarpus</i> <i>opulifolius</i> 'Lady in Red'	<i>Potentilla fruticosa</i> 'Abbotswood'
			
<i>Potentilla fruticosa</i> 'Gold Star'	<i>Prunus laurocerasus</i> 'Cherry Brandy'	<i>Prunus incisa</i> 'Kojo- no-Mai'	<i>Pyracantha</i> 'Orange Glow'
			
<i>Pyracantha</i> 'Red column'	<i>Rhus typhina</i> 'Laciniata'	<i>Rosa</i> 'Iceberg' = 'Korbin'	<i>Rosmarinus officinalis</i> 'Miss Jessopp's Upright'
			
<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	<i>Sorbaria sorbifolia</i> 'Sem'	<i>Spiraea japonica</i> 'Arguta'	<i>Spiraea japonica</i> 'Firelight'

			
<i>Spiraea japonica</i> 'Goldflame'	<i>Spiraea japonica</i> 'Shirobana'	<i>Syringa x josiflexa</i> 'Bellicent'	<i>Viburnum davidii</i>
			
<i>Vinca major</i> 'Maculata'	<i>Vinca minor</i> 'Ralph Shugert'	<i>Weigela</i> 'Kosteriana Variegata'	<i>Weigela florida</i> 'Foliis Purpureis'
			
<i>Wisteria floribunda</i> 'Domino' = 'Issai'			























## Appendix 2. Growth stage when Sumimax was applied for each species

			
<i>Abelia x grandiflora</i> 'Gold Spot'	<i>Amelanchier</i> 'Canadensis'	<i>Aucuba japonica</i> 'Variegata'	<i>Berberis thunbergii</i> f. <i>atropurpurea</i> 'Aurea'
			
<i>Berberis darwinii</i>	<i>Berberis x stenophylla</i>	<i>Buddleja davidii</i> 'Buzz Magenta'	<i>Caryopteris x</i> <i>clandonensis</i> 'Heavenly Blue'
			Not sprayed
<i>Ceanothus</i> 'Blue Mound'	<i>Ceanothus x delileanus</i> 'Gloire de Versailles'	<i>Ceratostigma</i> <i>plumbaginoides</i>	<i>Chaenomeles</i> 'Jet Trail'
			
<i>Cistus x</i> <i>pulverulentus</i> 'Sunset'	<i>Clematis</i> 'Piilu'	<i>Clematis</i> 'Polish Spirit'	<i>Convolvulus cneorum</i>
			
<i>Cornus alba</i> 'Baton Rouge'	<i>Cornus serica</i> 'Flaviramea'	<i>Cornus serica</i> 'Hedgerow Gold' (v)	<i>Cornus alba</i> 'Sibirica variegata'














			Not sprayed
<i>Coronilla valentina</i> subsp. <i>glauca</i> 'Citrina'	<i>Cotinus</i> 'Grace'	<i>Cotinus coggygria</i> 'Royal Purple'	<i>Cytisus</i> 'Boskoop Ruby'
			
<i>Cytisus</i> 'Lena'	<i>Cytisus</i> 'Porlock'	<i>Cytisus x praecox</i> 'Allgold'	<i>Elaeagnus pungens</i> 'Maculata'
			
<i>Escallonia</i> 'Peach Blossom'	<i>Escallonia</i> 'Red Dream'	<i>Euonymus fortunei</i> 'Emerald Gaiety'	<i>Euonymus fortunei</i> 'Emerald'n gold'
			
<i>Euonymus ovatus</i> 'Albus'	<i>Euonymus fortunei</i> 'Silver Queen'	<i>Euphorbia</i> 'Despina'	<i>Euryops pectinatus</i>
			
<i>Exochorda x macrantha</i> 'The Bride'	<i>Forsythia x intermedia</i> 'Lynwood Variety'	<i>Genista lydia</i>	<i>Hedera colchica</i> 'Dentata Variegata'
			Not sprayed
<i>Hedera helix</i> 'Glacier'	<i>Helichrysum</i> 'Icicles'	<i>Helichrysum italicum</i> 'Korma'	<i>Hydrangea macrophylla</i> 'Madame Emile'



			Mouillere'
			
<i>Hydrangea paniculata</i> 'Phantom'	<i>Hydrangea petiolaris</i>	<i>Hypericum</i> 'Hidcote Variegata'	<i>Hypericum x moserianum</i>
			
<i>Hypericum x moserianum</i> 'Tricolor'	<i>Ilex x altaclerensis</i> 'Golden King'	<i>Jasminum nudiflorum</i>	<i>Kerria japonica</i> 'Golden Guinea'
			
<i>Kolkwitzia amabilis</i> 'Pink Cloud'	<i>Lavatera x clementii</i> 'Burgundy Wine'	<i>Lavendula angustifolia</i> 'Vera'	<i>Lavendula stoechas</i> 'Regal Splendour'
			
<i>Leycesteria formosa</i> 'Golden Lanterns' = 'Notbruce'	<i>Ligustrum japonicum</i> 'Aureum'	<i>Ligustrum ovalifolium</i>	<i>Lonicera nitida</i> 'Baggesen's Gold'
			
<i>Lonicera japonica</i> 'Cream Cascade'	<i>Lonicera fragrantissima</i>	<i>Mahonia x media</i> 'Charity'	<i>Osmanthus x burkwoodii</i>

			
<i>Pachysandra terminalis</i> 'Green Carpet'	<i>Pachysandra terminalis</i> 'Variegata'	<i>Pelargonium</i> Angel eyes Bicolor 'Pabicolor'	<i>Philadelphus</i> 'Belle Etoile'
			
<i>Philadelphus</i> 'Manteau d'Hermine'	<i>Philadelphus</i> 'Starbright'	<i>Photinia</i> 'Scarlet Blaze'	<i>Physocarpus opulifolius</i> 'Angel Gold'
			
<i>Physocarpus opulifolius</i> 'Diabolo'	<i>Physocarpus opulifolius</i> 'Lady in Red'	<i>Pittosporum garnettii</i>	<i>Pittosporum tenuifolium</i> 'Tom Thumb'
			
<i>Prunus incisa</i> 'Kojino-Mai'	<i>Prunus laurocerasus</i> 'Cherry Brandy'	<i>Pyracantha</i> 'Mohave'	<i>Pyracantha coccinea</i> 'Red Column'
			
<i>Rosa</i> 'Iceberg' = 'Korbin'	<i>Sambucus nigra</i> f. <i>porphyrophylla</i> 'Eva'	<i>Santolina chamaecyparissus</i>	<i>Santolina rosmarinifolia</i> 'Primrose Gem'



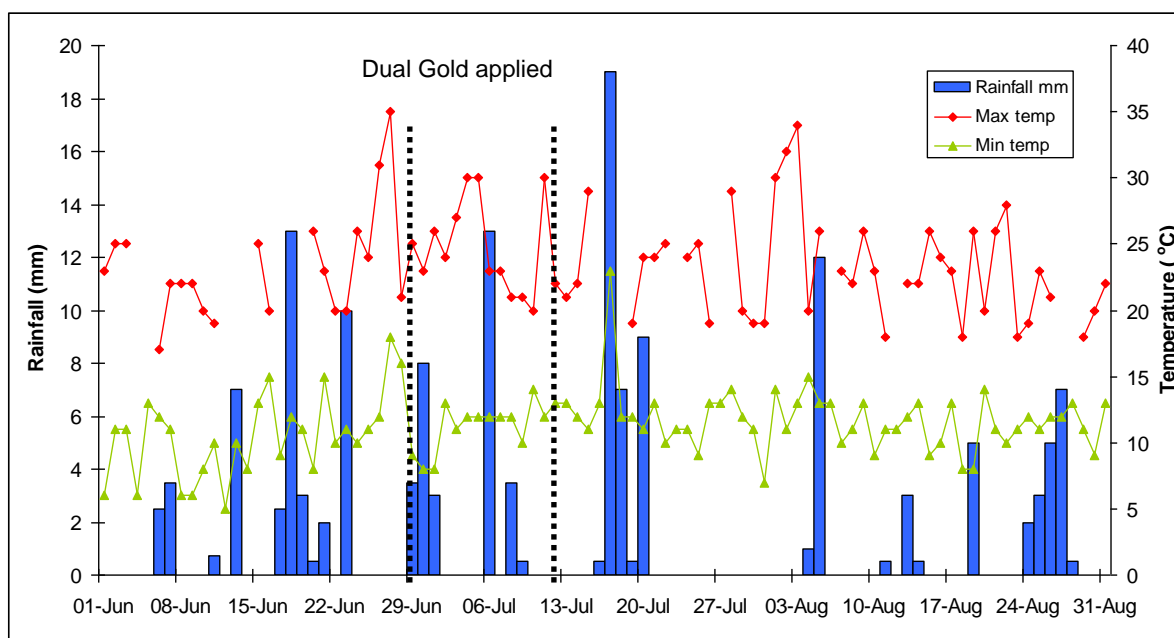
			
<i>Brachyglottis</i> (Dunedin Group) 'Drysdale'	<i>Sorbaria sorbifolia</i> 'Sem'	<i>Spiraea japonica</i> 'Arguta'	<i>Spiraea japonica</i> 'Firelight'
			
<i>Spiraea japonica</i> 'Golden Princess'	<i>Spiraea japonica</i> 'Goldflame'	<i>Spiraea japonica</i> 'Little Princess'	<i>Spiraea japonica</i> 'Shirobana'
			
<i>Syringa x josiflexa</i> 'Bellicent'	<i>Syringa meyeri</i> 'Palibin'	<i>Viburnum davidii</i>	<i>Weigela</i> 'Kosteriana variegata'
			
<i>Weigela florida</i> 'Foliis Purpureis'			

### **Appendix 3. Standard potting mix**

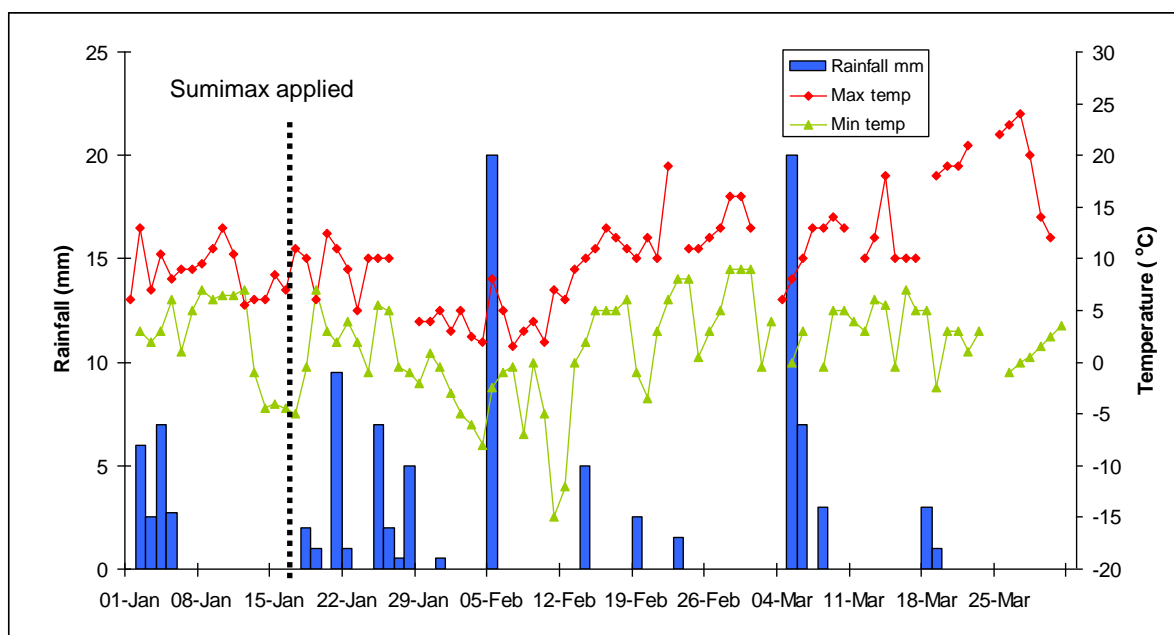
Fine peat 30%  
Medium peat 20%  
Coarse Peat 20%  
Pine bark 5-12 mm 20%  
Pine bark 0-8 mm 10%  
Osmocote exact standard 12-14 months 3 kg/cubic metre  
Dolomitic lime 2.5 kg/ cubic metre  
+wetting agent

Some varieties tested require specific mixes but this is the standard mix used on site for the majority of the subjects tested

#### Appendix 4. Weather data for 3 months post Dual Gold treatment application



#### Appendix 5. Weather data for 3 months post Sumimax treatment application



**Appendix 6.** Details of pot size, herbicide applications and irrigation by species in experiment 1 - Dual Gold

<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G @200kg/ha</b>	<b>Irrigation</b>
AMELANCHIER Canadensis	13/12/2010	3	Beyond 12 weeks	0+5
AUCUBA japonica Crotonoides	31/03/2011	3	09/04/2011	0+5
BERBERIS Admiration	20/05/2011	3	25/05/2011	0+5
BERBERIS Atropurpurea Nana	02/02/2011	2	Beyond 12 weeks	0+5
BERBERIS darwinii	30/03/2011	3	09/04/2011	0+5
BERBERIS ottowensis Purpurea	30/03/2011	3	09/04/2011	0+5
BUDDLEJA Alternifolia	24/05/2011	3	03/06/2011	0+5
BUDDLEJA Lochinch	20/05/2011	3	25/05/2011	0+5
CARYOPTERIS Heavenly Blue	05/05/2011	3	13/05/2011	0+5
CARYOPTERIS Worcester Gold	05/05/2011	3	13/05/2011	0+5
CEANOTHUS Gloire de Versailles	06/05/2011	3	13/05/2011	0
CERATOSTIGMA Forest Blue	15/04/2011	3	21/04/2011	0+5
CERATOSTIGMA plumbaginoides	05/05/2011	3	Not applied	0+5
CHAENOMELES Crimson & Gold	01/04/2011	3	09/04/2011	0+5
CHAENOMELES Pink Lady	01/04/2011	3	09/04/2011	0+5
CLEMATIS INTERFOLIA Petit Foucon	23/03/2011	3	29/03/2011	20mm+5
CLEMATIS montana Rubens	07/06/2011	3	15/06/2011	20mm+5
CORNUS Flaviramea	30/03/2011	3	09/04/2011	20mm+5
CORNUS Hedgerow Gold	06/05/2011	3	13/05/2011	20mm+5
CORNUS sanguinea Midwinter Fire	05/05/2011	7.5	13/05/2011	0+5
CORNUS Sibirica Variegata	30/03/2011	3	09/04/2011	20mm+5
COTINUS Grace	13/05/2011	3	17/05/2011	0+5
DEUTZIA crenata Nikko	06/05/2011	3	13/05/2011	0+5
ELAEAGNUS pungens Maculata	15/04/2011	3	21/04/2011	0
ESCALLONIA Red Dream	05/05/2011	7.5	13/05/2011	0
EXOCHORDA macrantha The Bride	08/04/2011	3	12/04/2011	0



<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Irrigation</b>
FORSYTHIA Lynwood	20/05/2011	3	25/05/2011	20mm+5
GENISTA Lydia	30/03/2011	3	not applied	0
HEDERA Dentata Variegata	06/05/2011	3	13/05/2011	0
HEDERA Glacier	15/04/2011	3	21/04/2011	0
HELICHRYSUM Korma	06/05/2011	3	13/05/2011	0
HYDRANGEA mac. Mme Emile Mouillere	31/05/2011	3	Not applied	0+5
HYDRANGEA petiolaris	28/02/2011	3	23/03/2011	0+5
HYDRANGEA Villosa	31/03/2011	3	not applied	0
HYPERICUM Hidcote	05/05/2011	3	13/05/2011	20mm+5
ILEX altaclarensis Golden King	27/09/2010	3	Beyond 12 weeks	0
JASMINUM humile Revolution	06/05/2011	3	13/05/2011	0+5
JASMINUM officinale Clotted Cream	13/05/2011	9	17/05/2011	0+5
KERRIA Golden Guinea	06/04/2011	3	12/04/2011	15mm+5
KOLKOWITZIA Pink Cloud	03/06/2011	3	08/06/2011	20mm+5
LAVATERA Rosea	05/05/2011	3	13/05/2011	0+5
LEYCESTERIA Golden Lanterns	24/05/2011	3	03/06/2011	0+5
LIGUSTRUM Aureum	05/05/2011	2	13/05/2011	0
LONICERA Baggesen's Gold	15/04/2011	3	21/04/2011	20mm+5
LONICERA Fragrantissima	19/05/2011	3	25/05/2011	0+5
MAHONIA media Lionel Fortescue	09/05/2011	3	17/05/2011	0
OSMANTHUS Burkwoodii	16/05/2011	9	25/05/2011	0+5
PEROVSKIA Blue Spire	13/04/2011	3	21/04/2011	0+5
PHILADELPHUS Manteau d'Hermine	06/05/2011	3	13/05/2011	0+5
PHYSOCARPUS OPULIFOLIUS Angel Gold	31/03/2011	3	09/04/2011	20mm+5
PHYSOCARPUS OPULIFOLIUS Lady in Red	08/04/2011	3	12/04/2011	20mm+5
POTENTILLA FRUTICOSA	17/05/2011	3	25/05/2011	20mm+5

Abbotswood				
<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Irrigation</b>
POTENTILLA FRUTICOSA Gold Star	17/05/2011	3	25/05/2011	20mm+5
PRUNUS Kojo-no-Mai	30/03/2011	3	09/04/2011	0+5
PYRACANTHA Orange Glow	27/05/2011	3	03/06/2011	0+5
PYRACANTHA Red Column	24/05/2011	3	03/06/2011	0+5
RHUS typhina Laciniata	02/02/2011	3	Beyond 12 weeks	0+5
ROSMARINUS Miss Jessopp's Var	20/05/2011	7.5	25/05/2011	0+5
SAMBUCUS Black Lace = Eva	03/06/2011	3	08/06/2011	15mm+5
SORBARIA sorbifolia Sem	27/05/2011	3	03/06/2011	15mm+5
SPIRAEA JAPONICA Arguta	21/04/2011	3	Not applied	20mm+5
SPIRAEA JAPONICA Firelight	24/05/2011	3	Not applied	20mm+5
SPIRAEA JAPONICA Goldflame	20/05/2011	3	Not applied	20mm+5
SPIRAEA JAPONICA Shirobana	06/05/2011	3	Not applied	20mm+5
SYRINGA josiflexa Bellicent	06/05/2011	3	13/05/2011	0+5
WEIGELA Kosteriana Variegata	20/05/2011	3	25/05/2011	20mm+5
WEIGELA Purpureis	03/06/2011	3	08/06/2011	20mm+5
WISTERIA formosa Issai	17/11/2010	3	Beyond 12 weeks	0+5
<b>Broad Fen Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Rainfall</b>
Abelia Goldsport	05/04/2011	2	Not applied	
Ceanothus Concha	26/05/2011	3	02/06/2011	
Clematis alpina Constance	04/04/2011	3	Not applied	
Clematis Avalanche	16/06/2011	2	to be applied	
Clematis macropetala	04/04/2011	3	Not applied	
Clematis macropetala Markham's Pink	04/04/2011	3	Not applied	
Cytisus Lena	29/03/2011	3	07/04/2011	
Cytisus praecox	29/03/2011	3	07/04/2011	
Fuchsia Delta's Sarah	27/04/2011	2	Not applied	

Hebe Silver Queen	03/05/2011	3	15/05/2011	
Hebe Margaret	04/05/2011	2	10/05/2011	
<b>Broad Fen Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Rainfall</b>
Hebe Sapphire	02/06/2011	2	09/06/2011	
Lavendula Hidcote	13/04/2011	26	19/04/2011	
Lavendula Regal Splendour	10/05/2011	26*	18/05/2011	
Lonicera japonica Halliana	04/05/2011	3	11/05/2011	
Photinia Red Robin	22/04/2011	3	12/05/2011	
Prunus laurocerasus Cherry Brandy	01/05/2011	5	?	
Rosa Iceberg	01/05/2011	5	?	
Viburnum davidii	01/05/2011	5	?	
Vinca major Maculata	02/06/2011	3	09/06/2011	
Vinca minor	04/05/2011	3	13/05/2011	

Purple background indicates indoor crops

\* Diameter of the pots, respectively 7L pots

**Appendix 7.** Details of pot size, herbicide applications and irrigation by species in experiment 2 - Sumimax

<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G@ 200kg/Ha</b>	<b>Flexidor@ 100ml/100L</b>	<b>Venzar Flo@ 1.3L/500L</b>
AMELANCHIER Canadensis	13/12/2010	3	20/10/2011	25/11/2011	✕
AUCUBA japonica Variegata	31/03/2011	3	20/10/2011	✕	✕
BERBERIS Aurea	30/03/2011	3	20/10/2011	25/11/2011	✕
BERBERIS darwinii	30/03/2011	3	✕	18/11/2011	✕
BERBERIS Stenophylla	01/04/2009	3	✕	18/11/2011	✕
CARYOPTERIS Heavenly Blue	05/05/2011	3	✕	18/11/2011	✕
CEANOTHUS Gloire de Versailles	02/04/2010	3	20/10/2011	25/11/2011	✕
CERATOSTIGMA plumbaginoides	05/05/2011	3	✕	✕	✕
CORNUS Baton Rouge	02/02/2011	3	✕	18/11/2011	✕
CORNUS Flaviramea	30/03/2011	3	✕	18/11/2011	✕
CORNUS Hedgerow Gold	06/05/2011	3	✕	18/11/2011	✕
CORNUS Sibirica Variegata	30/03/2011	3	✕	18/11/2011	✕
COTINUS Grace	13/05/2011	3	✕	18/11/2011	✕
COTINUS Royal Purple	02/02/2011	3	✕	18/11/2011	✕
ELAEAGNUS pungens Maculata	15/04/2011	3	20/10/2011	✕	✕
EXOCHORDA macrantha The Bride	08/04/2011	3	20/10/2011	✕	✕
FORSYTHIA Lynwood	20/05/2011	3	20/10/2011	✕	✕
GENISTA Lydia	30/03/2011	3	20/10/2011	✕	✕
HEDERA Dentata Variegata	24/05/2010	3	20/10/2011	✕	✕
HEDERA Glacier	15/04/2011	3	20/10/2011	✕	✕
HELICHRYSUM Korma	06/05/2011	3	✕	✕	✕
HYDRANGEA mac. Mme Emile Mouillere	31/05/2011	3	✕	✕	✕
HYDRANGEA paniculata Phantom	31/03/2011	3	✕	✕	✕
HYDRANGEA petiolaris	28/02/2011	3	✕	18/11/2011	✕
HYPERICUM Hidcote Variegata	21/05/2010	2	20/10/2011	25/11/2011	✕
Hypericum x moserianum	30/03/2011	3	✕	18/11/2011	✕
Hypericum x moserianum Tricolor	09/07/2010	3	20/10/2011	25/11/2011	✕

<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Flexidor</b>	<b>Venzar Flo</b>
ILEX altaclarensis Golden King	10/10/2011	3	24/10/2011	29/11/2011	✕
JASMINUM nudiflorum	01/04/2011	3	✕	18/11/2011	✕
KERRIA Golden Guinea	18/02/2010	3	✕	18/11/2011	✕
KOLKWITZIA Pink Cloud	02/07/2010	3	✕	18/11/2011	✕
LAVATERA Burgundy Wine	06/05/2010	3	✕	✕	✕
LEYCESTERIA Golden Lanterns	24/05/2011	3	✕	✕	✕
LIGUSTRUM Aureum	07/06/2011	2	20/10/2011	25/11/2011	✕
LIGUSTRUM ovalifolium	07/06/2011	3	✕	18/11/2011	✕
LONICERA Baggesen's Gold	15/04/2011	3	✕	25/11/2011	✕
LONICERA Cream Cascade	21/07/2011	3	20/10/2011	25/11/2011	✕
LONICERA Fragrantissima	06/04/2010	3	20/10/2011	25/11/2011	✕
MAHONIA media Charity	23/04/2010	3	✕	✕	✕
PACHYSANDRA Green Carpet	30/03/2011	3	20/10/2011	✕	✕
PACHYSANDRA Variegata	23/03/2010	3	20/10/2011	✕	✕
PHILADELPHUS Belle Etoile	15/04/2011	3	✕	18/11/2011	✕
PHILADELPHUS Manteau d'Hermine	06/05/2011	3	✕	18/11/2011	✕
PHILADELPHUS Starbright	13/04/2011	3	✕	18/11/2011	✕
PHYSOCARPUS OPULIFOLIUS Angel Gold	31/03/2011	3	✕	18/11/2011	✕
PHYSOCARPUS OPULIFOLIUS Diabolo	17/05/2011	3	✕	18/11/2011	✕
PHYSOCARPUS OPULIFOLIUS Lady in Red	08/04/2011	3	✕	18/11/2011	✕
PRUNUS Kojo-no-Mai	30/03/2011	3	✕	18/11/2011	06/10/2011
PYRACANTHA Mohave	27/05/2011	3	✕	✕	✕
PYRACANTHA Red Column	24/05/2011	3	✕	✕	✕
SAMBUCUS Black Lace = Eva	03/06/2011	3	✕	18/11/2011	✕
SORBARIA sorbifolia Sem	15/06/2011	3	20/10/2011	25/11/2011	✕
SPIRAEA JAPONICA Arguta	17/06/2011	3	✕	18/11/2011	06/10/2011
SPIRAEA JAPONICA Firelight	24/06/2011	3	✕	18/11/2011	✕
SPIRAEA JAPONICA Golden	07/06/2011	2	✕	18/11/2011	✕

Princess					
SPIRAEA JAPONICA Goldflame	20/05/2011	3	✖	18/11/2011	06/10/2011
SPIRAEA JAPONICA Little Princess	21/04/2011	3	✖	18/11/2011	06/10/2011
<b>Airfield Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Flexidor</b>	<b>Venzar Flo</b>
SPIRAEA JAPONICA Shirobana	06/05/2011	3	✖	18/11/2011	06/10/2011
SYRINGA josiflexa Bellicent	06/05/2011	3	20/10/2011	25/11/2011	✖
SYRINGA meyeri Palibin	05/05/2011	2	20/10/2011	25/11/2011	✖
WEIGELA Kosteriana Variegata	20/05/2011	3	✖	18/11/2011	✖
WEIGELA Purpureis	17/06/2011	3	✖	18/11/2011	✖
<b>Broad Fen Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Flexidor</b>	<b>Venzar Flo</b>
ABELIA Goldsport	04/04/2011	2	✖	26/11/2011	✖
BUDDLEJA 'buzz' Magenta	04/05/2011	2	✖	✖	✖
CEANOTHUS Blue Mound	06/07/2011	3	20/10/2011	26/11/2011	✖
CISTUS Sunset	not known	11 cm	03/10/2011	15/11/2011	✖
CLEMATIS Piilu	27/08/2011	3	✖	✖	Devrinol @4.5L/Ha 11/10/2011
CLEMATIS vit. Polish Spirit	26/08/2011	3	✖	✖	Devrinol @4.5L/Ha 11/10/2010
CONVOLVULUS cneorum	13/06/2011	2	11/10/2011	✖	✖
CORONILLA valentine glauca Citrina	05/10/2011	3	✖	✖	✖
CYTISUS Boskoop Ruby	21/03/2011	3	✖	✖	✖
CYTISUS Lena	29/03/2011	3	✖	✖	✖
CYTISUS Porlock	23/08/2011	2	13/10/2011	✖	✖
CYTISUS praecox Allgold	29/03/2011	7.5	✖	✖	✖
ESCALLONIA Peach Blossom	12/05/2011	3	20/10/2011	26/11/2011	✖
ESCALLONIA Red Dream	22/06/2011	2	✖	✖	✖
EUONYMUS Emerald Gaiety	12/05/2011	2	13/10/2011	26/11/2011	✖
EUONYMUS Emerald'n Gold	26/05/2011	2	13/10/2011	26/11/2011	✖

EUONYMUS ovatus Albus	18/05/2011	3	20/10/2011	26/11/2011	✕
EUONYMUS Silver Queen	18/05/2011	2	20/10/2011	26/11/2011	✕
EUPHORBIA Despina	18/05/2011	2	✕	✕	✕
EURYOPS pectinatus	06/06/2011	3	✕	✕	✕
<b>Broad Fen Site Varieties</b>	<b>Potting date</b>	<b>Pot Size</b>	<b>Ronstar 2G</b>	<b>Flexidor</b>	<b>Venzar Flo</b>
HELICHRYSUM Icicles	30/09/2011	3	11/10/2011		✕
LAVENDULA angustifolia Vera	not known	3	✕	✕	✕
LAVENDULA stoechas Regal Splendour	not known	2	✕	✕	✕
OSMANTHUS Burkwoodii	22/04/2011	2	13/10/2011	26/11/2011	✕
PELARGONIUM bicolor	10/08/2011	2	✕	✕	✕
PHOTINIA Scarlet Blaze	22/04/2011	3	13/10/2011	26/11/2011	✕
PITTOSPORUM garnettii	14/04/2011	2	20/10/2011	26/11/2011	✕
PITTOSPORUM Tom Thumb	28/04/2011	2	20/10/2011	26/11/2011	✕
PRUNUS laurocerasus Cherry Brandy	01/05/2011	5	✕	✕	✕
ROSA Iceberg	01/05/2011	5	✕	✕	✕
SANTOLINA chamaecyparissus	12/07/2011	3	✕	✕	✕
SANTOLINA Primrose Gem	11/08/2011	3	✕	✕	✕
BRACHYGLOTTIS Drysdale	13/06/2011	3	11/10/2011	✕	✕
VIBURNUM davidii	01/05/2011	5	✕	✕	✕

Yellow background indicates indoor crops