Project title:	Roses: Triazine-free herbicide programmes
Project number:	HNS 132
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Project collaborator:	Mr J Atwood, Senior Consultant, ADAS
Report:	Annual report Year 2, 2006
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Project locations:	Site 1: *Trials 1 & 2:* Ganger Farm, Jermyns Lane, Hants, SO51 0QA c/o Stewart Pocock Pocock's Roses Jermyns Lane Ampfield Romsey Hampshire, SO51 0QA Tel 01794 367500 Site 2: *Trial 1*: Weggs Farm, Diss, Norfolk, IP21 4PJ and *Trial 2*: White House Fm, Starston, Harleston, Norfolk IP20 9NH c/o Robert Wharton Wharton's Nurseries Ltd Harleston Norfolk, IP20 9AX Tel 01379 852157
Project co-ordinator:	Stewart Pocock, Pocock's Roses, Jermyns Lane, Ampfield, Romsey Hampshire, SO51 0QA, Tel 01794 367500
Date project commenced:	February 2005
Expected completion date:	January 2008
Key words:	Roses, hardy nursery stock, field-grown, herbicides, triazine-free, triazine, phytotoxicity, Artist (flufenacet + metribuzin), Butisan S (metazachlor), Calaris 400 SC (terbuthylazine + mesotrione), Centium 360 CS (clomazone), Crystal (flufenacet + pendimethalin), flazasulfuron, Flexidor 125 (isoxaben), Goal (oxyfluorfen), Javelin (diflufenican + isoproturon), Liberator (flufenacet + diflufenican), Ronstar Liquid (oxadiazon), simazine, Skirmish 495 SC (terbuthylazine + isoxaben), Stomp 400 SC, pendimethalin, Terano (flufenacet + metosulam).

CONTENTS

HNS 132

Roses: Triazine-free herbicide programmes

Headline

Several effective triazine free herbicide programmes have been identified with potential for use in field-grown roses including new products such as Artist and combinations of existing horticultural herbicides, Stomp, Flexidor and Butisan S.

Background and expected deliverables

As hand and mechanical weed control is not viable in field-grown roses with their 2-year production cycle and growth habit, herbicides are required for production to be economically viable. Rose herbicide programmes have traditionally relied on inexpensive triazine products such as simazine or atrazine but EU rulings have resulted in their withdrawal .from most uses .and Simazine will cease to be approved for use on hardy nursery stock in December 2007. Triazine-resistant weed populations such as fat hen, groundsel, annual meadow grass, American willowherb and pineapple weed have become a problem on some nurseries.

There has therefore been a need to re-evaluate some non-triazine herbicide programmes in field-grown roses. The last HDC funded work on this subject was concluded at HRI Efford in 1992, when some triazine-free programmes were moderately successful, but not as good as those incorporating .triazine herbicides. Since then, several new non-triazine candidates have become available. Other products containing the triazine, terbuthylazine, have recently been approved in the EC for use in pea & bean or forage maize crops and may have off-label potential for nursery stock.

The objectives of the project are to:

1 Assess the efficacy and crop safety of a range of new herbicide programmes on two commercial field-grown rose production sites and compare these with a standard programme containing, simazine.

2 Identify any specific weaknesses in the new programmes within the background weed spectra of test sites. This will help growers make informed choices for their site or alert them of extra measures that may be needed to control specific weeds.

3 Provide comparative costs of treatments.

Summary of the project (Year 2) and main conclusions to date

The work is being conducted on two commercial field sites in Hampshire (Site 1) and Norfolk (Site 2). Two successive trials are being conducted on each site (planted in Year 1 and Year 2 of the project). In each trial over the two-year crop cycle, herbicides have been applied at the conventional times – ie. post-planting of rootstocks (spring), post-budding (summer) and post-heading back (following winter). This annual report provides results following the final herbicide application to Trial 1 and the first two applications to Trial 2.

As a result of either poor weed control or phytotoxicity concerns in Trial 1, the herbicides Javelin, Centium 360CS, Crystal, Calaris 400SC and Liberator were omitted from Trial 2. Other herbicide treatments replaced these in Trial 2 (Treatments E, G, I, K and L). The full list of treatments in Trial 2 is found in Table 1, below.

Table 1 Herbicide Programme Treatments for Trial 2 (2006 / 2007)

Treatment	Post-Planting	Post-Budding	Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha
C	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha
D	Ronstar 4.0 L/ha + Stomp 3.3 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Ronstar 4.0 L/ha + Stomp 3.3 L/ha
E	Goal 4 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Goal 4 L/ha
F	Artist 2.5 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Artist 2.5 kg/ha
G	Artist 2.5 kg/ha + Stomp 5.0 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Artist 2.5 kg/ha + Stomp 5.0 L/ha
H	Stomp 5.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Butisan 2.5 L/ha
I	212H 0.06 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	212H 0.2 kg/ha
J	Flexidor 2.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flexidor 2.0 L/ha + Butisan 2.5 L/ha
K	Flazasulfuron 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flazasulfuron 0.2 kg/ha
L	Terano 0.75 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Terano 0.75 kg/ha

The full list of products used in the trials is found in Table 2, below.

Table 2 Herbicide products and active ingredients used in Trials 1 & 2

Product name	Active ingredients	a.i. content	Supplier
212H (experimental)	*confidential*	*confidential*	*confidential*
Artist	flufenacet + metribuzin	24 : 17.5 % w/w	Bayer CropScience
Butisan S	metazachlor	500 g/litre	BASF
Calaris 400 SC	terbuthylazine + mesotrione	330 : 70 g/litre	Syngenta
Centium 360 CS	clomazone	360 g/litre	Belchim
Crystal	flufenacet + pendimethalin	60 : 300 g/litre	BASF
Flazasulfuron	flazasulfuron	25 % w/w	Belchim / ISK
Flexidor 125	isoxaben	125 g/litre	Landseer
Goal	oxyfluorfen	240 g / litre	Makhteshim
Javelin	diflufenican + isoproturon	63.5 : 500 g/litre	Bayer CropScience
Liberator	flufenacet +diflufenican	400 : 100 g/litre	Bayer CropScience
Ronstar Liquid	oxadiazon	250 g/litre	Certis
Simazine (various)	simazine	500 g/litre	various
Skirmish 495 SC	terbuthylazine + isoxaben	420 : 75 g/litre	Syngenta
Stomp 400 SC	pendimethalin	400 g/litre	BASF
Terano	flufenacet + metosulam	60 : 2.5 % w/w	Bayer

NB as at spring 2007, the products 212H, Flazasulfuron and Goal, or equivalent formulations, are not available in the UK. Those others that are available in the UK for non-horticultural crops may be currently be used on nursery stock, at grower's risk, under the Long Term Arrangements for Extension of Use.

Phytotoxicity

Trial 1

- In spring 2006, bud-take was recorded on Trial 1 and did not show any significant treatment effects.
- The previous severe scorching to rootstocks in summer 2005 caused by Calaris in a post-budding application, did not have any apparent carry-over effect to maiden bush growth the following year.
- The diflufenican component of the Liberator and Javelin treatments in Trial 1 did cause some slight bleaching or spotting of lower leaves of new scion shoot growth on a few plants, but this was not serious and later foliage developed normally.
- Some transient bleaching of lower leaves was also attributed to the Centium component in one of the Trial 1 treatments at Site 1.

Trial 2

- Rootstock buds were breaking dormancy when treatments were applied.

- Treatments containing **Ronstar Liquid** and **Goal** both caused some severe scorch on newly emerged leaves, but subsequent new growth developed normally with no stunting of growth visible by the time stocks were budded.

- Like Ronstar Liquid, to avoid damage, it is clear that applications of Goal should not be applied to non-dormant crops.

- At Site 1, **Flazasulfuron** caused severe damage to stocks characterised by upcurled leaves, yellowing of older leaves and some shoot death. Surviving stocks were clearly still weaker at the end of the season. No such problems were observed at Site 2, however, and further observations, following the spring 2007 treatments, are needed.

Weed control

For Trial 1, the post-heading back treatments were applied on 11 March 2006 (Site 1) and 1 February (Site 2) with the final weed assessments on 4 July and 9 June respectively. The first herbicide treatments for Trial 2 (post-planting) were applied on 5 May 2006 (Site 1) and 10 April (Site 2) with weed assessments in mid June and August. Rootstocks were budded in mid July and post-budding herbicides applied 24 August (Site 1) and 9 August (Site 2) with weed assessments made on 21 November and 1 November respectively.

Grower standard

- The '**grower standard**' Trt B (**simazine + Butisan S**) treatment continued to give generally good weed control, but at Site 2 it showed weaknesses against triazine resistant groundsel, willowherb, cleavers, pansy and also poorer control of black bindweed and pale persicaria than some other treatments.

New triazine product

- The new triazine-containing **Skirmish** used in Trt C continued to look very good and performed better against groundsel and willowherb than Trt B suggesting that some groundsel on this site was triazine susceptible..

Triazine free

- Of the triazine-free alternatives, programmes incorporating **Artist** were amongst the most effective. It's weakness against black nightshade identified in Trial 1 were confirmed in Trial 2, although the addition of Stomp (Trt G) improved this.

- Trts H and J based on **Stomp** or **Flexidor** in combination with **Butisan S**, performed reasonably well overall, although at Site 1 sowthistle and mayweed in spring and summer were less well controlled. Also in Trial 2 at Site 2 high numbers of groundsel were present in the autumn which Stomp and Flexidor do not control. While Butisan is effective against groundsel, it is of relatively short persistence with little activity by autumn / winter from earlier summer applications.

- The choice of post-budding herbicides to the growing crop was limited to Butisan, Flexidor, Stomp and the new product Skirmish.

- Trt D, which incorporated **Ronstar**, did not give consistently good results at both sites. At Site 1 it failed to control annual meadow grass, sowthistle and dandelion seedlings as well as some other treatments.

- **Goal** in Trt E gave better weed control at Site 2 than Site 1 where dandelion seedlings, and some annual meadow grass were less well controlled. Higher levels of couch grass were also present in Trt E plots.

- **Flazasulfuron** (Trt K) gave generally good weed control, but further observations on its crop safety are needed following the final treatments in spring 2007. Flazasulfuron did not control black nightshade well.

- The experimental herbicide **212H** in Trt I failed to perform well with particularly poor control of annual meadow grass. However a higher rate is being used for the post-heading back spray in spring 2007.

- **Terano** in Trt L was also one of the poorer treatments which failed to control redshank, dandelion seedlings and mayweed well at Site 1, and was poor against groundsel at Site 2.

Financial benefits

A full assessment will be made in the final report. However pesticide material costs for the various herbicide programmes varied from about £130/ha to £480/ha in total for the three applications. The promising Treatments C, F, G & H for example appear good value at about £250, £180, £270 and £300/ha respectively with the 'grower standard' Trt B at £215/ha.

Action points for growers

- Simazine cannot be used after December 2007 so all existing stocks should be used by then.

- Consider trying out some of the promising treatments listed above, but note that some of these are off-label uses at grower's own risk.

- Some of these programmes may have wider applicability to other field-grown woody shrub and tree subjects, but further advice and small-scale trialling may be necessary first to assess their safety to the crop.

- HDC members are encouraged to relate experiences of efficacy and especially any phytotoxicity symptoms observed, to the Project leaders or HDC.

Science Section

INTRODUCTION

Field-grown roses remain one of the most important crop groups within the HNS sector with an estimated farm-gate value of £21 mill (Defra, 2005), of which most are eventually containerised for sale and form a significant proportion of the container HNS market valued at £281 mill.

Herbicides are still required for economic field production, and hand or mechanical weed control is currently not viable in this crop with its 2-year production cycle and growth habit. Rose herbicide programmes have traditionally centred on inexpensive triazines such as simazine or atrazine. The persistent triazines simazine and atrazine were withdrawn from non-agricultural uses in 2002, and an EU ruling significantly limited their use in agriculture from 2004. Simazine continues to be approved for use on hardy nursery stock but only until December 2007.

Triazine-resistant weed populations such as fat hen, groundsel, annual meadow grass, American willowherb and pineapple weed are also a developing problem on some nurseries.

Thus there is a need to re-evaluate some non-triazine herbicide programmes. The last HDC work on this subject was concluded at HRI Efford in 1992, when some triazine-free programmes were moderately successful, but not as good as those incorporating some triazines. Since then, several new non-triazine candidates have come onto the market. Recently the EC has approved two other products containing the triazine, terbuthylazine, for use in pea & bean or forage maize crops, but which may have off-label potential for nursery stock.

OBJECTIVES

1 Assess the efficacy and crop safety of a range of herbicide programmes on two commercial production sites for field-grown roses, compared to a typical grower's standard programme, which includes simazine.

2 Identify any specific weaknesses in the weed control spectrum of the herbicides (within the background weed spectra of test sites). This will help growers make informed choices for their site or alert them of extra measures that may be needed to control some weeds.

3 Provide comparative costs of treatments.

The previous annual report covered results up to autumn 2005 following the first two herbicide applications to Trial 1. This report covers the final herbicide application to the maiden crop in Trial 1 (spring 2006), and results of the first two herbicide applications to the rootstock crop of Trial 2 up to autumn 2006. The maiden crop results of Trial 2 in 2007 will be included in the final project report due by January 2008.

MATERIALS AND METHODS

Overview

The project is using two commercial field sites, one in Hampshire and the other in Norfolk. Over the three-year project duration, two successive trials are being conducted on each site (planted in Year 1 and Year 2). The conventional three timings of herbicides will be applied to each trial over the two-year crop cycle – ie post-planting of rootstocks (spring), post-budding (summer) and post-heading back (following winter). Thus in Year 2 of the project, Trials 1 and 2 will be running concurrently.

Weed names

Weeds are referred to by a common name in the main body of the report. Their latin binomials are given in Appendix 2, Table 1.

Sites

Site 1. Hampshire
Ganger Farm c/o Stewart Pocock, Pocock's Roses, Romsey.
Jermyns Lane
Ampfield
Romsey
Hants SO51 0QA

Roses form part of a rotation with soft fruit, vegetables and sweetcorn on a PYO holding. The field for Trial 1 was of clay loam soil texture and was cropped with sweetcorn in 2004. The field for Trial 2 (soil texture light sandy loam) was previously cropped with strawberries.

Site 2. Norfolk c/o Robert Wharton, Wharton's Nurseries Ltd, Harleston.
Trial 1
Weggs Farm
Common Road
Dickleburgh
Diss
Norfolk IP21 4PJ

The site for Trial 1 was previously cropped with winter wheat in 2004.
Soil texture: Sandy clay loam

Trial 2
White House Farm
Cross Road
Starston
Harleston
Norfolk IP20 9NH

Trial 2 site was previously cropped with winter wheat in 2005.
Soil texture: Sandy clay loam

Treatments

The herbicide treatments with rates of use for Trials 1 and 2 are detailed in Tables 1 and 2 respectively. Table 3 details the active ingredients and suppliers of the products used. Untreated controls were included to give a measure of the background weed pressure and range of species present. The range of herbicide treatments tested included active ingredients relatively new to the UK and currently only approved on arable crops, alongside existing horticultural herbicides in combinations designed to give a comprehensive weed control spectrum.

Table 1 Herbicide Programme Treatments for Trial 1 (2005 / 2006)

Treatment	Post Planting	Post Budding	Post Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha
C	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha
D	Ronstar 4.0 L/ha + Stomp 3.3 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Ronstar 4.0 L/ha + Stomp 3.3 L/ha
E	Ronstar 4.0 L/ha + Javelin 1.0 L/ha	Butisan 2.5 L/ha + Stomp 3.3 L/ha	Ronstar 4.0 L/ha + Javelin 1.0 L/ha
F	Artist 2.5 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Artist 2.5 kg/ha
G	Stomp 5.0 L/ha + Centium 0.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Centium 0.5 L/ha
H	Stomp 5.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Butisan 2.5 L/ha
I	Crystal 4.0 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Crystal 4.0 L/ha
J	Flexidor 2.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flexidor 2.0 L/ha + Butisan 2.5 L/ha
K	Calaris 1.5 L/ha	Calaris 1.5 L/ha	Calaris 1.5 L/ha
L	Liberator 0.6 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Liberator 0.6 L/ha

Trial 1 treatments

Treatment B, simazine + Butisan S for each application, was the standard programme against which other treatments were being compared. This is a commonly used treatment where simazine is supplemented with Butisan S to provide control of resistant weeds such as groundsel and willowherb plus improved control of *Polygonum* weeds.

In Treatment C, Skirmish replaced simazine, employing the alternative triazine, terbuthylazine, which is only available in mixtures with a small amount of isoxaben.

Treatments D and E were based around Ronstar Liquid. An effective herbicide but relatively weak on chickweed and grasses. The supplements Stomp or Javelin were designed to give chickweed and grass control. Because of the contact action of Ronstar liquid, it is not possible to use this post-budding, so either Butisan S + Stomp or Butisan S + Flexidor were used, the latter to avoid double applications of Stomp.
In treatment F the new potato and vegetable herbicide Artist (flufenacet + metribuzin) was used after planting and post heading back. Metribuzin is a long established active

used on potatoes, the addition of flufenacet in the new product improves cleavers and grass control. Metribuzin has shown some promise in other nursery stock experiments (HNS 111) when used on dormant crops and is used on some ornamentals in Germany. It has a strong contact action, so Butisan + Stomp was used instead as the post-budding treatment.

Treatments G, H and I were based around Stomp (pendimethalin) either as tank mixtures or as the formulated product Crystal (pendimethalin + flufenacet). The addition of Centium (treatment G) or Butisan (metazachlor) was chosen to improved control of composite weeds such as mayweed and groundsel, against which Stomp is weak.

Treatment J utilised the existing horticultural herbicides Flexidor and Butisan in combination to achieve a reasonable weed control spectrum.

Treatment K tested the new active ingredient mesotrione with terbuthylazine in the formulated product Calaris. As little is known of the safety on ornamentals it was decided to apply a three-spray programme including its use after budding.

Treatment L tested the new arable product Liberator comprising the active ingredients diflufenican and flufenacet, both of which are thought to be reasonably safe for use on dormant roses.

Table 2 Herbicide Programme Treatments for Trial 2 (2006 / 2007)

Treatment	Post Planting	Post Budding	Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha
C	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha
D	Ronstar 4.0 L/ha + Stomp 3.3 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Ronstar 4.0 L/ha + Stomp 3.3 L/ha
E	Goal 4 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Goal 4 L/ha
F	Artist 2.5 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Artist 2.5 kg/ha
G	Artist 2.5 kg/ha + Stomp 5.0 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Artist 2.5 kg/ha + Stomp 5.0 L/ha
H	Stomp 5.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Butisan 2.5 L/ha
I	212H 0.06 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	212H 0.2 kg/ha
J	Flexidor 2.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flexidor 2.0 L/ha + Butisan 2.5 L/ha
K	Flazasulfuron 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flazasulfuron 0.2 kg/ha
L	Terano 0.75 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Terano 0.75 kg/ha

Table 3 Herbicide products and active ingredients

Product name	Active ingredients	a.i. content	Supplier
212H (experimental)	*confidential*	*confidential*	*confidential*
Artist	flufenacet + metribuzin	24 : 17.5 % w/w	Bayer CropScience
Butisan S	metazachlor	500 g/litre	BASF
Calaris 400 SC	terbuthylazine + mesotrione	330 : 70 g/litre	Syngenta
Centium 360 CS	clomazone	360 g/litre	Belchim
Crystal	flufenacet + pendimethalin	60 : 300 g/litre	BASF
Flazasulfuron	flazasulfuron	25 % w/w	Belchim / ISK
Flexidor 125	isoxaben	125 g/litre	Landseer
Goal	oxyfluorfen	240 g / litre	Makhteshim
Javelin	diflufenican + isoproturon	63.5 : 500 g/litre	Bayer CropScience
Liberator	flufenacet + diflufenican	400 : 100 g/litre	Bayer CropScience
Ronstar Liquid	oxadiazon	250 g/litre	Certis
Simazine (various)	simazine	500 g/litre	various
Skirmish 495 SC	terbuthylazine + isoxaben	420 : 75 g/litre	Syngenta
Stomp 400 SC	pendimethalin	400 g/litre	BASF
Terano	flufenacet + metosulam	60 : 2.5 % w/w	Bayer

NB as at spring 2007, the products 212H, Flazasulfuron and Goal, or equivalent formulations, are not available in the UK. Those others that are available in the UK for non-horticultural crops may be currently be used on nursery stock, at grower's risk, under the Long Term Arrangements for Extension of Use.

Trial 2 treatments

See the comments above for Trial 1 for treatments common to Trial 2.

After evaluating results in 2006 in Trial 1, the following products were not taken forward for further evaluation in Trial 2: Calaris 400 SC, Centium 360 CS, Crystal, Javelin, and Liberator. This was either due to poorer weed control than other treatments, or concerns about phytotoxicity.

For Trial 2, these dormant season treatments were replaced by Goal (oxyfluorfen) in Trt E., Artist plus Stomp was tried in Trt G, an experimental product 212H in Trt I, Flazasulfuron in Trt K, and Terano (flufenacet + metosulam) in Trt L.

Goal is reputed to be a potent herbicide controlling a wide spectrum of annual and some perennial weeds, but chickweed is resistant. Flazasulfuron is also supposed to have a very broad spectrum of weed control. Terano (like the product Artist and the previously trialled products Crystal and Liberator) also contains flufenacet (mainly a grass control herbicide) but in combination with metosulam to increase its broadleaf weed control spectrum. 212H is an experimental herbicide reputed to have a wide spectrum of control on broadleaf and some grass weeds.

Herbicide options for the summer post-budding application are more limited because of contact activity of several herbicides, and the risk of crop damage. Butisan has proved safe on rootstocks and controls a useful range of weeds, even if it's persistence is limited to only about three months or so. Butisan was therefore used in all the treatments, often in combination with either Stomp or Flexidor depending on whether either had already been used in the programme in spring. Skirmish plus Butisan was

also tested in summer in Trt C as a permitted triazine replacement to the 'grower standard' three-application simazine plus Butisan programme Trt B.

Trial design

See Appendix 1 for details of layouts and plans.

On both sites a randomised block design was used for both Trials 1 & 2 with 12 treatments x 4 blocks = 48 plots.

Trial 1
For Site 1 (Hants), plots were 3.67 m wide x 4.0 m long comprising four crop rows on two 1.83 m wide beds. This gave a treated area of 14.7 m^2 per plot. Rootstock spacings were nominally 150 mm in-row giving approx 108 plants per treated plot.

A 0.5 m buffer zone at each end of the plot was ignored for weed assessments leaving an area for recording of 3.0 m length x 3 alleys (2.5 m) width = 7.5 m^2.

An uncropped tractor access alley was left either side of the 8 row trial area which was sprayed with the standard Simazine + Butisan S treatment.

For Site 2 (Norfolk), plots were 4 m wide x 4 m long containing six crop rows. As at Site 1, weed records were restricted to a central area within each plot.

Trial 2
At Site 1, Trial 2 was laid out in a similar way to Trial 1, but using 3.0 m long plots giving a treated area of 11.0 m^2 per plot and approx. 80 plants per treated plot. As before, a 0.5 m buffer zone at each end of the plot was ignored for weed assessment giving a 2.0 m x 3 alley (2.5 m) width = 5.0 m^2.

At Site 2, plots were 3.0 m long by two rows (1.5 m) wide.

Application of herbicide treatments

Table 3, below, gives the key activity dates including herbicide treatments and weed assessments.

At Site 1, Trial 1, herbicides were applied using a Flow Techniques nursery sprayer powered by a 12V pump. The pressure regulator was set to maintain 2.0 Bar at the boom fitted with F80/1.6/3 nozzles. A double pass was used to ensure even coverage and sprays were applied in a water volume of 720 L/ha for the post-planting treatments, 680 L/ha for the post-budding spray, and 655 L/ha for the post-heading back applications.

For Trial 2, plot sizes were small enough to apply treatments using a Cooper-Pegler CP15 knapsack sprayer, which was more convenient to use. The same boom and nozzle arrangement was used, and a 2.0 Bar pressure control valve fitted to help ensure a consistent output. Again a double pass over the plots was done, and calibrations gave an application volume of 770 L/ha for the post-planting treatments, and 730 L/ha for the post-budding treatments.

At Site 2, treatments were applied to both Trials 1 and 2 with an Oxford Precision Sprayer using compressed CO_2 to maintain a constant output. Herbicides were applied at 2.0 Bar using 03-F110 nozzles in a volume of 750 L/ha for all spray applications.

Weed assessments

Trial 1

At Site 1 (Hants), following the post-heading back treatments in mid March, relatively little annual weed emerged on the herbicide treated plots in the spring, and so an assessment was delayed until early July 2006. At this stage there was heavy weed cover on the untreated plots, so a visual assessment of proportion weed cover was made, and the main species present noted. As in Year 1, weeds by species were counted within the central 3 alleys and centre 3.0 m length (7.5 m^2 area) on herbicide treated plots.

At Site 2 (Norfolk), post-heading back treatments were applied earlier than at Site 1 (early February), and a weed assessment was carried out in early May. Apart from the untreated control plots, there was still only a small amount of weed at this time. Another assessment was done in early June following more weed germination. Weeds were counted within a central area of each plot of 6.9 m^2 for both these assessments. At this time, there was a mixture of older and young weed seedlings present, and so a percentage weed cover assessment was also carried out on each plot as the analysis of weed numbers alone might have given a misleading impression of weed competition.

Trial 2

At Site 1, delivery of imported rootstocks was delayed due to freezing conditions in Europe, and coupled with the wet spring in the UK, planting was delayed until mid April 2006. A period of dry weather followed, so the first herbicide treatments were not applied until early May. The first weed assessment was in mid June at which stage weed numbers were still relatively low. Budding did not take place until mid July but the weather was too dry for the post-budding herbicides to be applied until late August. Prior to that, in early August, a second 'summer weed record' was taken when weed numbers had developed more to better assess the effects of the post-planting treatments. Finally, a weed count in late November assessed the effects of the post-budding herbicide. At Site 1, all weed counts were taken in a the central three alley zone (2.5 m wide x 2.0 m long = 5.0 m^2) per plot, leaving a 0.5 m long buffer zone at the ends of each plot. Weeds were removed from all plots during or shortly after recording for the summer assessments. Autumn weeds were left to die down over winter although some were removed by hand (especially from the Untreated Trt A plots) early in 2007 prior to applying the final post-heading back treatments.

For Site 2 (Norfolk), weed assessments were based on 2.6 m^2 per plot, however, this area was sufficient as this site had a generally higher weed population. Following the mid April post-planting herbicide application, weeds were recorded in early June, and in early November following the early August post-budding treatments.

Phytotoxicity observations

Rootstocks were observed for any signs of damage such as leaf scorching, yellowing, distorted growth etc. following herbicide applications. Any damage was noted and photographed where possible.

A bud-take assessment was made on both sites following the heading back of rootstocks in Year 2. Numbers of plants present, and those with viable scion buds were recorded on a whole plot basis for Site 1 and part plot for Site 2. The record was left until early May to allow time for any late breaking scion buds to shoot. It also meant that any phytotoxicity symptoms from post-budding herbicide treatments could be noted at the same time.

Analysis of results

Weed count data from each Trial and Site were standardised to weeds per m^2. For Site 1, Hants, the estimates of weed cover for the untreated plots (Trt A) in Trial 1 were not included in the statistical analyses because weed numbers were obviously so much larger than the other treatments. In Trial 2 on both Sites, however, weed counts were possible from untreated Trt A plots along with the herbicide treatments and were included in the formal statistical analyses.

As is typical in field experiments on weed control, the distribution of weeds was patchy and variable, and for individual species there were a lot of zero count plots. A $\log_{10}$ (count + 1) transformation was thus used to improve the non-normality of the data and make it better suited to analyses of variance. Likewise, an angular transformation was applied to percentage weed cover data from Trial 1 Site 2 (Norfolk) weed assessment in June 2006 before subjecting to ANOVA.

Individual ANOVA's for the most abundant weed species recorded were carried out as well as for total weed numbers.

No further analysis of the bud-take records was deemed worthwhile after calculating mean treatment effects.

Diary of key operations

Table 3 Dates of main activities

Trial 1		
Activity	**Site 1, Hampshire**	**Site 2, Norfolk**
Plant rootstocks	w/c 7/3/05	11/4/05
Post-planting herbicide treatments	23/3/05	21/4/05
Summer weed assessment	20-27/6/05	27/5/05
Rootstocks budded	w/c 25/7/05	w/c 18/7/05
Post-budding herbicide treatments	9/8/05	15/8/05
Autumn weed assessment	23/11/05	14/11/05
Rootstocks headed back	late February	early January
Post-heading back herbicide treatments	11/3/06	1/2/06
Spring / summer weed assessment(s)	-	4/5/06
- ditto -	4/7/06	9/6/06
Trial 2		
Activity	**Site 1, Hampshire**	**Site 2, Norfolk**
Plant rootstocks	w/c 17/4/06	w/c 30/1/06
Post-planting herbicide treatments	5/5/06	10/04/06

Summer weed assessment(s)	12-13/6/06	9/6/06
- ditto -	9/8/06	-
Rootstocks budded	w/c 17/7/06	w/c 10/7/06
Post-budding herbicide treatments	24/8/06	9/08/06
Autumn weed assessment	21/11/06	1/11/06

Perennial weed growth in Trial 1 at Site 1 (Hants) had required spot treatment by hand with a brush using glyphosate as Roundup Biactive on a few occasions during the first year (2005). Thistles were the predominant perennial weed present, particularly at the west end of the trial, followed by dandelion distributed generally throughout the area. There were also some patches of creeping cinquefoil, and perennial sowthistle, and much smaller numbers of dock and buttercup. In the second year, perennials (mainly dandelion and creeping cinquefoil) were again treated with glyphosate in mid May 2006. Untreated Trt A plots, which had developed a covering of mainly annual weed, were also hand hoed at this time (Appx 3, Photo 3).

Plots were generally cleaned of annual and perennial weed as weed records were taken or shortly afterwards. Any small weed present prior to applying herbicide treatments was hoed (e.g. for the post-budding spray where there was a gap since the last weed assessment). For Trial 2, Site 1 in summer 2006, glyphosate was not used as only dandelion plus a few perennial sowthistle were the main perennials present, and large weeds (mainly Trt A plots) were removed by hand with a border fork in mid August. Following the autumn weed assessment in November 2006, it was decided to leave cleaning up the trial (particularly Untreated Trt A plots) until after heading back and before the final herbicide application in 2007, as most annual weeds would normally die back overwinter.

RESULTS AND DISCUSSION

TRIAL 1

Bud-take (see Appendix 4, Tables 1 – 4)

Bud-take was better at Site 2 in Norfolk (overall mean 94%) than Site 1, Hants (overall mean 73%). However, there was no indication that herbicide treatments had any major effect. Follow-through effects from the previous year might have been expected on Trt K, Calaris, where rootstocks suffered significant scorch and premature leaf drop after the post-budding spray in 2005, but this was not the case. The bud-take results were more variable at Site 1 between replicate plots within treatments, but this was probably a reflection of the different cultivars budded sequentially through the trial rather than herbicide effects. Even the untreated Trt A plots on this site, which had been smothered in tall weeds during part of the summer in 2005 and which had stunted growth, had similar numbers of plants present and broadly similar bud-take to the herbicide treatments. These plants were smaller, however, and would have produced fewer Class 1 bushes by the time they were lifted (although final grade-out was not assessed).

Phytotoxicity

For Trial 1, the major phytotoxicity problem in the first year had been foliage scorch caused by contact action from the use of Calaris (Trt K) as a summer post-budding spray on rootstocks in 2005. As reported above, there did not appear to be any significant carry-over effects on scion bud development and no other symptoms appeared following the dormant season post-heading back application in spring 2006.

It is thought that the diflufenican component of some herbicide treatments caused some transient symptoms to appear on young scion shoot growth in 2006. At Site 1, this appeared as pale pink spots on the lower leaves of some plants in three of the four replicate plots of Trt L, Liberator (flufenacet + diflufenican), particularly on those cultivars with dark red immature foliage. At Site 2, Trt E, Javelin (diflufenican + isoproturon) + Ronstar (oxadiazon) caused some slight bleaching on lower leaves of cv Alfresco. Symptoms were not found in all plots with herbicide treatments containing diflufenican on both sites though, and any symptoms seen did not persist and later foliage developed normally. In spring 2005, some transient yellowing, scorching and twisting of young rootstock leaves seen in Trt E on Site 1 was also attributed to the diflufenican component of Javelin.

Finally, some transient bleaching of lower scion leaves was observed on Trt G, Centium + Stomp plots, on Site 2 (but not Site 1). In 2005, similar symptoms were observed following the post-planting application on rootstock foliage on Site 1 (but not Site 2). This was attributed to the Centium (clomazone) component as no other treatments containing Stomp were affected.

Control of weeds

Tables of treatment means for weed populations and statistical analyses are given for the main individual weed subjects present, and more scattered occurrences of other species are grouped together under ‘other weeds’. Data in bold highlight the most weed free treatments not significantly different from one another at P<5% (analysis of transformed data). Original data of counts of all weed species recorded by plot are presented in Appendix 4, Tables 5 - 12.

Although the emphasis of the project is on the control of annual weeds, perennials such as dandelion and creeping thistle were present in significant numbers and were recorded, as the herbicide treatments did influence their populations. This was probably down to control of seedlings, rather than vegetative reproduction, but could nevertheless be relevant when considering the overall efficacy of particular herbicides. At Site 1, most of the 'other grass' (ie not annual meadow grass), was subsequently identified as the perennial common couch rather than volunteer cereals. However, these records were included as apparent differences between treatments could indicate some suppressive activity of treatments against couch.

Trial 1, Site 1, Hampshire

There was little weed emergence on any of the herbicide treated plots in the spring following the herbicide application on 11 March, so an assessment was delayed until early July. The untreated Trt A plots, however, developed significant cover of annual and some perennial weed by mid May, especially annual meadow grass, mayweed, dandelion, and sowthistle, and this was cleaned by hand.

Final assessment 4th July 2006 (Table 4)
The regrowth of weed on the untreated Trt A plots by the 4th July assessment was too great for a count of individual weeds (Appx 3, Photo 5). Weed cover was about 85% for plot 3, 80% for plots 20 and 42, and 70% for plot 25. The main weed species visible were hawk's beard (flowering), sowthistle, annual meadow grass, scarlet pimpernel, redshank, groundsel, mayweed and dandelion with some pansy, other grasses, buttercup, spurge, fat hen, creeping cinquefoil, black bindweed, and willowherb.

For the herbicide treatments, weed populations were fairly low throughout, with the worst treatment (Trt I, Crystal) averaging about 4.0 weeds/m^2 and the best (Trt C, Skirmish + Butisan) averaging 0.4 weeds/m^2 (Table 4). The best treatments overall were C (Skirmish + Butisan), K (Calaris), B (Simazine + Butisan), F (Artist), E (Ronstar + Javelin) and H (Stomp + Butisan). The weakest were I (Crystal), G (Stomp + Centium) and L (Liberator).

The main weakness with Trt G (Stomp + Centium) was control of sowthistle, of which most was found in one heavily infested patch (plot 29), which also caused problems in the first year. Trt I (Crystal) was weaker on sowthistle, dandelion, 'other grasses' (i.e. not annual meadow grass), and several other weeds present. Trt L (Liberator) let through some black nightshade as well as sowthistle, dandelion and miscellaneous weed. Plots of Trt D (Ronstar + Stomp) while otherwise appearing clean of most species at this assessment, did contain 'other grasses', dandelion and low numbers of sowthistle.

Of the better herbicides overall, Artist (Trt F), failed to control nightshade very well, and Ronstar + Javelin (Trt E) was weaker on 'other grasses'.

Table 4. Trial 1, Site 1, Hants. Mean weed numbers on herbicide treated plots 4 July 2006.

Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post heading back)[1]	Sowthistle	Dandelion	'Other Grass'	Black Nightshade	Thistle	Black Bindweed	Other Weeds[2]	Total Weeds
B. Simazine + Butisan S	**0.098 (0.25)**	**0.039 (0.09)**	**0.000 (0.00)**	**0.037 (0.09)**	**0.026 (0.06)**	**0.039 (0.09)**	**0.123 (0.33)**	**0.276 (0.89)**
C. Skirmish + Butisan S	**0.046 (0.11)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.077 (0.20)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.026 (0.06)**	**0.131 (0.35)**
D. Ronstar + Stomp lo	**0.101 (0.26)**	0.191 (0.55)	0.157 (0.44)	**0.000 (0.00)**	**0.076 (0.19)**	**0.000 (0.00)**	**0.014 (0.03)**	0.425 (1.66)
E. Ronstar + Javelin	**0.000 (0.00)**	**0.099 (0.26)**	0.182 (0.52)	**0.039 (0.09)**	**0.037 (0.09)**	**0.000 (0.00)**	**0.076 (0.19)**	**0.343 (1.20)**
F. Artist	**0.060 (0.15)**	**0.039 (0.09)**	**0.046 (0.11)**	0.138 (0.38)	**0.014 (0.03)**	**0.037 (0.09)**	**0.110 (0.29)**	**0.341 (1.19)**
G. Stomp hi + Centium	0.420 (1.63)	**0.026 (0.06)**	**0.097 (0.25)**	**0.050 (0.12)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.088 (0.22)**	0.560 (2.63)
H. Stomp hi + Butisan S	**0.169 (0.48)**	**0.095 (0.24)**	**0.039 (0.09)**	**0.000 (0.00)**	0.129 (0.35)	**0.000 (0.00)**	**0.027 (0.06)**	**0.362 (1.30)**
I. Crystal	0.286 (0.93)	0.296 (0.98)	0.198 (0.58)	**0.000 (0.00)**	**0.064 (0.16)**	**0.027 (0.06)**	0.287 (0.94)	0.698 (3.99)
J. Flexidor + Butisan S	**0.095 (0.24)**	0.162 (0.45)	**0.000 (0.00)**	**0.000 (0.00)**	**0.039 (0.09)**	0.065 (0.16)	0.191 (0.55)	0.399 (1.51)
K. Calaris	**0.000 (0.00)**	**0.000 (0.00)**	**0.062 (0.15)**	**0.062 (0.15)**	**0.000 (0.00)**	**0.014 (0.03)**	**0.014 (0.03)**	**0.143 (0.39)**
L. Liberator	**0.171 (0.48)**	**0.134 (0.36)**	**0.069 (0.17)**	0.099 (0.26)	**0.072 (0.18)**	**0.039 (0.09)**	0.190 (0.55)	0.482 (2.03)
SED (30 df)	*0.1221*	*0.0669*	*0.0694*	*0.0408*	*0.0517*	*0.0251*	*0.0543*	*0.1208*
LSD (5%)[3]	*0.249*	*0.137*	*0.142*	*0.083*	*0.106*	*0.051*	*0.111*	*0.247*
Significance, P[4]	*0.051*	*0.002*	*0.047*	*0.023*	*0.313*	*0.145*	*<.001*	*0.002*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Treatment A (Untreated) not included in this analysis because weed growth was too great for individual weeds to be counted.

[2] Other weeds = annual meadow grass, groundsel, buttercup, speedwell, persicaria, spurge, charlock, mouse-eared chickweed, clover, willowherb, cleavers, fat hen, scarlet pimpernel, sharp-leaved fluellen, fumitory, hawk's beard, knotgrass.

[3] Least significant difference for comparing transformed means at P<0.05

[4] Overall significance of treatment effects in ANOVA

Table 5. Trial 1, Site 2, Norfolk. Mean weed numbers on herbicide treated plots 4 May 2006.
Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post heading back)	**Groundsel**	**Mayweed**	**Cleavers**	**Other Weeds[1]**	**Total Weeds**
A. Untreated	0.511 (2.24)	0.342 (1.20)	0.213 (0.63)	0.696 (3.97)	0.973 (8.40)
B. Simazine + Butisan S	**0.000 (0.00)**	**0.000 (0.00)**	**0.126 (0.34)**	**0.068 (0.17)**	**0.165 (0.46)**
C. Skirmish + Butisan S	**0.015 (0.04)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.028 (0.07)**
D. Ronstar + Stomp lo	**0.015 (0.04)**	**0.069 (0.17)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.082 (0.21)**
E. Ronstar + Javelin	**0.015 (0.04)**	**0.029 (0.07)**	**0.000 (0.00)**	**0.015 (0.03)**	**0.057 (0.14)**
F. Artist	**0.057 (0.14)**	**0.000 (0.00)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.070 (0.17)**
G. Stomp hi + Centium	**0.042 (0.10)**	**0.067 (0.17)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.104 (0.27)**
H. Stomp hi + Butisan S	**0.028 (0.07)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.028 (0.07)**
I. Crystal	0.188 (0.54)	**0.098 (0.25)**	**0.137 (0.37)**	**0.000 (0.00)**	0.337 (1.17)
J. Flexidor + Butisan S	**0.015 (0.04)**	**0.000 (0.00)**	**0.028 (0.07)**	**0.000 (0.00)**	**0.042 (0.10)**
K. Calaris	**0.039 (0.09)**	**0.015 (0.04)**	0.163 (0.46)	**0.000 (0.00)**	**0.194 (0.56)**
L. Liberator	0.167 (0.47)	**0.015 (0.04)**	**0.000 (0.00)**	**0.068 (0.17)**	0.236 (0.72)
SED (33 df)	*0.0599*	*0.0587*	*0.0756*	*0.04657*	*0.0935*
LSD (5%)	*0.122*	*0.119*	*0.154*	*0.095*	*0.190*
Significance, P	*<.001*	*<.001*	*0.04*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weeds = annual meadow grass, willowherb spp., speedwell spp., pale persicaria, black bindweed and pansy

Table 6. Trial 1, Site 2, Norfolk. Mean weed numbers on herbicide treated plots 9 June 2006.

Transformed data as $\log_{10}$ (weeds/m^2 + 1) or arcsine square root transformation for % cover. Back-transformed data, as weeds/m^2 or % cover, is in brackets.

Treatment (post heading back)	Groundsel	Cleavers	Pale Persicaria	Mayweed	Pansy	Black Bindweed	Other Weeds[1]	Total Weeds	% Cover
A. Untreated	0.957 (8.06)	**0.279 (0.90)**	**0.171 (0.48)**	0.360 (1.29)	**0.082 (0.21)**	0.320 (1.09)	0.816 (5.55)	1.288 (18.41)	66.6 (84.2)
B. Simazine + Butisan S	0.572 (2.73)	**0.203 (0.60)**	0.223 (0.67)	**0.028 (0.07)**	0.221 (0.66)	**0.104 (0.27)**	**0.102 (0.26)**	0.897 (6.89)	**7.1 (1.5)**
C. Skirmish + Butisan S	0.509 (2.23)	**0.028 (0.07)**	**0.028 (0.07)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.059 (0.15)**	**0.000 (0.00)**	**0.555 (2.59)**	**4.1 (0.5)**
D. Ronstar + Stomp lo	**0.339 (1.18)**	**0.093 (0.24)**	**0.115 (0.30)**	**0.078 (0.20)**	**0.000 (0.00)**	**0.000 (0.00)**	0.140 (0.38)	**0.555 (2.59)**	**7.6 (1.7)**
E. Ronstar + Javelin	**0.200 (0.58)**	0.229 (0.69)	**0.015 (0.04)**	**0.028 (0.07)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.432 (1.70)**	**1.4 (0.1)**
F. Artist	0.861 (6.26)	**0.015 (0.04)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.000 (0.00)**	0.170 (0.48)	**0.042 (0.10)**	0.908 (7.09)	**3.8 (0.4)**
G. Stomp hi + Centium	**0.068 (0.17)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.089 (0.23)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.098 (0.25)**	**0.220 (0.66)**	**5.7 (1.0)**
H. Stomp hi + Butisan S	0.496 (2.13)	**0.077 (0.19)**	**0.015 (0.04)**	**0.000 (0.00)**	**0.054 (0.13)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.572 (2.73)**	**2.9 (0.3)**
I. Crystal	0.652 (3.49)	0.438 (1.74)	0.261 (0.82)	**0.064 (0.16)**	**0.015 (0.04)**	**0.028 (0.07)**	**0.124 (0.33)**	0.989 (8.75)	23.2 (15.5)
J. Flexidor + Butisan S	0.603 (3.01)	**0.093 (0.24)**	**0.028 (0.07)**	**0.015 (0.04)**	**0.077 (0.19)**	**0.000 (0.00)**	**0.097 (0.25)**	0.770 (4.89)	**3.9 (0.5)**
K. Calaris	**0.250 (0.78)**	**0.181 (0.52)**	**0.000 (0.00)**	**0.059 (0.15)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.067 (0.17)**	**0.453 (1.84)**	**1.4 (0.1)**
L. Liberator	0.662 (3.59)	0.118 (0.31)	0.561 (2.64)	**0.015 (0.04)**	**0.000 (0.00)**	**0.121 (0.32)**	**0.079 (0.20)**	0.962 (8.16)	16.8 (8.4)
SED (33 df)	*0.1873*	*0.1103*	*0.0847*	*0.0553*	*0.0789*	*0.0783*	*0.0643*	*0.1768*	*5.58*
LSD (5%)	*0.381*	*0.224*	*0.172*	*0.113*	*0.161*	*0.159*	*0.131*	*0.360*	*11.4*
Significance, P	*<.001*	*0.015*	*<.001*	*<.001*	*0.234 (NS)*	*0.005*	*<.001*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weeds = annual meadow grass, willowherb, other grasses / cereals, swinecress, chickweed, speedwell, fat hen, knotgrass, field penny-cress, charlock, scarlet pimpernel, red dead nettle.

Trial 1, Site 2, Norfolk

The post-heading back herbicide application had been applied over a month earlier (1 February) on this site than at Site 1 (11 March). An initial weed assessment was made on 4 May while weed levels on herbicide treated plots were still quite low compared to untreated controls (Table 5). A final assessment was recorded on 9 June (Table 6).

Assessment 4th May 2006 (Table 5)
The most prevalent weeds in May were groundsel, mayweed and cleavers. 'Other weeds' present were mainly annual meadow grass, willowherb and speedwell, with small numbers of pale persicaria, black bindweed and pansy. Nearly all the 'other weed' was confined to the untreated Trt A plots.

Untreated Trt A plots averaged 8.4 weeds/m^2 compared to <0.1 – 1.2 weeds/m^2 for the herbicide treatments. The weakest treatment was Crystal (Trt I) with 1.2 weeds/m^2 much of which was due to groundsel. However this treatment was not significantly different from Liberator (Trt L), Calaris (Trt K) or the grower standard simazine + Butisan (Trt B) at $P<0.05$.

Crystal (Trt I) had small numbers of groundsel, cleavers and mayweed present; for Liberator (Trt L) a few groundsel and for Calaris (Trt K) mainly cleavers. The weeds present in the simazine + Butisan treatment were restricted to a few cleavers in two plots and pansy in one plot.

Final assessment 9th June 2006 (Table 6)
By early June there was a mixture of older larger weed present and a lot of young seedling weed, particularly newly emerged groundsel. The % ground cover assessment gave a better indication of the competitive effect of weed at this stage than simply weed numbers. The untreated plots had a mean of 84% weed cover, followed by Trt I (Crystal) with 15% cover and Trt L (Liberator) with 8% cover. Mean cover estimates for the remaining herbicide treatments were between 0.1% and 1.7%. A lot of the weed cover in Trts I and L were due to older plants of groundsel, for Crystal, cleavers, and for Liberator, persicaria, that were beginning to emerge by the May assessment.

In terms of weed numbers, Trts G (Stomp + Centium), E (Ronstar + Javelin), K (Calaris), C (Skirmish + Butisan), D (Ronstar + Stomp) and H (Stomp + Butisan) had the fewest total weeds present with means of 0.7 – 2.7 weeds/m^2.

Artist (Trt F), which had generally performed well previously, had allowed significant numbers of groundsel seedlings through, and also some black bindweed. The grower standard Trt B simazine + Butisan, was let down by poorer control of groundsel, pansy (particularly on one plot), black bindweed, pale persicaria and cleavers than some other treatments. Trt C (Skirmish + Butisan) was better than simazine + Butisan for most of these weeds, but still failed to control some groundsel.

By 9th June, it is likely that the potency of some of the herbicides applied four months earlier were beginning to wear off. Butisan S is known to have a relatively short persistence of about 3 months. Simazine is also known to be weaker on cleavers and pansy, and the evidence from this trial is that the groundsel population was also at least partly triazine resistant, as demonstrated by the weaker control from Trts B and C.

Treatments containing either Stomp or Ronstar (Trts D, E, G & H) generally performed well, although some groundsel was not as well controlled in Trt H (Stomp + Butisan) as in Trt C (Stomp + Centium). Stomp does not control groundsel well and Butisan's effect would have worn off by then.

Summary of herbicide performance in Trial 1

The standard simazine + Butisan based (Trt B) continued to give generally good weed control, but at Site 2, its weaknesses against triazine resistant groundsel, cleavers, pansy, black bindweed and pale persicaria were beginning to show up compared to some other treatments.

Trt C (Skirmish + Butisan) performed well, but also showed some weakness against triazine resistant groundsel on Site 2.

Trt D (Ronstar + Stomp / Butisan + Flexidor), and Trt E (Ronstar + Javelin / Butisan + Flexidor), also performed reasonably well but were not consistently as good on both sites. Ronstar + Javelin could be weaker on 'other grasses'. Javelin could cause some transient phytotoxicity symptoms.

Trt F (Artist / Butisan + Stomp) generally also gave good weed control. It did, however, appear to be weaker on black nightshade, groundsel and black bindweed in Year 2.

Trt G (Stomp + Centium / Butisan + Flexidor) gave good control in Year 2 but some mayweed, sowthistle and annual grasses were not so well controlled, particularly in Year 1. Centium could cause some transient phytotoxicity.

Trt H (Stomp + Butisan / Butisan / Flexidor) performed well on both sites, but did not give complete groundsel control once the Butisan began to lose efficacy 3 months after application.

Trt I (Crystal / Butisan + Flexidor) was one of the poorest herbicides and failed to give very good control of a range of weeds including mayweed, grasses, volunteer cereals, redshank and groundsel.

Trt J (Flexidor + Butisan / Butisan + Stomp). Average results overall. Not as good as several of the other triazine-free options, and Trt J gave poorer control of dandelion seedlings, volunteer cereals and some other grasses, cleavers, and redshank.

Trt K (Calaris). Generally good weed control, but was clearly phytotoxic when sprayed on actively growing tissue including rootstock foliage as a post-budding spray. Did not show any real advantage over the other 'permitted triazine' programme, Trt C.

Trt L (Liberator / Butisan + Stomp) was one of the poorer herbicide treatments in the trial. Various weeds including black nightshade, sowthistle, dandelion, groundsel, pale persicaria, cleavers and some annual grasses and volunteer cereals were not very well controlled. Optimum activity for Liberator requires moist soil conditions both at and after application, and it is possible that periods of dry soil conditions may have limited its efficacy in this trial.

TRIAL 2

Phytotoxicity

At Site 1, because of the dry conditions, the first post-planting application of herbicides was delayed until 5 May after the already late mid April planting, and by this time some of the stocks were leafing out. An observation of scorch of rootstock leaves was made six days later on 11 May (Table 7 & Appx 3, Photo 7).

Table 7. Trial 2, Site 1 (Hants). Scorch of rootstock leaves 6 days post-spray

	Treatment											
Scorch severity	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Very slight	X	X	X									
Slight			X			X	X	X		X	X	X
Moderate							X	X	X	X		X
Severe				X	X							

Some damage was apparent even from the plain water sprays applied to Trt A, probably in response to the sunny conditions present when spraying. Trt D (Ronstar + Stomp) and Trt E (Goal) were the worst affected, with a large proportion of leaf completely scorched, while Trt B (simazine + Butisan) and Trt C (Skirmish + Butisan) mainly suffered some scorch on leaf tips. At this stage, Trt K (Flazasulfuron) showed little damage.

By about a month later at the time of the June weed record, most of the treatments were growing away from any initial scorch including Trt D (Ronstar + Stomp), but plants of both Trt E (Goal) and Trt K (Flazasulfuron) were smaller. Trt K had distinct upward curling of younger leaves and older leaves were showing yellowing. By early July, the Goal plots had largely recovered, but Flazasulfuron treated plants were still distinctly smaller with shoot death evidence on some. Some of Trt K plants could not be budded subsequently, and the stunting of plots was still evident when the post-budding treatments were applied in late August (see Appx 3, Photos 8 – 12)

At Site 2, buds on rootstocks were also bursting when the post-planting treatments were applied, although they were slightly less advanced than at Site 1. Some leaf scorch also occurred from Trt D (Ronstar + Stomp), and more severely from Trt E (Goal), but all plots grew away normally, and there was little evidence of earlier phytotoxicity by June. No problems were experienced with Flazasulfuron (Trt K) on this site, and it is not clear why there was a problem on the broadly similar soil type at Site 1. Further information will be obtained from observations following the repeat of treatments post-heading back in spring 2007.

Control of weeds

Trial 2, Site 1, Hampshire

Assessment 13th June 2006 (Table 8)

By mid June the Untreated Trt A plots contained quite a lot of large annual meadow grass, sowthistle, mayweed and redshank. Also present were fat hen, cleavers, shepherd's purse, scarlet pimpernel and others. Total weed numbers averaged almost 30 weeds/m^2 in the Trt A plots. The next worst treatment was Trt I (212H) with a mean

Table 8. Trial 2, Site 1, Hampshire. Mean weed numbers on herbicide treated plots 13 June 2006.
Transformed data as $\log_{10}$ (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post planting)	'Other Grasses'	Annual Meadow Grass	Sowthistle	Redshank	Mayweed	Other Weeds[1]	Total Weeds
A. Untreated	**0.149 (0.41)**	0.709 (4.12)	0.712 (4.15)	0.735 (4.43)	0.689 (3.89)	0.885 (6.67)	1.484 (29.48)
B. Simazine + Butisan S	**0.110 (0.29)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.059 (0.15)**	**0.157 (0.44)**
C. Skirmish + Butisan S	**0.190 (0.55)**	**0.000 (0.00)**	**0.064 (0.16)**	**0.000 (0.00)**	**0.037 (0.09)**	**0.064 (0.16)**	**0.331 (1.14)**
D. Ronstar + Stomp lo	0.342 (1.20)	**0.128 (0.34)**	**0.161 (0.45)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.051 (0.12)**	0.534 (2.42)
E. Goal	0.491 (2.10)	**0.107 (0.28)**	**0.107 (0.28)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.095 (0.24)**	0.598 (2.96)
F. Artist	**0.051 (0.12)**	**0.000 (0.00)**	**0.056 (0.14)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.088 (0.22)**	**0.195 (0.57)**
G. Artist + Stomp hi	0.417 (1.61)	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.040 (0.10)**	0.444 (1.78)
H. Stomp hi + Butisan S	**0.132 (0.36)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.075 (0.19)**	0.181 (0.52)	**0.115 (0.30)**	0.404 (1.54)
I. 212 H	0.338 (1.18)	0.727 (4.33)	**0.146 (0.40)**	**0.020 (0.05)**	0.186 (0.53)	**0.056 (0.14)**	0.926 (7.43)
J. Flexidor + Butisan S	**0.104 (0.27)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.040 (0.10)**	0.164 (0.46)	**0.168 (0.47)**	0.398 (1.50)
K. Flazasulfuron	**0.000 (0.00)**	**0.000 (0.00)**	**0.104 (0.27)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.124 (0.33)**
L. Terano	0.325 (1.11)	**0.051 (0.12)**	**0.000 (0.00)**	0.321 (1.09)	**0.093 (0.24)**	**0.171 (0.48)**	0.662 (3.59)
SED (33 df)	*0.1534*	*0.1030*	*0.1347*	*0.0695*	*0.0607*	*0.0878*	*0.1239*
LSD (5%)	*0.312*	*0.210*	*0.274*	*0.141*	*0.124*	*0.179*	*0.252*
Significance, P	*0.053*	*<.001*	*<.001*	*<.001*	*<.001*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weed = fat hen, cleavers, dandelion, shepherd's purse, bindweed, scarlet pimpernel, chickweed, groundsel, spurge, geranium, speedwell, mouse-eared chickweed, nightshade, plantain, annual nettle, buttercup

of over 7 weeds/m^2. Much of this was due to its poor control of annual meadow grass. All other treatments controlled this weed quite well at this stage.

Other relatively poor treatments overall were Terano (Trt L), Goal (Trt E) and Ronstar + Stomp (Trt D), which all had over 2 weeds/m^2 on average. Much of this was due to poorer control of 'other grasses' including couch. Trt I (212H) and Trt G (Artist + Stomp) also had high numbers of these grasses in two or three replicate plots.

The treatments with fewest weeds overall at the June assessment were Flazasulfuron (Trt K), simazine + Butisan (Trt B), Artist (Trt F) and Skirmish + Butisan (Trt C).

Other notable weaknesses were for redshank control with Terano (Trt L). Mayweed was relatively poorly controlled by 212H (Trt I), Stomp + Butisan (Trt H) and Flexidor + Butisan (Trt J).

Assessment 9th August 2006 (Table 9)
Following rootstocks being budded in mid July, but before post-budding herbicides were applied in late August, weed growth since the June record was assessed. The main weeds present at this time were 'other grasses', dandelion and sowthistle followed by black nightshade, redshank, annual meadow grass and mayweed. For total weed numbers, untreated Trt A averaged over 15 weeds/m^2 and herbicide treatments ranged from 0.8 to 5.3 weeds/m^2. Best treatments were Artist + Stomp (Trt G), simazine + Butisan (Trt B), Artist (Trt F) and Stomp + Butisan (Trt H) followed by Flexidor + Butisan (Trt J) and Skirmish + Butisan (Trt C). Poorest were Ronstar + Stomp (Trt D), Terano (Trt L), Goal (Trt E), 212H (Trt I) and Flazasulfuron (Trt K).

Although the levels of annual meadow grass were not very high at this time, as found at the June record, 212H (Trt I), Ronstar + Stomp (Trt D) and Goal (Trt E) gave poorer control.

'Other grasses' were present in many plots in varying numbers, although they were not recorded in any of the untreated plots because of competition by the high numbers of other weed species present. Nearly all this grass was common couch, typically not well controlled by many residual herbicides. However, there were apparent differences between treatments. As in June, Goal had the most of this weed, followed by Ronstar + Stomp and Terano (Trt L). Artist + Stomp (Trt G) averaged 0.5/m^2 of other grass, although this was not significantly different from Artist alone (Trt F) at 0.1/m^2.

Dandelion was not a problem in June, but by August significant amounts were present in some treatments. Trts K, G, B, C, J, H & F were the cleanest treatments with means of <0.5 weeds/m^2. Trt D (Ronstar + Stomp) gave poorest control (mean 2.8/m^2) and was not significantly different from the untreated Trt A (5.0/m^2), and Terano (Trt L), Goal (Trt E) and 212H (Trt I) were the next weakest for control.

There was only a little redshank present on most herbicide plots, but as found in June, Terano (Trt L) had significantly more present (mean 1.1/m^2) than the rest, at a similar level to the untreated plots. Black nightshade was also present in low numbers, but there was a significant amount in the Flazasulfuron (Trt K) plots, and poor control of this weed appeared to be its main weakness amongst the weed spectrum present. Some nightshade was also present in each of the Artist (Trt F) plots, although the addition of Stomp (Trt G), gave good control.

Table 9. Trial 2, Site 1, Hampshire. Mean weed numbers on herbicide treated plots 9 August 2006.
Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post planting)	'Other Grasses'	Annual Meadow Grass	Dandelion	Redshank	Black Nightshade	Mayweed	Other Weeds[1]	Total Weeds
A. Untreated	**0.000 (0.00)**	0.210 (0.62)	0.775 (4.96)	0.330 (1.14)	0.191 (0.55)	0.403 (1.53)	0.726 (4.32)	1.218 (15.52)
B. Simazine + Butisan S	**0.135 (0.36)**	**0.000 (0.00)**	**0.076 (0.19)**	**0.064 (0.16)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.037 (0.09)**	**0.263 (0.83)**
C. Skirmish + Butisan S	**0.179 (0.51)**	**0.000 (0.00)**	**0.113 (0.30)**	**0.103 (0.27)**	**0.020 (0.05)**	**0.040 (0.10)**	**0.217 (0.65)**	0.496 (2.13)
D. Ronstar + Stomp lo	0.289 (0.95)	0.173 (0.49)	0.584 (2.84)	**0.040 (0.10)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.154 (0.43)**	0.797 (5.27)
E. Goal	0.438 (1.74)	0.167 (0.47)	0.304 (1.01)	**0.020 (0.05)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.163 (0.46)**	0.712 (4.15)
F. Artist	**0.056 (0.14)**	**0.000 (0.00)**	**0.171 (0.48)**	**0.020 (0.05)**	0.158 (0.44)	**0.000 (0.00)**	**0.040 (0.10)**	**0.343 (1.20)**
G. Artist + Stomp hi	**0.186 (0.53)**	**0.000 (0.00)**	**0.073 (0.18)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.255 (0.80)**
H. Stomp hi + Butisan S	**0.132 (0.36)**	**0.020 (0.05)**	**0.151 (0.42)**	**0.071 (0.18)**	**0.000 (0.00)**	**0.084 (0.21)**	**0.146 (0.40)**	**0.427 (1.67)**
I. 212 H	**0.169 (0.48)**	0.209 (0.62)	0.279 (0.90)	**0.051 (0.12)**	**0.056 (0.14)**	**0.073 (0.18)**	**0.181 (0.52)**	0.632 (3.29)
J. Flexidor + Butisan S	**0.140 (0.38)**	**0.056 (0.14)**	**0.146 (0.40)**	**0.037 (0.09)**	**0.040 (0.10)**	**0.056 (0.14)**	**0.180 (0.51)**	0.464 (1.91)
K. Flazasulfuron	**0.051 (0.12)**	**0.037 (0.09)**	**0.020 (0.05)**	**0.000 (0.00)**	0.484 (2.05)	**0.000 (0.00)**	**0.132 (0.36)**	0.573 (2.74)
L. Terano	0.256 (0.80)	**0.020 (0.05)**	0.351 (1.24)	0.314 (1.06)	**0.084 (0.21)**	**0.103 (0.27)**	**0.183 (0.52)**	0.747 (4.58)
SED (33 df)	*0.1112*	*0.0655*	*0.0972*	*0.0652*	*0.053*	*0.0515*	*0.1254*	*0.1007*
LSD (5%)	*0.226*	*0.133*	*0.198*	*0.133*	*0.108*	*0.105*	*0.255*	*0.205*
Significance, P	*0.035*	*0.002*	*<.001*	*<.001*	*<.001*	*<.001*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weed = sowthistle, bindweed, fat hen, common amaranth, shepherd's purse, thistle, groundsel, scarlet pimpernel, cleavers, buttercup, willowherb, spurge, cranesbill, common fumitory, knotgrass

There was less Mayweed present overall compared to June and no significant differences in its control between herbicide treatments. However, as in June, Trts L (Terano), H (Stomp + Butisan), I (212H) and J (Flexidor + Butisan) had the most mayweed present on average.

With the assortment of 'other weed', this was mainly scattered through the trial with no treatments containing significantly more than any others. There was a large number of perennial sowthistle in one replicate plot of the untreated Trt A.

Assessment 21st November 2006 (Table 10)
Overall, there did not appear to be any overriding effect of the post-budding herbicide treatments (applied in late August) on the weeds present at the November assessment, and it seems as though there were carry-over effects of the spring herbicide treatments on weed numbers even though their direct activity was likely to be weak by the autumn. For example, the relatively high numbers of annual meadow grass present in Trt I that had Butisan + Stomp post-budding compared to Trts E, F, J, K and L, was probably a reflection of the poorer control shown by 212H earlier in the year. Likewise, the higher numbers of dandelion in Trts D (Butisan + Flexidor post-budding), I and L (Butisan + Stomp post-budding) reflected the higher numbers on these treatments in August. Trts D and E also had high numbers of 'other grasses' in November, again mirroring weed levels earlier in the year.

Untreated plots had high numbers of annual meadow grass, dandelion, mayweed and willowherb, but few 'other grasses' such as common couch compared to the herbicide treated plots.

Compared to Trt A, mayweed was well controlled by all the herbicide treatments at this assessment, even though the Stomp + Butisan and Flexidor + Butisan treatments applied in spring (Trts H and J) had let through some mayweed by June. The remaining 'other weeds' were mainly confined to untreated plots with large numbers of willowherb in one Trt A plot.

Table 10. Trial 2, Site 1, Hampshire. Mean weed numbers on herbicide treated plots 21 November 2006.
Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post planting / post budding)	'Other Grasses'	Annual Meadow Grass	Dandelion	Other Weeds[1]	Total Weeds
A. Untreated	**0.169 (0.48)**	1.037 (9.89)	0.886 (6.69)	0.801 (5.32)	1.394 (23.77)
B. Sim + But / Sim + But	**0.353 (1.25)**	**0.000 (0.00)**	**0.093 (0.24)**	**0.073 (0.18)**	**0.438 (1.74)**
C. Skirmish + But / Skirmish + But	**0.415 (1.60)**	**0.000 (0.00)**	**0.142 (0.39)**	**0.107 (0.28)**	**0.538 (2.45)**
D. Ron + St lo / But + Flexidor	0.612 (3.09)	**0.071 (0.18)**	0.439 (1.75)	**0.159 (0.44)**	0.843 (5.97)
E. Goal / But + Stomp	0.851 (6.10)	**0.051 (0.12)**	**0.128 (0.34)**	**0.040 (0.10)**	0.895 (6.85)
F. Artist / But + Stomp	**0.249 (0.77)**	**0.000 (0.00)**	**0.171 (0.48)**	**0.020 (0.05)**	**0.376 (1.38)**
G. Artist + St hi / But + Flexidor	**0.491 (2.10)**	**0.000 (0.00)**	**0.076 (0.19)**	**0.020 (0.05)**	**0.530 (2.39)**
H. St hi + But / But + Flexidor	**0.301 (1.00)**	**0.000 (0.00)**	**0.168 (0.47)**	**0.040 (0.10)**	**0.415 (1.60)**
I. 212H / But + Stomp	**0.440 (1.75)**	0.329 (1.13)	0.351 (1.24)	**0.103 (0.27)**	0.798 (5.28)
J. Flex + But / But + Stomp	**0.352 (1.25)**	**0.020 (0.05)**	**0.215 (0.64)**	**0.000 (0.00)**	**0.488 (2.08)**
K. Flazasulfuron / But + Stomp	**0.166 (0.47)**	**0.132 (0.36)**	**0.071 (0.18)**	**0.076 (0.19)**	**0.400 (1.51)**
L. Terano / But + Stomp	**0.475 (1.99)**	**0.000 (0.00)**	0.336 (1.17)	**0.020 (0.05)**	**0.636 (3.33)**
SED (33 df)	*0.2054*	*0.1020*	*0.0859*	*0.0869*	*0.1685*
LSD (5%)	*0.418*	*0.208*	*0.175*	*0.177*	*0.343*
Significance, P	*0.103 (NS)*	*<.001*	*<.001*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weed = mayweed, willowherb, sowthistle, dock, chickweed, groundsel, shepherd's purse, thistle, buttercup, geranium, spurge, sharp-leaved fluellen, cleavers, speedwell

Trial 2, Site 2, Norfolk

Assessment 9th June 2006 (Table 11)
The predominant weed present on untreated plots by June was groundsel (mean 7.1 weeds/m^2), followed by willowherb. Apart from Trt H (Stomp + Butisan), where a small number of groundsel were present (mean 0.6/m^2), there were very few groundsel in remaining treatments. All herbicide treatments had negligible numbers of willowherb or other weed present.

Assessment 1st November 2006 (Table 12)
The rootstocks had been budded in mid July and post-budding herbicides applied in early August. By the November assessment, there were large numbers of weed in the trial, and more than at the Hampshire site at this time.

The predominant weed present was groundsel followed by willowherb then sowthistle, annual meadow grass and moderate numbers of mayweed. The only other weed recorded, and not analysed separately, were a few hairy bitter-cress found in just two plots.

The untreated plots had least groundsel because they had been much weedier with other species for longer during the autumn, and willowherb, sowthistle and annual meadow grass had taken up most of the space. There was approximately full weed cover on the untreated plots by the assessment. There was evidence that both triazine resistant and susceptible groundsel was present in this trial. Trt B (simazine + Butisan for both spring and summer applications) gave poor control once the residual acitivty of Butisan had gone. Interestingly, Trt C containing Skirmish gave better control suggesting that the terbuthylazine component was more effective than simazine, even though it was also a triazine. Groundsel is not controlled by Stomp nor Flexidor, and the post-budding herbicide treatments rely on the Butisan component for this weed. However, by November it is likely that Butisan would have lost its activity. There is evidence of a carry over effect from some of the other products used in spring that were relatively good against groundsel – ie Artist, Goal, Skirmish, Ronstar and Flazasulfuron in Trts F, E, C, G, D and K. These treatments had less groundsel than Trts H and J which contained only Stomp or Flexidor plus Butisan, and Trts I and L which had received 212H or Terano in spring.

There were very high numbers of willowherb in the untreated plots. Most herbicide treatment plots had at least a few willowherb, but there were clear treatment differences in control. Stomp can give partial control of willowherb, whereas it is resistant to Flexidor. Trts E, I, L, F, K and J which all had Butisan + Stomp post-budding gave better control than Trts G and H which had Butisan + Flexidor. It is surprising, however, that Trt D, which also had Butisan + Flexidor post-budding, had amongst the fewest willowherb present. Even though the Ronstar applied in spring should have given good control, its activity by late summer should have run out. The Skirmish component of Trt C appeared to be responsible for its good control of willowherb compared to simazine in Trt B. Some populations of willowherb are known to be simazine resistant.

Sowthistle was also prevalent in untreated plots compared to herbicide treatments generally. Both Flexidor and Stomp would be expected to be weak against sowthistle, and carry over effects from the spring treatments would be needed to back up Butisan's relatively short persistence. Trts J and H, used combinations of these three herbicides for both application dates, which might explain their poorer performance. Simazine +

Butisan (Trt B), also failed to control sowthistle well, and this suggests that it might have developed some resistance.

Table 11. Trial 2, Site 2, Norfolk. Mean weed numbers on herbicide treated plots 9 June 2006.
Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post planting)	Groundsel	Other Weeds[1]	Total Weeds
A. Untreated	0.907 (7.07)	0.768 (4.86)	1.114 (12.00)
B. Simazine + Butisan S	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
C. Skirmish + Butisan S	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
D. Ronstar + Stomp lo	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
E. Goal	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
F. Artist	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
G. Artist + Stomp hi	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
H. Stomp hi + Butisan S	0.214 (0.64)	**0.035 (0.08)**	0.227 (0.69)
I. 212 H	**0.000 (0.00)**	**0.035 (0.08)**	**0.035 (0.08)**
J. Flexidor + Butisan S	**0.035 (0.08)**	**0.083 (0.21)**	**0.119 (0.32)**
K. Flazasulfuron	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**
L. Terano	**0.071 (0.18)**	**0.035 (0.08)**	**0.097 (0.25)**
SED (33 df)	*0.0478*	*0.0466*	*0.0600*
LSD (5%)	*0.097*	*0.095*	*0.122*
Significance, P	*<.001*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

[1] Other weed = willowherb, annual meadow grass, cereal, speedwell, black bindweed, scarlet pimpernel

Table 12. Trial 2, Site 2, Norfolk. Mean weed numbers on herbicide treated plots 1 November 2006.
Transformed data as log_{10} (weeds/m^2 + 1). Back-transformed data as weeds/m^2 in brackets.

Treatment (post planting / post budding)	Groundsel	Willowherb	Sowthistle	Mayweed	Annual Meadow Grass	Total Weeds
A. Untreated	**0.427 (1.67)**	1.479 (29.13)	1.058 (10.43)	0.373 (1.36)	1.124 (12.30)	1.798 (61.81)
B. Sim + But / Sim + But	1.302 (19.04)	0.596 (2.94)	0.441 (1.76)	**0.000 (0.00)**	0.153 (0.42)	1.427 (25.73)
C. Skirmish + But / Skirmish + But	**0.744 (4.55)**	**0.097 (0.25)**	**0.145 (0.40)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.796 (5.25)**
D. Ron + St lo / But + Flexidor	0.959 (8.10)	**0.177 (0.50)**	**0.225 (0.68)**	**0.249 (0.77)**	**0.000 (0.00)**	**1.070 (10.75)**
E. Goal / But + Stomp	**0.713 (4.16)**	**0.238 (0.73)**	**0.097 (0.25)**	**0.035 (0.08)**	**0.000 (0.00)**	**0.807 (5.41)**
F. Artist / But + Stomp	**0.705 (4.07)**	**0.287 (0.94)**	**0.253 (0.79)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.826 (5.70)**
G. Artist + St hi / But + Flexidor	0.879 (6.57)	0.488 (2.08)	**0.246 (0.76)**	0.336 (1.17)	**0.035 (0.08)**	1.092 (11.36)
H. St hi + But / But + Flexidor	1.151 (13.16)	0.652 (3.49)	0.434 (1.72)	**0.000 (0.00)**	**0.035 (0.08)**	1.313 (19.56)
I. 212H / But + Stomp	0.979 (8.53)	**0.253 (0.79)**	**0.097 (0.25)**	**0.071 (0.18)**	**0.000 (0.00)**	**1.055 (10.35)**
J. Flex + But / But + Stomp	1.329 (20.33)	0.406 (1.55)	0.357 (1.28)	**0.035 (0.08)**	**0.000 (0.00)**	1.390 (23.55)
K. Flazasulfuron / But + Stomp	0.967 (8.27)	**0.356 (1.27)**	**0.198 (0.58)**	**0.000 (0.00)**	**0.000 (0.00)**	1.089 (11.27)
L. Terano / But + Stomp	1.169 (13.76)	**0.269 (0.86)**	**0.238 (0.73)**	**0.000 (0.00)**	**0.000 (0.00)**	1.221 (15.63)
SED (33 df)	*0.1787*	*0.1468*	*0.1179*	*0.1528*	*0.0750*	*0.1351*
LSD (5%)	*0.364*	*0.299*	*0.240*	*0.311*	*0.153*	*0.275*
Significance, P	*<.001*	*<.001*	*<.001*	*0.112 (NS)*	*<.001*	*<.001*

Bold data highlight the most weed-free treatment means that are not significantly different from one another at P<5%. However non-bold means will not necessarily be significantly weedier than some of those in bold – the LSD statistic allows individual treatments (back-transformed data) to be compared.

Annual meadow grass was almost exclusively confined to untreated plots apart from some in one plot of Trt B. There was very little of this grass seen at the June assessment, even in untreated plots, so it is possible that it germinated late from blown-in seed during the summer, but that all herbicide treatments controlled it well. Mayweed was not present in all the untreated plots (possibly because of competition by other species) and was mainly confined to a cluster in a single replicate plot of each of Trts D and G. Treatments showed no significant differences overall for this weed. However, one would normally expect Flexidor (used post-budding in Trts D and G) to control mayweed.

Overall at the November assessment, the best treatments were Trt C (Skirmish + Butisan / *repeat*), Trt E (Goal / Butisan + Stomp), and Trt F (Artist / Butisan + Stomp), and weakest were the grower standard Trt B (simazine + Butisan / *repeat*), Trts J and H (Flexidor + Butisan / Butisan + Stomp and *vice versa*), and Trt L (Terano / Butisan + Stomp).

Summary of herbicide performance to date in Trial 2

Trt B (simazine + Butisan), the 'grower standard', generally performed well at Site 1 (Hants) but at Site 2 (Norfolk) it gave poor weed control by autumn mainly due to high populations of simazine resistant groundsel and willowherb.

Trt C (Skirmish + Butisan) performed generally better than Trt B and remained one of the most effective of the treatments. It did not show any obvious weaknesses in its range of weed control and performed better against willowherb and groundsel than Trt B, though did not totally control triazine resistant groundsel.

Trt D (Ronstar + Stomp / Butisan + Flexidor). This treatment gave reasonably good control overall, but performed worse at Site 1 (Hants) where higher levels of couch were present in this treatment. It also failed to control annual meadow grass, sowthistle and dandelion seedlings as well as some other treatments.

Trt E (Goal / Butisan + Stomp) again performed better at Site 2 (Norfolk) than Site 1 (Hants) due to higher levels of couch, dandelion seedlings and some annual meadow grass in this treatment. Goal showed no obvious weaknesses at Site 2, but at both sites this herbicide did cause leaf scorch when applied to non-dormant rootstocks post planting in spring. Like Ronstar, growers would need to be aware that it should only be applied to dormant crops to avoid damage.

Trt F (Artist / Butisan + Flexidor). As in Trial 1, Artist has been one of the best of the new herbicides. There was some evidence in Trial 1 that it was less effective against black bindweed, black nightshade and groundsel than some of the other herbicides. In Trial 2, its poorer control of black nightshade was confirmed, although the addition of Stomp in Trt G (Artist + Stomp / Butisan + Flexidor) improved this. Trial 2 did not show Artist, however, to be significantly weaker on groundsel than any of the other herbicides.

Trt H (Stomp + Butisan / Butisan + Flexidor) and Trt J (Flexidor + Butisan / Butisan + Stomp) were similar programmes but used opposite timings of Stomp and Flexidor between spring and summer and used half rate Flexidor when used in summer. Trt H generally performed well in Trial 1, but both Trts H and J gave only moderate performance overall in Trial 2. The high level of groundsel late in the year at Site 2 exposed the weakness of Flexidor and Stomp against this weed once the Butisan's activity had worn off, and sowthistle was less well controlled than with other

programmes. Mayweed in spring and summer was also rather poorly controlled at Site 1.

Trt I (212H / Butisan + Stomp) did not perform well. The experimental herbicide 212H gave particularly poor control of annual meadow grass at Site 1 post-planting at the 0.06 kg/ha rate used then. Mayweed and dandelion seedlings were also not well controlled. 212H is being used at a higher rate of 0.2 kg/ha post-heading back.

Trt K (Flazasulfuron / Butisan + Stomp). From the Site 1 results, black nightshade appeared to be a weakness in Flazasulfuron's weed control spectrum, but apart from that, the treatment gave generally good weed control. It is unclear why the significant phytotoxicity observed on Site 1 (Hants) was not reflected at Site 2 (Norfolk), and we will need to wait for further observations following the final application in spring 2007 before making final conclusions about its crop safety.

Trt L (Terano / Butisan + Stomp) was also one of the poorer treatments. Terano did not give good control of redshank or dandelion seedlings at Site 1, and levels of 'other grasses' and mayweed were higher than some other treatments. The treatment also proved poor against groundsel at Site 2.

Conclusions to date

The final post-heading back treatment applications will be made to Trial 2 in spring 2007, and this will give further information on both phytotoxicity and weed control efficacy by summer of that year.

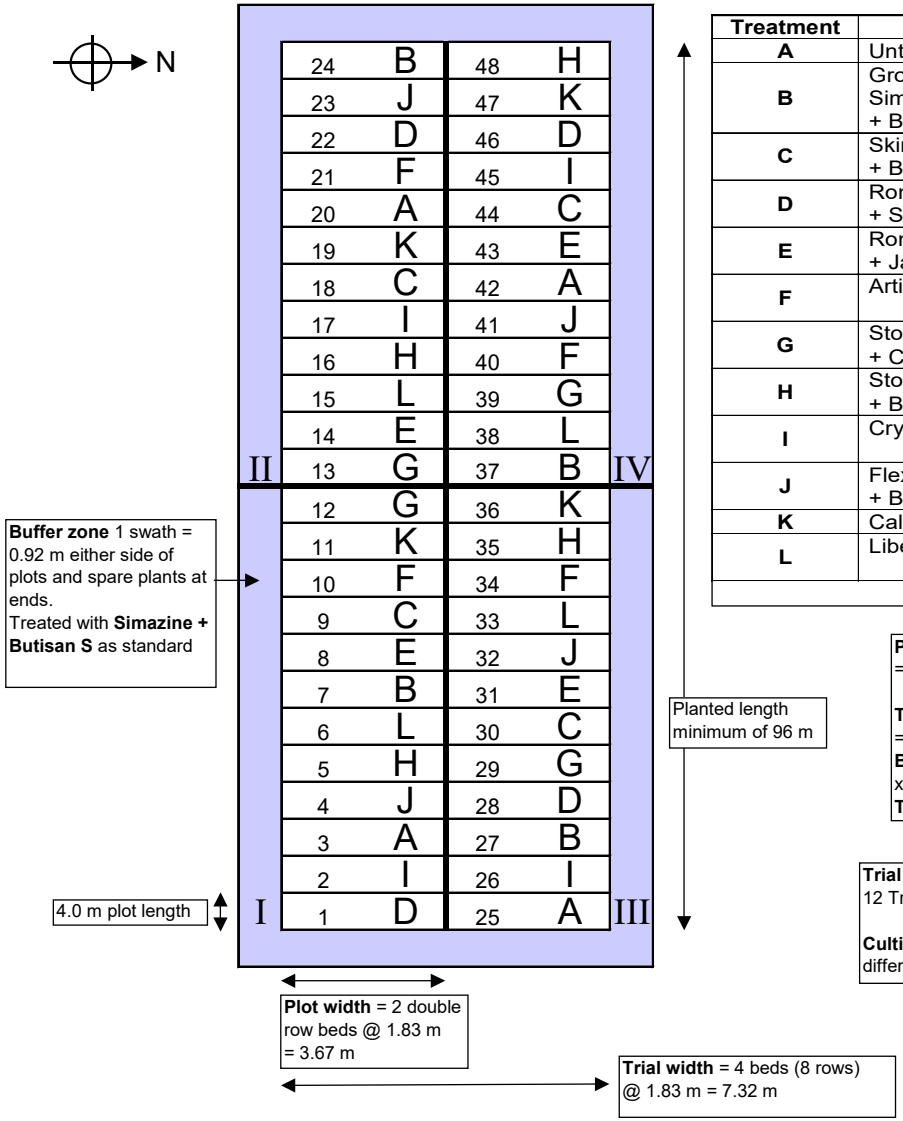
Meanwhile, results so far indicate that a range of herbicide programmes have been identified satisfactory alternatives to simazine once its use for nursery stock is finally revoked in December 2007. Like simazine, most of the herbicides do have specific weaknesses against certain weeds, so some knowledge of the expected weed spectrum in a new cropping site will be helpful in making the best choice. Butisan S, while of relatively short persistence, remains an important component in the overall herbicide programme. Choice of herbicides for use post-budding is more restricted to Butisan mixed with one of Stomp, Flexidor or Skirmish. Of the new residuals trialled for post-planting / heading back application to dormant plants, Artist and Skirmish still appear very promising, with Goal and Flazasulfuron also worth considering pending further information about possibly phytotoxicity and commercial availability.

APPENDIX 1

TRIAL PLANS

HNS 132 - Roses: Triazine-free herbicide programmes

Trial 1 - Planted Spring 2005 **Site 1 - Hampshire, c/o Pocock's Roses**



Treatment	Post Planting	Post Budding	Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha
C	Skirmish 1.0 l/ha + Butisan 2.5 l/ha	Skirmish 1.0 l/ha + Butisan 2.5 l/ha	Skirmish 1.0 l/ha + Butisan 2.5 l/ha
D	Ronstar 4.0 l/ha + Stomp 3.3 l/ha	Butisan 2.5 l/ha + Flexidor 1.0 l/ha	Ronstar 4.0 l/ha + Stomp 3.3 l/ha
E	Ronstar 4.0 l/ha + Javelin 1.0 l/ha	Butisan 2.5 l/ha + Stomp 3.3 l/ha	Ronstar 4.0 l/ha + Javelin 1.0 l/ha
F	Artist 2.5 kg/ha	Butisan 2.5 l/ha + Stomp 5.0 l/ha	Artist 2.5 kg/ha
G	Stomp 5.0 l/ha + Centium 0.5 l/ha	Butisan 2.5 l/ha + Flexidor 1.0 l/ha	Stomp 5.0 l/ha + Centium 0.5 l/ha
H	Stomp 5.0 l/ha + Butisan 2.5 l/ha	Butisan 2.5 l/ha + Flexidor 1.0 l/ha	Stomp 5.0 l/ha + Butisan 2.5 l/ha
I	Crystal 4.0 l/ha	Butisan 2.5 l/ha + Flexidor 1.0 l/ha	Crystal 4.0 l/ha
J	Flexidor 2.0 l/ha + Butisan 2.5 l/ha	Butisan 2.5 l/ha + Stomp 5.0 l/ha	Flexidor 2.0 l/ha + Butisan 2.5 l/ha
K	Calaris 1.5 l/ha	Calaris 1.5 l/ha	Calaris 1.5 l/ha
L	Liberator 0.6 l/ha	Butisan 2.5 l/ha + Stomp 5.0 l/ha	Liberator 0.6 l/ha

Plot area 3.67 m x 4.0 m = 14.68 m2

Trial area = 96 m x 7.32 m = 703 m2
Buffer zone = 214 m perimeter x 0.92 m = 197 m2
Total area = **900 m2**.

Number of plants per plot:
4 rows wide x approx 27 plants long (assuming 15 cm in-row spacing) = approx 108 plants

Trial Design - Randomised block.
12 Treatments x 4 replicate blocks = 48 plots total

Cultivars budded along complete rows. Up to 4 different cvs. per plot may be used.

HNS 132 - Roses: Triazine-free herbicide programmes

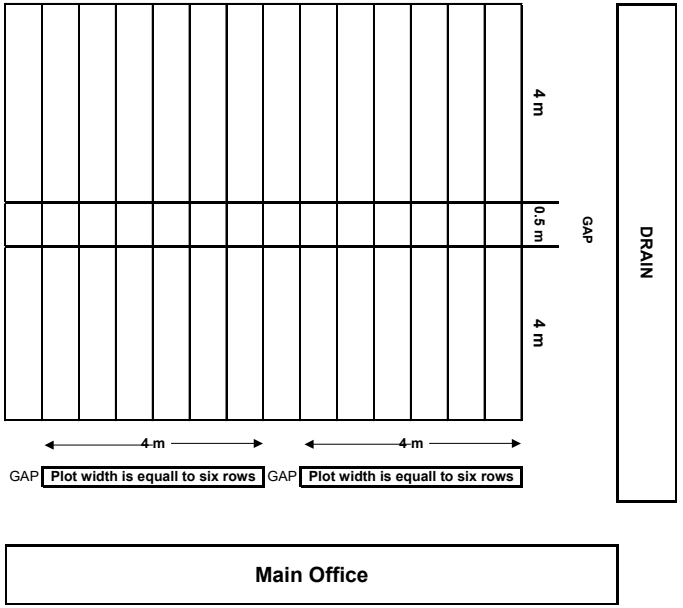
Trial 1 - Planted Spring 2005 Site 2 - Norfolk c/o Wharton's Roses

Main Office

Plot no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Block	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
Treatment	L	D	H	B	G	C	F	E	I	A	J	K	I	L	E	G	C	K	H	B	A	F	D	J
Plot no.	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Block	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4
Treatment	A	I	C	F	K	G	D	E	H	J	B	L	J	G	K	A	L	B	I	C	F	D	E	H

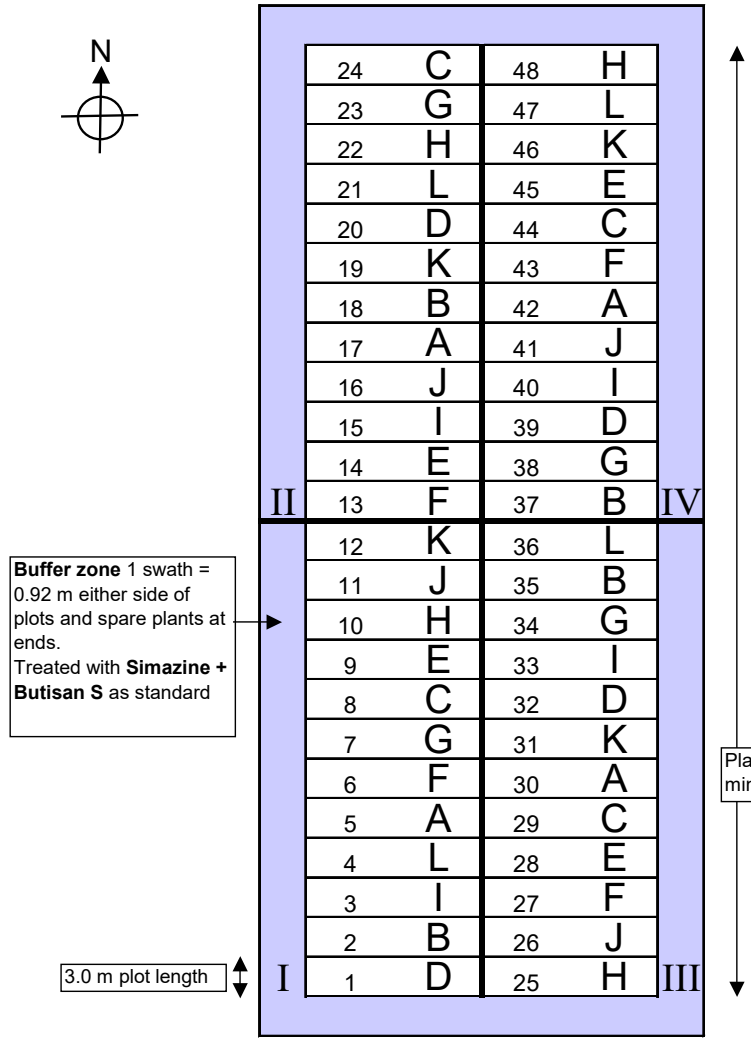
Drain

	Treatment - Post planting	Treatment - Post budding	Treatment - Heading back
A	Untreated control	**Untreated control**	**Untreated control**
B	Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha
C	Skirmish 1 l/ha + Butisan 2.5 l/ha	Skirmish 1 l/ha + Butisan 2.5 l/ha	Skirmish 1 l/ha + Butisan 2.5 l/ha
D	Ronstar 4 l/ha + Stomp 3.3 l/ha	Butisan 2.5 l/ha + Flexidor 1 l/ha	Ronstar 4 l/ha + Stomp 3.3 l/ha
E	Ronstar 4 l/ha + Javelin 1 l/ha	Butisan 2.5 l/ha + Stomp 3.3 l/ha	Ronstar 4 l/ha + Javelin 1 l/ha
F	Artist 2.5 kg/ha	Butisan 2.5 l/ha + Stomp 5 l/ha	Artist 2.5 kg/ha
G	Stomp 5 l/ha + Centium 0.5 l/ha	Butisan 2.5 l/ha + Flexidor 1 l/ha	Stomp 5 l/ha + Centium 0.5 l/ha
H	Stomp 5 l/ha + Butisan 2.5 l/ha	Butisan 2.5 l/ha + Flexidor 1 l/ha	Stomp 5 l/ha + Butisan 2.5 l/ha
I	Crystal 4 l/ha	Butisan 2.5 l/ha + Flexidor 1 l/ha	Crystal 4 l/ha
J	Flexidor 2 l/ha + Butisan 2.5 l/ha	Butisan 2.5 l/ha + Stomp 5 l/ha	Flexidor 2 l/ha + Butisan 2.5 l/ha
K	Calaris 1.5 l/ha	Calaris 1.5 l/ha	Calaris 1.5 l/ha
L	Liberator 0.6 l/ha	Butisan 2.5 l/ha + Stomp 5 l/ha	Liberator 0.6 l/ha



HNS 132 - Roses: Triazine-free herbicide programmes

Trial 2 - Planted Spring 2006 **Site 1 - Hampshire, c/o Pocock's Roses**



Treatment	Post Planting	Post Budding	Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha
C	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha
D	Ronstar 4.0 L/ha + Stomp 3.3 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Ronstar 4.0 L/ha + Stomp 3.3 L/ha
E	Goal 4 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Goal 4 L/ha
F	Artist 2.5 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Artist 2.5 kg/ha
G	Artist 2.5 kg/ha + Stomp 5.0 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Artist 2.5 kg/ha + Stomp 5.0 L/ha
H	Stomp 5.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Butisan 2.5 L/ha
I	212H 0.06 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	212H 0.2 kg/ha
J	Flexidor 2.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flexidor 2.0 L/ha + Butisan 2.5 L/ha
K	Flazasulfuron 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flazasulfuron 0.2 kg/ha
L	Terano 0.75 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Terano 0.75 kg/ha

Plot area 3.67 m x 3.0 m = 11.01 m2

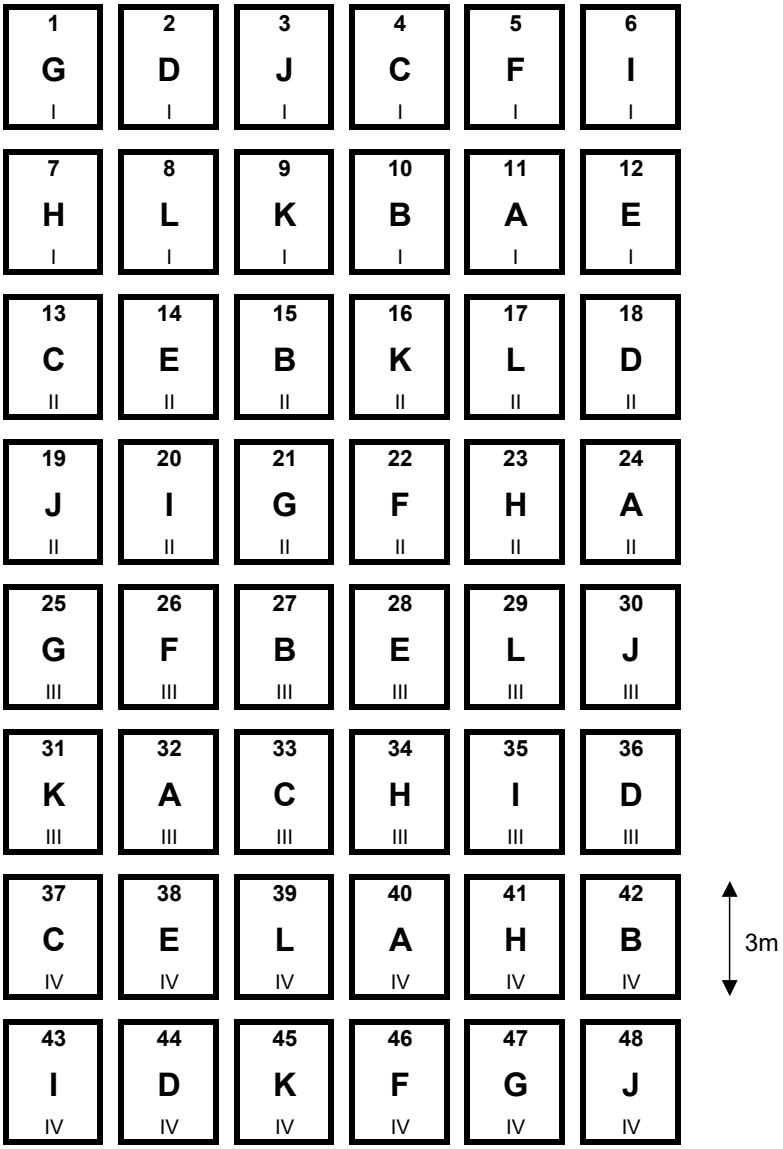
Trial area = 72 m x 7.32 m = 527 m2
Buffer zone = 160 m perimeter x 0.92 m = 147 m2
Total area = 675 **m2**.

Number of plants per plot:
4 rows wide x approx 20 plants long (assuming 15 cm in-row spacing) = approx 80 plants

Trial Design - Randomised block.
12 Treatments x 4 replicate blocks = 48 plots total

Cultivars budded as per grower requirements.

HNS 132 - Rose herbicides - Trial 2 planted 2006
Site 2 - Norfolk, c/o Wharton's Roses



Treatment	Post Planting	Post Budding	Heading Back
A	Untreated control	Untreated control	Untreated control
B	Grower's standard: Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha	Simazine 3.4 L/ha + Butisan 2.5 L/ha
C	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha	Skirmish 1.0 L/ha + Butisan 2.5 L/ha
D	Ronstar 4.0 L/ha + Stomp 3.3 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Ronstar 4.0 L/ha + Stomp 3.3 L/ha
E	Goal 4 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Goal 4 L/ha
F	Artist 2.5 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Artist 2.5 kg/ha
G	Artist 2.5 kg/ha + Stomp 5.0 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Artist 2.5 kg/ha + Stomp 5.0 L/ha
H	Stomp 5.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Flexidor 1.0 L/ha	Stomp 5.0 L/ha + Butisan 2.5 L/ha
I	212H 0.06 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	212H 0.2 kg/ha
J	Flexidor 2.0 L/ha + Butisan 2.5 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flexidor 2.0 L/ha + Butisan 2.5 L/ha
K	Flazasulfuron 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Flazasulfuron 0.2 kg/ha
L	Terano 0.75 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Terano 0.75 kg/ha

APPENDIX 2

COMMON WEED NAMES AND LATIN BINOMIALS

Appx 2 Table 1. Common and latin names of weeds referred to in report

Common name	Latin binomial
Annual meadow grass	*Poa annua*
Black bindweed	*Fallopia convolvulus*
Black nightshade	*Solanum nigrum*
Canadian fleabane	*Conzya canadensis*
Charlock	*Sinapsis arvensis*
Chickweed	*Stellaria media*
Cleavers	*Galium aparine*
Common amaranth	*Amaranthus retroflexus*
Common couch	*Elytrigia repens*
Common fumitory	*Fumaria officinalis*
Cranesbill	*Geranium* spp.
Creeping buttercup	*Ranunculus repens*
Creeping cinquefoil	*Potentilla repens*
Creeping thistle	*Cirsium arvense*
Dandelion	*Taraxacum officinale*
Docks	*Rumex* spp.
Fat hen	*Chenopodium album*
Field forget-me-not	*Myosotis arvensis*
Field pansy	*Viola arvensis*
Field penny-cress	*Thlaspi arvense*
Groundsel	*Senecio vulgaris*
Hairy bitter-cress	*Cardamine hirsuta*
Hawk's-beard (various)	*Crepis* spp.
Knotgrass	*Polygonum aviculare*
Mayweed (various)	*Matricaria* spp., *Tripleurospermum inodurum*
Mouse-eared chickweed	*Cerastium fontanum*
Oat	*Avena* spp.
Pale persicaria	*Polygonum lapathifolium*
Plaintain	*Plantago* spp.
Red deadnettle	*Lamium purpureum*
Redshank	*Polygonum persicaria*
Scarlet pimpernel	*Anagallis arvensis*
Sharp-leaved fluellen	*Kickxia elatine*
Shepherd's purse	*Capsella bursa-pastoris*
Small nettle	*Urtica urens*
Sowthistle (annual)	*Sonchus oleraceus*
Sowthistle (perennial)	*Sonchus arvensis*
Speedwell (various)	*Veronica* spp.
Spurge	*Euphorbia* sp.
Swinecress	*Coronopus squamatus*
Vetch (Common)	*Vicia sativa*
Willowherbs (various)	*Epilobium* spp.

APPENDIX 3

PHOTOGRAPHS

Photo 1. Trial 1, Site 1 Hants. Clean overwinter apart from untreated Trt A plots, 10 January 2006.

Photo 2. Trial 1, Site 1, creeping cinquefoil present overwinter.

Photo 3. Trial 1, Site 1. Untreated Trt A plot – at stage when cleared of weed by hand 11 May 2006.


Photo 4. Trial 1, Site 1. Young growth of maiden crop and weed on untreated plots 12 June 2006.

Photo 5. Trial 1, Site 1 at stage of final weed record 4 July 2006. The yellow flowering weed in the untreated plots is Hawk's beard (*Crepis spp.*).

Photo 6. Trial 2, Grower's walk 25 May 2006 at Site 2, Norfolk.

Photo 7. Trial 2, Site 1. Rootstocks 11 May 2006, five days after applying treatments. Slight scorch (left) versus severe scorch (right).

Photo 8. Trial 2, Site 1. Damage from Trt K, Flazasulfuron (left) showing characteristic upcurled leaves and yellowed older leaves. Trt E, Goal (right) showing thinner (delayed) leaf development following severe early scorch. 15 June 2006.

Photo 9. Trial 2, Site 1. First weed assessment 15 June 2006.

Photo 10. Trial 2, Site 1. Two plots of Trt K Flazasulfuron (foreground and background) showing weak growth at 4 July 2006.

Photo 11. Trial 2, Site 1. Plant from Trt K, Flazasulfuron showing yellowed dead shoots 4 July 2006.

Photo 12. Trial 2, Site 1. General shot 24 August 2006 about a week after budding. Trt K still showing weaker growth of stocks.

APPENDIX 4

RAW DATA - BUD TAKE (TRIAL 1) & WEED RECORDS

Appx 4 Table 1, Trial 1, Site 1 Hants. Percent bud take of plants present

	Treatment											
Block	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
I	61.2	72.2	77.7	86.5	79.1	66.3	82.4	62.8	77.9	79.2	74.5	68.8
II	76.8	47.3	80.4	52.1	85.3	81.3	81.4	86.0	92.2	68.1	88.5	70.1
III	75.3	80.8	69.1	77.6	75.8	74.7	62.1	61.3	64.9	65.0	62.5	64.9
IV	75.5	55.2	87.9	64.5	81.3	82.7	73.0	57.9	67.0	83.3	67.3	68.4
Mean	***72.2***	***63.9***	***78.8***	***70.2***	***80.4***	***76.3***	***74.7***	***67.0***	***75.5***	***73.9***	***73.2***	***68.0***

Appx 4 Table 2, Trial 1, Site 1 Hants. Numbers of plants per plot present

	Treatment											
Block	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
I	85	97	94	96	91	92	91	94	95	96	98	96
II	95	91	97	94	95	91	97	93	90	91	96	87
III	89	99	97	98	91	91	95	93	97	100	96	94
IV	98	96	91	93	96	98	100	95	94	90	98	98
Mean	***91.8***	***95.8***	***94.8***	***95.3***	***93.3***	***93.0***	***95.8***	***93.8***	***94.0***	***94.3***	***97.0***	***93.8***

Appx 4 Table 3, Trial 1, Site 2 Norfolk. Percent bud take of plants present

	Treatment											
Block	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
I	95.5	90.6	95.9	94.1	96.0	95.8	92.5	90.3	100.0	90.7	92.5	91.8
II	93.1	94.7	96.0	78.2	88.9	93.1	90.4	91.8	93.0	90.4	97.1	94.7
III	94.1	95.7	94.3	98.5	94.4	96.3	95.0	95.5	97.4	98.6	97.2	94.0
IV	95.4	98.5	91.5	96.9	96.8	96.9	92.6	94.8	100.0	94.9	96.9	97.3
Mean	***94.5***	***94.9***	***94.4***	***91.9***	***94.0***	***95.5***	***92.6***	***93.1***	***97.6***	***93.7***	***95.9***	***94.5***

Appx 4 Table 4, Trial 1, Site 2 Norfolk. Numbers of plants per part-plot sampled

	Treatment											
Block	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
I	66	85	74	68	75	71	80	72	73	75	80	85
II	72	76	75	78	72	72	73	73	71	73	69	76
III	85	70	70	67	72	81	80	67	77	72	71	67
IV	65	67	71	65	63	64	68	58	69	59	64	74
Mean	***72.0***	***74.5***	***72.5***	***69.5***	***70.5***	***72.0***	***75.3***	***67.5***	***72.5***	***69.8***	***71.0***	***75.5***

Appx 4 Table 5. Trial 1 Site 1 Hants, Original Data 4th July 2006

			Recorded 4 July 2006 - Weeds per 7.5 sq m (Trt A Control plots excluded)																							
Plot no.	Treatment	Block	Annual Meadow Grass	Other grass	Dandelion	Thistle	Groundsel	Sowthistle	Buttercup	Nightshade	Speedwell	Bindweed	Persicaria	Spurge	Charlock	Mouse-eared Chickweed	Clover	Willowherb	Cleavers	Fat Hen	Scarlet Pimpernel	Sharp-leaved Fluellen	Fumitory	Hawksbeard	Knotgrass	Bramble
3	A	I																								
20	A	II																								
25	A	III																								
42	A	IV																								
7	B	I						2		3		1		1		1										
24	B	II				2		4				2				1					6					
27	B	III			2			2						1							1					
37	B	IV			1																					
9	C	I								1																
18	C	II																								2
30	C	III						4		6																
44	C	IV																								
1	D	I		7		3		3																		
22	D	II			10	2		2																		
28	D	III		7	1			2																		
46	D	IV		1	9	1	1	1																		
8	E	I		2	4	3				2				1												
14	E	II	2	7	1		1																			
31	E	III		1	1					1												2				
43	E	IV		7	2																					
10	F	I			1		1			4																
21	F	II				1		4				3	1		3											
34	F	III					1			5																
40	F	IV		4	2			1	1	3										1		1				
12	G	I		4	2			4		3																
13	G	II	1	3				2		1					1	1										
29	G	III		1				82										2								
39	G	IV					1	8								1										
5	H	I			5	3		15																		
16	H	II		2				3																		1
35	H	III		1	1			1																		
48	H	IV			2	10									1											
2	I	I		1	7	1		11	6			1														
17	I	II		1	1	1	1	15				1				2				6		1		1		
26	I	III		8	15	3	1	5						1		2				3				1		
45	I	IV		10	10			1						2	1								1			
4	J	I			2	1	3					2			2				1	3						
23	J	II			5	2	1	5				1									1				1	
32	J	III			2			1								1										
41	J	IV			5		1	2				2				1	1				1				1	
11	K	I								3																
19	K	II		3																		1				
36	K	III		2						2																
47	K	IV										1														
6	L	I			4	4	1	8		1	1	2		4						1	1	2				
15	L	II			2		1	5		2							1									
33	L	III		5	3	2		3		4		1		4												
38	L	IV		1	2		2			1																

Appx 4 Table 6. Trial 1 Site 2 Norfolk, Original Data 4th May 2006

			Recorded 4/5/06 weeds per 6.9 sqM								
Plot No	Treatment	Block	Groundsel	Pale Persicaria	Black bindweed	Mayweed	Cleaver	AnnMeadowGrass	Willowherb	Speedwell	Pansy
10	A	I	14	2	4	12	17	17	6	7	
21	A	II	8		1	17	3	2	13	8	2
25	A	III	30			10		22	12		
40	A	IV	15				3	3	9	5	
4	B	I									
20	B	II					7				6
35	B	III					4				
42	B	IV									
6	C	I									
17	C	II									
27	C	III	1			1					
44	C	IV									
2	D	I	1			1					
23	D	II				1					
31	D	III				3					
46	D	IV									
8	E	I	1			1					
15	E	II									
32	E	III				1					
47	E	IV							1		
7	F	I	2								
22	F	II	1								
28	F	III									
45	F	IV	1				1				
5	G	I	2			2					
16	G	II									
30	G	III				3					
38	G	IV	1								
3	H	I									
19	H	II									
33	H	III	2								
48	H	IV									
9	I	I	3			1	12				
13	I	II									
26	I	III	12			8					
43	I	IV	3				2				
11	J	I									
24	J	II									
34	J	III	1								
37	J	IV					2				
12	K	I	3			1	5				
18	K	II					7				
29	K	III									
39	K	IV					2				
1	L	I	1	3	3	1					
14	L	II									
36	L	III	7								
41	L	IV	7								

Appx 4 Table 7. Trial 1 Site 2 Norfolk, Original Data 9th June 2006

			Recorded 9/6/06 weeds per 6.9 sqM																		
Plot No	Treatment	Block	Pale Persicaria	Groundsel	Cleavers	BlackBindweed	Chickweed	Mayweed	Charlock	Pansy	Pennycress	Willowherb	AMG	Speedwell	ScarletPimpernell	DeadNettle	Swincress	FatHen	Knotgrass	Cereal/Grass	% cover
10	A	I	3	62	19	33	1	6				17	25		1	1					90
21	A	II	7	66	5	9	2	12		2		15		2	2		20				75
25	A	III	2	62		3	9	19		3		17									100
40	A	IV	2	37	7			3		1		11	31	1					1		50
4	B	I	10	25	4			2			2										1
20	B	II	5		11	4				34										1	5
35	B	III	3	84	4	1				2								5			1
42	B	IV	2	15		3															0.5
6	C	I	2	39		5															0.1
17	C	II			2																0.1
27	C	III		23				1													5
44	C	IV		19																	0
2	D	I	13	11	3			3	1												10
23	D	II			3													5	3	2	0.1
31	D	III		23	1			3									2				3
46	D	IV		7																	0
8	E	I			8			2													0.1
15	E	II	1		11																0.1
32	E	III		27	1																0.1
47	E	IV		2	2																0
7	F	I		122		11															0.1
22	F	II		7		2														2	1
28	F	III		65		3															1
45	F	IV	1	42	1															1	0.1
5	G	I		6				3													5
16	G	II						4		1										8	2
30	G	III																			0.1
38	G	IV																		1	0
3	H	I	1	7						1											0.1
19	H	II			4																0
33	H	III		34						3											1
48	H	IV		49	2																0.5
9	I	I	12	10	52	2					1										20
13	I	II	1	14	33			1		1										4	5
26	I	III	12	39				4									5				50
43	I	IV	2	50	1																2
11	J	I	2	2	3			1						4						2	0.5
24	J	II		2	3					4										1	0.1
34	J	III		82																1	0.5
37	J	IV		76	1					2											1
12	K	I			4															2	0.1
18	K	II			11															3	0.1
29	K	III		41	2			5													0.1
39	K	IV		3																	0
1	L	I	65	26	1	3	1	1													25
14	L	II	15	9	7	2														4	1
36	L	III	10	90	2	1															5
41	L	IV	8	13		3														1	10

Appx 4 Table 8. Trial 2 Site 1 Hants, Original Data 13th June 2006

			Recorded 13th June. Weeds per 5 m2																					
Plot no.	Treatment	Block	Other grass	AMG	Dandelion	Sowthistle	Groundsel	Redshank	Spurge	Nightshade	Cleavers	Fat Hen	Mayweed	Shep purse	Scarlet pimp	Ann Nettle	Speedwell	Buttercup	Geranium	Plantain	Chickweed	MEC	Bindweed	Fumitory
5	A	I		70	7		1	22				19	17	3	5	1	1	1		2				
17	A	II	4	26		27		35				13	40	21	2				1		2	1	4	
30	A	III	6	18		93		23	3			2	10	1	2						3			1
42	A	IV		3		23	1	13	2		31	5	19		2		2		4		4			2
2	B	I	1				1																	
18	B	II	1																					
35	B	III	1		1																			
37	B	IV	3		1																			
8	C	I	19																					
24	C	II			3								2									1		
29	C	III	1			4																		
44	C	IV																						
1	D	I	14	4		6							1											
20	D	II		4						1				1									1	
32	D	III	12																					
39	D	IV	4			5																		
9	E	I	8	3		3																		
14	E	II	19	2		1																		
28	E	III	18		5	2																		
45	E	IV	3	1																	1			
6	F	I				2																		
13	F	II			2	1				1														
27	F	III	3		2																			
43	F	IV											1											
7	G	I	9				1																	
23	G	II					1																	
34	G	III	13																					
38	G	IV	18																					
10	H	I	5										1											
22	H	II	2					5					6											
25	H	III	1		1							2											1	
48	H	IV			1		1						5								1			
3	I	I	3	38		3							4						2					
15	I	II	17	26				1					2											
33	I	III	11	5																			1	
40	I	IV		33		7							6											
11	J	I					1				1		4											
16	J	II	8	1				1					4											
26	J	III						1															7	
41	J	IV							2				2											
12	K	I																						
19	K	II																				1		
31	K	III				8																		
46	K	IV																						
4	L	I	1					14	1				1											
21	L	II	10	3				13				1	2										2	
36	L	III	18		2																			
47	L	IV	1		1		2	2	1				2											

Appx 4 Table 9. Trial 2 Site 1 Hants, Original Data 9th August 2006

			Recorded 9 August 2006. Weeds per 5 m2																					
Plot no.	Treatment	Block	Other grass	AMG	Dandelion	Sowthistle	Groundsel	Redshank	Spurge	Nightshade	Cleavers	Fat Hen	Mayweed	Shep purse	Scarlet pimp	Buttercup	Geranium	Bindweed	Fumitory	Thistle	Knotgrass	Sharp-leaved Fluellen	Willowherb	
5	A	I		4	31			2		4		2	9	1					1			2	2	
17	A	II		11	33		1	13				2	14	10								3		
30	A	III			11	87		8		4		1	3		2							2		
42	A	IV		1	31		1	3		4	4	6	7		1							2		
2	B	I	4					4		1														
18	B	II	1		1																			
35	B	III	3		2	1						1												
37	B	IV			1																			
8	C	I	13		1			1					1											
24	C	II			2			4				2	1			3	1							
29	C	III	1		1	6		1		1		1												
44	C	IV	1		2		1					1												
1	D	I	3	3	28			1												1				
20	D	II	2	6	6		1	1				1				1		2				2		
32	D	III	11	2	12	1																		
39	D	IV	5		17		1																	
9	E	I	8	4																9				
14	E	II	12	4	6																			
28	E	III	15	1	12			1					1											
45	E	IV	3	1	6	1						2												
6	F	I			1	1				2														
13	F	II	2		7					3														
27	F	III	1		1					1														
43	F	IV			2		1	1		3														
7	G	I	4		2					1														
23	G	II					1																	
34	G	III	2																					
38	G	IV	6		2																			
10	H	I	2		1																			
22	H	II			2			3					1											
25	H	III	7		5													11						
48	H	IV		1	1			1					4		1									
3	I	I	1	6	2			3		1														
15	I	II	6	8	4		1			2			2											
33	I	III	4		5							1			1			1		1		1		
40	I	IV		1	8	6							2											
11	J	I	2	1	1						1		1									1		
16	J	II	8	2	3			2		1		1	2											
26	J	III																8						
41	J	IV			5					1					1									
12	K	I		2	1					5														
19	K	II								15								1						
31	K	III	3			9				13														
46	K	IV								10														
4	L	I	1		3			8					4								1	2		
21	L	II	8		6			4		1			1					6				1		
36	L	III	12		13			3	1				1									1		
47	L	IV		1	5			7		4														

Appx 4 Table 10. Trial 2 Site 1 Hants, Original Data 21st November 2006

			Recorded 21 November 2006. Weeds per 5 m2																
Plot no.	Treatment	Block	Other grass	AMG	Dandelion	Sowthistle	Groundsel	Thistle	Spurge	Cleavers	Mayweed	Shep purse	Buttercup	Willowherb	Chickweed	Geranium	Dock	Sharp-leaved Fluellen	Speedwell
5	A	I		##	40						40	9	1	23	4				
17	A	II	2	32	37	3					1						4		
30	A	III	12	83	30	3	1				19				5		2		1
42	A	IV		15	28	4					5		1		2		9		
2	B	I	9																
18	B	II	7		1					1						1			
35	B	III	3		2		1									1			
37	B	IV	7		2														
8	C	I	30		1														
24	C	II	2		1		1						1						
29	C	III	4		3	1													
44	C	IV	8		3		3												
1	D	I	19	1	17			6											
20	D	II	5		13	1										1			
32	D	III	23	3	1	1					1								
39	D	IV	21		10														
9	E	I	22	3															
14	E	II	51		4		1												
28	E	III	53				1												
45	E	IV	13		4														
6	F	I			2														
13	F	II	8		4														
27	F	III	14		1				1										
43	F	IV			3														
7	G	I	7		1														
23	G	II									1								
34	G	III	24		2														
38	G	IV	28		1														
10	H	I	15		2														
22	H	II			2		1												
25	H	III	15		7														
48	H	IV											1						
3	I	I	2	2	7														
15	I	II	38	7	5											1			
33	I	III	19	2	7			1											
40	I	IV		17	6	4													
11	J	I	5		3														
16	J	II	27		4														
26	J	III	5		2														
41	J	IV		1	4														
12	K	I		1	3								1						
19	K	II		5														2	
31	K	III	18																
46	K	IV		2	1						1								
4	L	I	3		2				1										
21	L	II	18		7														
36	L	III	40		10														
47	L	IV	1		6														

Appx 4 Table 11. Trial 2 Site 2 Norfolk, Original Data 9th June 2006

			Recorded 9 June 2006. Weeds per 2.6 m2						
Plot No	Treatment	Block	Groundsel	Willowherb	AMG	Cereal	Speedwell	Black bindweed	Scarlet Pimpernel
11	A	I	22	19	1	1			
24	A	II	18	7		2	1		
32	A	III	18	8	1				
40	A	IV	16	9	1		1	1	1
10	B	I							
15	B	II							
27	B	III							
42	B	IV							
4	C	I							
13	C	II							
33	C	III							
37	C	IV							
2	D	I							
18	D	II							
36	D	III							
44	D	IV							
12	E	I							
14	E	II							
28	E	III							
38	E	IV							
5	F	I							
22	F	II							
26	F	III							
46	F	IV							
1	G	I							
21	G	II							
25	G	III							
47	G	IV							
7	H	I	2						
23	H	II	1						
34	H	III							
41	H	IV	5			1			
6	I	I							
20	I	II							
35	I	III							
43	I	IV				1			
3	J	I							
19	J	II	1						
30	J	III							
48	J	IV				2			1
9	K	I							
16	K	II							
31	K	III							
45	K	IV							
8	L	I							
17	L	II							
29	L	III	1						
39	L	IV	1			1			

Appx 4 Table 12. Trial 2 Site 2 Norfolk, Original Data 1st November 2006

Recorded 1 November 2006. Weeds per 2.6 m2												
Plot No	Treatment	Block	Groundsel	Willowherb	Sowthistle	Mayweed	AMG	Bittercress				
11	A	I	59	67	27	5	50					
24	A	II	3	70	37	25	16					
32	A	III		88	13		31					
40	A	IV		80	40		41					
10	B	I	51	10	2							
15	B	II	46	7	2							
27	B	III	50	8	6							
42	B	IV	51	6	12		8	13				
4	C	I	15									
13	C	II	13	2	3							
33	C	III	9									
37	C	IV	11	1	2							
2	D	I	52	7	2							
18	D	II	24		4	12						
36	D	III	16	1	2			2				
44	D	IV	9			2						
12	E	I	13			1						
14	E	II	9	1	1							
28	E	III	5	4								
38	E	IV	21	4	2							
5	F	I	4	2								
22	F	II	26	4	5							
26	F	III	7	2	1							
46	F	IV	14	2	4							
1	G	I	6	2	2							
21	G	II	20	3	3	4						
25	G	III	30	32		20						
47	G	IV	21	2	4		1					
7	H	I	42	2								
23	H	II	36	14	6							
34	H	III	39	12	7		1					
41	H	IV	23	14	9							
6	I	I	56			1						
20	I	II	21	1	2	1						
35	I	III	12	5								
43	I	IV	16	4	1							
3	J	I	64	5	2	1						
19	J	II	51	8	2							
30	J	III	48	4	5							
48	J	IV	50	1	5							
9	K	I	34									
16	K	II	21	4	1							
31	K	III	26	10								
45	K	IV	11	3	9							
8	L	I	50	2								
17	L	II	30	3	1							
29	L	III	45	2	4							
39	L	IV	24	2	4							