Project title:	Roses: Triazine-free herbicide programmes
Project number:	HNS 132
Project leader:	Mr C M Burgess, CB Consultant Agronomist
Project collaborator:	Mr J Atwood, Senior Consultant, ADAS
Report:	Final Report
Key workers:	Mr C Burgess, Author of report. Project manager for Hampshire site – herbicide treatment applications and weed assessments. Mr J Atwood, Project manager for Norfolk site - weed assessments & herbicide treatment selections. Mr J Carpanini, Senior Scientific Officer, ADAS Arthur Rickwood. Herbicide treatment applications - Norfolk site.
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 (as above)
Date project commenced:	February 2005
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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), Chikara (flazasulfuron), Flexidor 125 (isoxaben), Goal (oxyfluorfen), Javelin (diflufenican + isoproturon), Liberator (flufenacet + diflufenican), Ronstar Liquid (oxadiazon), simazine, Skirmish (terbuthylazine + isoxaben), Stomp 400 SC (pendimethalin), SumiMax (flumioxazin), Terano (flufenacet + metosulam).

CONTENTS

Grower Summary

Headline

Several effective herbicide programmes have been identified for use in field-grown roses including new triazine-free products such as Artist and SumiMax, a permitted new triazine (Skirmish) and combinations of the 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 upon inexpensive triazine products such as simazine or atrazine but EU rulings resulted in their withdrawal from most uses and Simazine ceased 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 also become a problem on some nurseries.

There was therefore 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 were 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 highlight extra measures that may be needed to control specific weeds.

3 Provide comparative costs of treatments.

Summary of the project and main conclusions

The work was conducted on two commercial field sites in Hampshire (Site 1) and Norfolk (Site 2). Two successive trials were run on each site (planted in Year 1 and Year 2 of the project). In each trial over the two-year crop cycle, herbicides were applied at the conventional times – ie. post-planting of rootstocks (spring), post-budding (summer) and post-heading back (following winter / early spring).

As a result of either poor weed control or phytotoxicity concerns in Trial 1, the herbicides Javelin, Centium 360 CS, Crystal, Calaris 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 Trial 2 treatments is shown in Table 1.

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

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	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	SumiMax* 0.1 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	SumiMax* 0.33 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	Chikara 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Chikara 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

* In the trial, a 50% w/w WP formulation of flumioxazin, coded 212H, was used as an experimental herbicide. However, the equivalent rates of the now commercially available liquid formulated product, SumiMax, are shown here. Although a higher rate was used post heading back in the trial, agricultural (winter wheat) approval for SumiMax granted in May 2007 was for a maximum 0.1 litres/ha rate.

Choice of herbicides for summer application are more limited because of phytotoxic contact activity of many residuals. Options were Skirmish, Stomp or Flexidor, each mixed with Butisan S to extend the range of weeds controlled.

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

Table 2 Herbicide products and active ingredients

Product name	Active ingredients	a.i. content	Supplier
Artist	flufenacet + metribuzin	24 : 17.5 % w/w	Bayer CropScience
Butisan S	metazachlor	500 g/litre	BASF
Calaris	terbuthylazine + mesotrione	330 : 70 g/litre	Syngenta
Centium 360 CS	clomazone	360 g/litre	Belchim
Chikara	flazasulfuron	25 % w/w	NoMix Enviro
Crystal	flufenacet + pendimethalin	60 : 300 g/litre	BASF
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	terbuthylazine + isoxaben	420 : 75 g/litre	Syngenta
Stomp 400 SC	pendimethalin	400 g/litre	BASF
SumiMax (formerly coded 212H)	flumioxazin	300 g/litre	Interfarm (UK) Ltd
Terano	flufenacet + metosulam	60 : 2.5 % w/w	Bayer

NB as at March 2008, the products Goal, and Terano, or equivalent formulations, were not available in the UK.

Phytotoxicity

- **Calaris** was used as a summer spray post budding in Trial 1 and the mesotrione component caused severe scorch to rootstock tops. Although no carry over effect to maiden bush growth was found the following year, it was dropped from further trialling as it offered no weed control advantages over the other safer, permitted product containing a triazine, **Skirmish**.

- The diflufenican component of **Liberator** and **Javelin** treatments in Trial 1 caused some slight bleaching or spotting of lower leaves of new scion shoot growth. Transient bleaching of lower leaves was also attributed to clomazone in **Centium** on Site 1 in Trial 1. While these effects were not serious and later foliage developed normally, they were no more effective against weeds than other safer products and so were not taken forward to Trial 2.

- **Chikara** (flazasulfuron), caused severe damage to rootstocks from a post planting application at Site 1 but not Site 2. This was characterised by upcurled leaves, yellowing of older foliage and some shoot death. Surviving stocks were still weaker at the end of the season. At Site 2 (but not Site 1), some transient interveinal yellowing was seen on leaves of the scion cv. Warm Wishes following the post heading back spray.

- Treatments containing **Ronstar Liquid** and **Goal** caused some severe scorch on newly emerged leaves when sprayed to either rootstocks (post planting) or scion buds (post heading back) that were not fully dormant when sprayed. Subsequent rootstock growth developed normally, but potentially damage could be much more serious from post heading back sprays in the maiden bush year and this has previously been reported for Goal. When used as recommended on fully dormant stocks, no damage occurred.

Weed control

For both trials, weeds were typically assessed 3 – 4 months after each herbicide application (ie usually June and November records), although sometimes an interim assessment was made before this if weeds started to develop early. Untreated control plots helped indicate the level and spectrum of weed species present. Plots were cleaned of weeds following assessment. Some spot treatments of perennial weeds with glyphosate were needed during the trials. Any perennial weeds were usually disregarded in assessments, but at Site 1, dandelion seedlings, and common couch, were included as both were widespread, and herbicides gave partial control.

Predominant background weeds at Site 1 in both trials were dandelion seedlings, sowthistle, annual meadow grass (AMG), *Persicaria* spp. and mayweeds. At Site 2, there were large numbers of groundsel in both trials, particularly simazine resistant groundsel in Trial 2. Also significant levels of mayweeds, AMG, cleavers, volunteer cereals, willowherbs, sowthistle, black bindweed and *Persicaria* spp.

Previous grower standard (simazine no longer permitted)

- The previous '**Grower standard**' treatment (**simazine + Butisan S**) gave generally good weed control overall, but some weaknesses were evident particularly persistence of control of triazine resistant groundsel, but also willowherb, cleavers and pansy, and also some poorer control of black bindweed and pale persicaria.

New triazine product

- The new triazine-containing **Skirmish** (mixed with **Butisan S**) performed very well in the trial, and better against simazine resistant groundsel and willowherb than the simazine + Butisan S standard. As well as spring applications, it was safe to use over crop foliage in summer, post budding.

Triazine free

- **Crystal**, **Liberator**, **Centium**, **Stomp** and **Terano** were rejected due to poorer efficacy than other treatments in the trials. **Crystal** provided poor control of mayweed, grasses, volunteer cereals, redshank and groundsel. **Liberator** was weak in trial against black nightshade, sowthistle, dandelion seedlings, groundsel, persicarias, cleavers, annual grasses and volunteer cereals. Liberator is particularly sensitive to dry soil conditions, which may have affected performance. **Centium** has a more limited spectrum of activity (good for cleavers, chickweed, shepherd's purse and deadnettle), and therefore is mixed with **Stomp** to extend activity, but nevertheless mayweeds, annual grasses and sowthistle were still poorly controlled. Finally, **Terano**, also gave generally poor weed control, and especially against redshank, mayweed, dandelion and groundsel.

- Programmes containing **Artist** were amongst the most effective of the triazine-free alternatives. It was weak against black bindweed, black nightshade, and less effective for groundsel control than some other herbicides. The addition of **Stomp** to Artist improved control, including slightly better control of groundsel, even though **Stomp** is supposed to be weak on compositae.

- **Butisan S** is of short persistence (typically 3 months) and while it is a very valuable addition to many mixtures, and provides good control of annual grasses, willowherb, and compositae including groundsel, these weeds often began to develop as Butisan's activity wore off.

- **Stomp** or **Flexidor** in combination with **Butisan S** could be used in spring and summer applications. Both products are weak against compositae, and once activity of Butisan S wore off, weaker control of groundsel in particular, mayweed, sowthistle and dandelion seedlings sometimes occurred, and with **Flexidor** also willowherb. **Stomp** + **Butisan S** appeared the better choice of the two for spring applications.

- **Ronstar** in combination with **Stomp** gave reasonably good weed control overall, but annual meadow grass, sowthistle, and dandelion seedlings were not as well controlled at Site 1 as some treatments, and it gave poorer than expected control of the high levels of groundsel at Site 2 in the final year.

- Both **Goal** and **Chikara** were very effective herbicides and amongst the cleanest treatments. **Goal** let through some AMG, and there were more dandelion seedlings and couch than some other treatments at Site 1. Black nightshade appeared to be resistant to **Chikara**. However, crop safety issues were a problem with both herbicides, and the absence of UK approval on crops means these are not currently an option for growers.

- **SumiMax** was trialled as an experimental formulation (212H) for spring treatments. It performed very well at a high rate equivalent to 3 times the now approved product, notably providing very good control of a high background level of groundsel. When trialled at the normal rate the previous year however, it only offered moderate weed control, particularly against AMG, mayweed and dandelion seedlings. As SumiMax is now commercially available, it could be useful as a non-triazine option when mixed with **Stomp** to improve its activity, though this mixture was not tested in the project.

Availability of products trialled and their approval status

Products used in the trial which currently have full label approval for Hardy Nursery Stock:

- **Butisan S**
- **Flexidor 125**
- **Ronstar Liquid**

Products included in the trial currently with Off Label use permitted under Long Term Arrangement for Extension of Use, but which will require SOLA's in the near future:

- **Artist**
- **Skirmish**
- **Stomp 400 SC**
- **SumiMax**

Products currently unavailable in the UK, or no approval for crop use:

- **Simazine**
- **Goal**
- **Terano**
- **Chikara** (approval for non-crop areas only)

Table 3 (on next page) summarises some herbicide programme options for field bush roses in relation to strengths and weaknesses of herbicides for specific weeds.

Financial benefits

- Herbicide material costs for a combination of two spring applications and one summer spray during the life of a crop varied from about £200 to £480 / ha.

- The new herbicides Artist, Skirmish and SumiMax are relatively cheap, and the herbicide costs for 3-spray programmes based on these could be about £250, and similar to the previous simazine + Butisan S standard.

- The herbicide cost is only a proportion of the full application costs, and choice of herbicide should be dictated more by the weeds to be controlled and the relative efficacy of the herbicides.

- The labour costs of additional hand weeding or spot treatment needed to rectify poor weed control is likely to be much greater than the extra cost of a more

expensive herbicide if that one is the better choice for the weed spectrum present.

Table 3 Summary of useful herbicide treatment options for field bush roses arising from HNS 132

Product	Rate of use	Comments
Spring - post planting and heading back		
Artist + Stomp 400 SC	2.5 kg/ha 5.0 litres/ha*	Artist weaker on black nightshade, black bindweed, cleavers, AMG and groundsel. Stomp good on cleavers, knotgrass and redshank, charlock moderately resistant, and weak on compositae – e.g. groundsel, sowthistle, mayweed. Mixture, therefore, not best choice if groundsel a major problem, otherwise one of the best non-triazine options, and inexpensive.
Flexidor 125 + Butisan S	2.0 litres/ha 2.5 litres/ha	Flexidor strong on crucifers and polygonums. Weaker on AMG, cleavers, groundsel, willowherb, black nightshade, sowthistle, volunteer cereals. Butisan S good for annual grasses, groundsel, Canadian fleabane, willowherb. Moderate control of black bindweed, cleavers, corn spurrey, fat hen, redshank, small nettle. Weak on fumitory, knotgrass, field penny cress, charlock, pansy, volunteer cereals, wild oat. Mixture therefore likely to be poorer if volunteer cereals, cleavers a problem, and compositae once Butisan runs out of activity. Relatively expensive treatment.
Ronstar + Stomp 400 SC	4.0 litres/ha 3.3 litres/ha	Ronstar good on groundsel including triazine resistant, cleavers, knotgrass, willowherb. Weaker on grasses and does not control chickweed. Mixture in trial was not as good as expected with high levels groundsel, nor against AMG, sowthistle and dandelion seedlings. Relatively expensive treatment.
Skirmish + Butisan S	1.0 litre/ha 2.5 litres/ha	Skirmish weaker on polygonums (e.g. knotgrass, persicaria) and fumitory and black bindweed. Butisan also weaker on fumitory and black bindweed. Mixture was amongst best for triazine resistant groundsel in trial and generally was very good in trial, and inexpensive.
SumiMax + Stomp 400 SC	0.1 litres/ha 5.0 litres/ha*	This mixture not trialled in HNS 132, but SumiMax at this rate likely to need addition to be effective. SumiMax could be good against simazine resistant groundsel, but was weaker on polygonums, AMG and dandelion seedlings in trial. Need tank cleaner after spraying SumiMax. Mixture inexpensive.
Stomp 400 SC + Butisan S	5.0 litres/ha* 2.5 litres/ha	Mixture susceptible to poor control of compositae once Butisan activity runs out. Also poor control of charlock.
Artist + Butisan S	2.5 kg/ha 2.5 litres/ha	Not trialled in HNS 132. Mixture could be poor against black bindweed and cleavers, and also groundsel once Butisan activity fades.
Summer - post budding and optional maiden year summer treatment		
Skirmish + Butisan S	1.0 litre/ha 2.5 litres/ha	See above.
Flexidor 125 + Butisan S	2.0 litres/ha 2.5 litres/ha	See above.
Stomp 400	5.0	See above.

SC + Butisan S	litres/ha* 2.5 litres/ha	

*The 5 L/ha rate is being phased out, all new pendimethalin 400 g/L products now have a maximum rate of 3.3 L/ha. This is likely to affect control of cleavers and knotgrass control, for example, where the partner product in mixtures does not control these weeds well (e.g. Butisan S + Stomp).

Action points for growers

- Identify the predominant weed species present during previous cropping, in sites where roses are planned in future. Allow plenty of time to control perennial weeds prior to planting rootstocks.

- Simazine can no longer be used. Table 3 here should be used to help choose the most appropriate herbicide programme for field grown roses depending on weeds present.

- As at March 2008, Artist, Skirmish, Stomp and SumiMax can still be used off-label under LTAEU, but SOLA's will be required in the near future, and grower's should check the latest approval status.

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

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. Approval for use of Simazine on hardy nursery stock ended in 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 was 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 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.

This final report summarises the early results of Trials 1 and 2, and gives detailed results relating to the maiden crop year of Trial 2 in 2007 that have not been previously reported. While this report covers the main findings, conclusions and recommendations for the whole project, some readers may wish to refer to the previously published Years 1 and 2 Annual reports for the detailed tables of results of Trials 1 and 2 up to autumn 2006.

Availability and use of herbicides referred to in this report (also see Table 6)

Some of the herbicides used in the project were not commercially available in the UK as at March 2008, although were included as possible candidates for the future. At this time some of the others that are available in the UK, and have approval for non-horticultural crops, may still be used on nursery stock, at grower's risk, under the Long Term Arrangements for Extension of Use. However, LTAEU for non-edible

crops are currently being phased out by PSD and replaced by SOLA's to bring pesticide approvals into line with EU based legislation. SOLA's will not automatically be granted, so growers should first check the current status of products without label approval (e.g. via www.pesticides.gov.uk) before use.

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.

MATERIALS AND METHODS

Overview

The project used two commercial field sites, one in Hampshire and the other in Norfolk. Over the three-year project duration, two successive trials were conducted on each site (planted in Year 1 and Year 2). The conventional three timings of herbicides were 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 ran 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
Jermyns Lane
Ampfield
Romsey

c/o Stewart Pocock, Pocock's Roses, 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 was 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 were 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	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	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	SumiMax* 0.1 L/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	SumiMax* 0.33 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	Chikara 0.2 kg/ha	Butisan 2.5 L/ha + Stomp 5.0 L/ha	Chikara 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

* In the trial, a 50% w/w WP formulation of flumioxazin, coded 212H, was used as an experimental herbicide. However, the equivalent rates of the now commercially available liquid formulated product, SumiMax, are shown here. Although a higher rate was used post heading back in the trial, agricultural (winter wheat) approval for SumiMax, granted in May 2007, was for a maximum 0.1 litres/ha rate.

Table 3 Herbicide products and active ingredients

Product name	Active ingredients	a.i. content	Supplier
Artist	flufenacet + metribuzin	24 : 17.5 % w/w	Bayer CropScience
Butisan S	metazachlor	500 g/litre	BASF
Calaris	terbuthylazine + mesotrione	330 : 70 g/litre	Syngenta
Centium 360 CS	clomazone	360 g/litre	Belchim
Chikara	flazasulfuron	25 % w/w	NoMix Enviro
Crystal	flufenacet + pendimethalin	60 : 300 g/litre	BASF
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	terbuthylazine + isoxaben	420 : 75 g/litre	Syngenta
Stomp 400 SC	pendimethalin	400 g/litre	BASF
SumiMax (formerly coded 212H)	flumioxazin	300 g/litre	Interfarm (UK) Ltd
Terano	flufenacet + metosulam	60 : 2.5 % w/w	Bayer

NB as at January 2008, the products Chikara, Goal, and Terano, or equivalent formulations, were not available in the UK.

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, 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, SumiMax (flumioxazin, trialled as an experimental herbicide, 212H) in Trt I, Chikara (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. Chikara 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. SumiMax is reputed to have a wide spectrum of control on broadleaf and some grass weeds and is an established herbicide in other parts of the world, including the USA on roses. However, because there was so little experience in its use in the UK prior to 2006, it was decided to trial a standard rate in spring 2006 and 3.3X higher rate in spring 2007 within Trial 2.

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, 730 L/ha post-budding, and 760 L/ha post-heading back.

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

The effects of the post planting herbicide were assessed in May – June with one or two assessment dates depending on when the herbicide had been applied, and the degree of weed growth before rootstocks were budded. Plots were usually cleaned of any weed prior to budding (July), and the post-budding herbicide applications applied. Another weed assessment was then carried out in the autumn (November). A further herbicide treatment was applied the following spring after heading back rootstocks, and a final weed record was taken in June of the maiden year.

Normally weeds were counted, by species, for a central area within the total sprayed area in each plot. For Site 1, for example, this comprised the central 3 alleys and centre 3.0 m length (7.5 m^2 area) for Trial 1 and 2.0 m length (5.0 m^2 area) for Trial 2. On some occasions weed growth (particularly in the untreated control plots) was too great for individual weeds to be counted, in which case an estimate of ground cover was made, and the predominant weed species noted.

Phytotoxicity observations

Growth from rootstocks and headed back maidens were observed for any signs of damage such as leaf scorching, yellowing, distorted growth etc. following herbicide applications in the spring. Also, rootstock foliage was observed following the post budding summer herbicide treatments. Any damage was noted and photographed where possible.

For Trial 1, a bud-take assessment was made on both sites following the heading back of rootstocks in the maiden year. 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. For Trial 2, a bud take assessment was only carried out for Site 2 in Norfolk in June 2007. Site 1 rootstocks had been budded with a mixture of cultivars across the trial, and it was not possible to reliably assess possible affects of herbicide treatments on bud-take or grade-out. However, any observations of phytotoxicity were noted.

Analysis of results

Weed count data from each Trial and Site were standardised to weeds per m^2. 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 some of the Site 2 (Norfolk) weed assessments 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
Rootstocks headed back	late Feb / early March	early December

Post heading back herbicide treatments	15/3/07	8/3/07
Summer (final) weed assessment	12/6/07	11/6/07

Removal of weeds between assessments

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.

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. Spot treatment with glyphosate as Roundup Biactive using a carefully directed spray with a hand sprayer was carried out in early March 2007, taking care to direct the spray away from headed back rootstocks. Most of the weed present such as annual meadow grass (AMG) was in the Untreated plots, but some dandelion, thistle, couch grass, buttercup and a few other annual weeds were generally present. Site 2 was also sprayed in mid February 2007 with PDQ (paraquat + diquat) using a directed spray away from headed back rootstocks to remove the mainly annual weed present.

RESULTS AND DISCUSSION

TRIAL 1

Background weed populations

At Site 1, some perennial weeds were particularly troublesome throughout Trial 1, particularly large numbers of perennial thistles at one end of the trial, and perennial sowthistle in some plots. Creeping cinquefoil and dandelion was also widespread. Some spot treatments with Roundup (glyphosate) were used to keep these under control. Couch grass was also present. Perennial weeds were not recorded as part of the trial except for dandelion (most of which were from seed), and couch grass, as many of the herbicide treatments had at least some suppressive effect on both of these species. A wide range of common annual weeds were present at Site 1 but with no obviously dominant species.

Perennial weeds were not a significant problem at Site 2. There were particularly large numbers of redshank, mayweeds, cleavers, volunteer cereals, and groundsel recorded in Untreated plots over the course of Trial 1, but other annuals were also present.

Summary of herbicide programme performance in Trial 1 (early spring treatments / summer treatment)

High levels of weed developed in untreated Trt A plots on both sites, and against this background, all herbicide treatments gave good weed control. However, there were treatment differences and annual weed on some of the weakest herbicide treatments could have become of economic significance if left to develop and not hand-weeded or sprayed after assessment. Weed numbers were much lower at the post budding autumn assessment than the previous and final summer records.

The 'grower standard' Trt B (simazine + Butisan all timings) gave generally good weed control, but at Site 2, its weaknesses against triazine resistant groundsel, willowherb, cleavers, pansy, black bindweed and pale persicaria were evident compared to some other treatments.

Trt C (Skirmish + Butisan all timings) performed well, and was usually better for those weeds where Trt B failed to give total control, but Trt C still showed some weakness against triazine resistant groundsel on Site 2 in summer 2006

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. Javelin could cause some transient phytotoxicity symptoms.

Trt F (Artist / Butisan + Stomp) generally gave good weed control. Artist 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 treatments as Crystal 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 grasses, cleavers, and redshank.

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

Phytotoxicity and bud take

The major phytotoxicity problem in Trial 1 was foliage scorch caused by contact action from the use of Calaris (Trt K) as a post budding spray on rootstocks in summer 2005. This was caused by the mesotrione component of Calaris, not the terbuthylazine ingredient, as no phytotoxicity was caused by Skirmish, which also contains terbuthylazine.

The diflufenican component of Javelin caused some transient yellowing, scorching and twisting of young rootstock leaves in spring 2005 on Site 1. Javelin resulted in some bleaching of lower leaves of one scion cultivar in 2006 at Site 2, and Liberator

(flufenacet + diflufenican) caused some pink spotting on the dark red first leaves of some cultivars at Site 1. Symptoms did not persist, however and later foliage developed normally. Some transient bleaching of lower scion leaves was observed on Trt G (Centium + Stomp) plots on Site 2 but not Site 1, attributable to the clomazone component of Centium.

There were no herbicide treatment effects on the proportion of bud take.

TRIAL 2

Calaris, Centium 360 CS, Crystal, Javelin, and Liberator used in Trial 1 were not taken forward for further assessment in Trial 2, either because of their relatively poor weed control, or concerns about phytotoxicity.

For Trial 2, these dormant season treatments were replaced by Goal (oxyfluorfen) in Trt E., In addition to Artist alone in Trt F, Artist plus Stomp was tried in Trt G. SumiMax was used in Trt I at the standard rate post planting, and at a factor of 3.3 higher rate post heading back. Chikara (flazasulfuron) was trialled in Trt K, and Terano (flufenacet + metosulam) in Trt L.

Background weed population

Perennial weeds were much less of a problem at Site 1 in this trial, although some common couch grass, a few thistles and moderately high numbers of dandelion seedlings were present throughout the site. Common couch was not recorded in this trial, but dandelion seedlings were. AMG, sowthistle, mayweeds, redshank and pale persicaria, and willowherb were the predominant annuals present in Untreated plots during the trial.

At Site 2, large flushes of groundsel were the predominant weed pressure during the trial. Willowherb, AMG, sowthistle, speedwell and black bindweed were also present in significant numbers in Untreated plots.

Phytotoxicity

At Site 1, rootstocks could not be planted until mid April, and due to dry conditions which followed, the post planting herbicide treatments were further delayed until early May. At this stage some stocks were leafing out. All treatments developed at least some temporary scorch of rootstock leaves a few days later, because of the sunny conditions while spraying, but most continued to grow away normally without any check. Young leaves on treatments containing Ronstar (Trt D) and Goal (Trt E), however, were more severely scorched, and while they did recover later in the summer, Goal plots did suffer a slight check to growth. At Site 2, some temporary leaf scorch also occurred from Treatments D and E, but there was little evidence of any damage by June.

Rootstocks sprayed with Trt K, Chikara (flazasulfuron) were quite severely damaged at Site 1 but no problems were observed at Site 2. It is conceivable, though impossible to confirm subsequently, that an error in mixing may have caused an overdose to be applied. Symptoms showed a few weeks after spraying as an

upcurling of younger leaves, and a yellowing or scorching of older leaves, followed by some shoot death. Plants remained stunted, and some were too small to be budded.

Roostocks were headed back much earlier at Site 2 (early December) than Site 1 (late February / early March). Scion bud development was thus more advanced when final treatments were applied on 8 March at Site 2 than at Site 1 for the treatment spray on 15 March. Some temporary scorch did occur to scion buds at Site 2 from Ronstar (Trt D) and Goal (Trt E) (Appendix 3, Photo 5). Later shoot growth appeared to be normal, although there was a suspicion that a check to growth from the Goal treatment on Site 2 might have resulted in a slightly poorer grade-out at lifting. Unfortunately the crop was lifted before a grade record could be made.

Following the post heading back spray of Chikara, no damage was seen on scion growth of remaining plants at Site 1, but interestingly a few plants at Site 2 showed some interveinal yellowing (Appendix 3, Photo 6).

Bud take

Bud take was not assessed at Site 1 because of the wide mixture of cultivars budded. At Site 2, stocks were budded with a single cultivar, Warm Wishes, and the assessment in June 2007 gave an average 95% bud take across herbicide treatments, but mean differences between herbicide treatments were small and not statistically significant.

Control of weeds

Trial 2, Site 1, Hampshire

Table 4 gives details of weed numbers at the final assessment in mid June 2007, not previously reported. The post heading back herbicides were applied in mid March, and with dry weather during most of April and early May, there was little weed growth until the 12 June assessment after significant rain in mid-late May. At this stage, there was a lot of weed in the Untreated Trt A controls (mean 23 weeds/m^2), but relatively little annual weed in the herbicide treated plots. Despite a relatively low overall weed presence at this time, some differences in control between herbicide treatments were still evident (Appendix 3, Photos 7 – 8).

Overall, the cleanest treatments were Goal (Trt E), Artist + Stomp (Trt G), Chikara (Trt K), Skirmish + Butisan (Trt C) and SumiMax (Trt I) with a mean of 0.3 – 1.1 weeds/m^2. Simazine + Butisan (Trt B) was not significantly worse overall than Trt C, but did have more dandelion seedlings present at this assessment.

Terano (Trt L) was the poorest treatment (mean 2.6 weeds/m^2), showing similar weaknesses as in 2006 against redshank, mayweed and dandelion. Ronstar + Stomp (Trt D), Flexidor + Butisan (Trt J) and Stomp + Butisan (Trt H) were not

significantly better than Trt L for mean total weed numbers, although distribution of several weeds were patchy such that one replicate plot might have about 10 sowthistle (Trts D and H) or bindweed (Trts H and J), while the other replicates had none. Willowherb was consistently less well controlled in plots of Trts J and H, even though numbers were relatively low. Butisan normally gives good control of willowherb, but may have partly degraded by June. Also, Flexidor (Trt J) is weaker on willowherb.

Artist + Stomp (Trt G) performed very slightly better than Artist alone (Trt F) due to better control of dandelion seedlings and groundsel, though differences in groundsel numbers and overall weed populations were not statistically significant.

An unusually wet late June and July encouraged a lot of weed growth throughout the Site 1 trial and the remainder of the commercial crop during summer and autumn up to lifting. No further formal weed assessments were carried out after 12 June, but observations indicated that much was perennial weed such as common couch, dandelion and some patches of thistle and perennial sowthistle. In herbicide treated plots, annual weeds were not present in very high numbers, but large individual weeds such as mayweeds, redshank, Canadian fleabane, fat hen, and groundsel had developed.

Table 4. Trial 2, Site 1, Hampshire. Mean weed numbers on herbicide treated plots 12 June 2007.

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

Treatment (post heading back)	Sowthistle	Dandelion	Groundsel	AMG	Redshank	Fat Hen	Mayweed	Willowherb	Other Weed[1]	Total Weed
A. Untreated	0.531 (2.40)	0.467 (1.93)	0.539 (2.46)	0.528 (2.37)	0.418 (1.62)	0.536 (2.44)	0.217 (0.65)	0.357 (1.28)	0.454 (1.84)	1.372 (22.55)
B. Simazine + Butisan S	**0.000 (0.00)**	0.171 (0.48)	**0.020 (0.05)**	**0.020 (0.05)**	**0.040 (0.10)**	**0.000 (0.00)**	**0.056 (0.14)**	0.088 (0.22)	**0.103 (0.27)**	**0.354 (1.26)**
C. Skirmish + Butisan S	**0.075 (0.19)**	**0.020 (0.05)**	**0.040 (0.10)**	**0.020 (0.05)**	**0.091 (0.23)**	**0.000 (0.00)**	**0.037 (0.09)**	**0.037 (0.09)**	**0.084 (0.21)**	**0.291 (0.95)**
D. Ronstar + Stomp lo	**0.132 (0.36)**	**0.135 (0.36)**	**0.119 (0.32)**	**0.091 (0.23)**	**0.071 (0.18)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.192 (0.56)**	0.530 (2.39)
E. Goal	**0.000 (0.00)**	**0.064 (0.16)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.040 (0.10)**	**0.122 (0.32)**
F. Artist	**0.000 (0.00)**	0.188 (0.54)	**0.176 (0.50)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.076 (0.19)**	**0.000 (0.00)**	**0.059 (0.15)**	**0.390 (1.45)**
G. Artist + Stomp hi	**0.020 (0.05)**	**0.020 (0.05)**	**0.051 (0.12)**	**0.000 (0.00)**	**0.051 (0.12)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.051 (0.12)**	**0.183 (0.52)**
H. Stomp hi + Butisan S	**0.119 (0.32)**	**0.091 (0.23)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.059 (0.15)**	0.127 (0.34)	**0.209 (0.62)**	0.409 (1.56)
I. SumiMax (hi rate)	**0.000 (0.00)**	0.227 (0.69)	**0.000 (0.00)**	**0.076 (0.19)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.073 (0.18)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.321 (1.09)**
J. Flexidor + Butisan S	**0.020 (0.05)**	**0.095 (0.24)**	**0.000 (0.00)**	**0.020 (0.05)**	**0.020 (0.05)**	**0.000 (0.00)**	**0.110 (0.29)**	0.171 (0.48)	0.251 (0.78)	0.498 (2.15)
K. Chikara	**0.075 (0.19)**	**0.079 (0.20)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.000 (0.00)**	**0.071 (0.18)**	**0.206 (0.61)**
L. Terano	**0.000 (0.00)**	0.184 (0.53)	**0.000 (0.00)**	**0.000 (0.00)**	0.227 (0.69)	**0.020 (0.05)**	0.247 (0.77)	**0.059 (0.15)**	**0.183 (0.52)**	0.561 (2.64)
SED (33 df)	*0.1457*	*0.0625*	*0.1457*	*0.0831*	*0.0760*	*0.0819*	*0.0638*	*0.0364*	*0.1118*	*0.1391*
LSD (5%)	*0.296*	*0.127*	*0.296*	*0.169*	*0.155*	*0.167*	*0.130*	*0.074*	*0.228*	*0.283*
Significance, P	*0.048*	*<.001*	*0.048*	*<.001*	*<.001*	*<.001*	*0.005*	*<.001*	*0.02*	*<.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 (transformed data) to be compared.

[1] Other weeds = shepherd's purse, black bindweed, Canadian fleabane, cleavers, scarlet pimpernel, spurge, black nightshade, chickweed, knotgrass, cranesbill, sharp-leaved fluellen, common fumitory

Trial 2, Site 2, Norfolk

At Site 2, post heading back, groundsel was by far the most predominant weed. Apart from Untreated Trt A plots, where there were also some significant numbers of AMG and willowherb, there were just the occasional willowherb, bittercress, AMG, speedwell, sowthistle and pansy on a few of the herbicide treated plots. Because of the large numbers of groundsel seedlings present, these were not counted, but weed cover estimated. Table 5 summarises the % cover, which was almost all from groundsel.

There were very large treatment differences in the amount of weed from a mean of over 95% cover for Untreated plots to nil for Goal (Trt E). Appendix 3, Photos 9 – 12, illustrates differences in weed levels between some of the treatments. The cleanest treatments, with nil or only the occasional groundsel present were Goal (Trt E), SumiMax high rate (Trt I), Skirmish + Butisan (Trt C) and Chikara (Trt K). Results in November 2006 had indicated that the groundsel population was largely simazine resistant, and this was confirmed by the difference in control shown by Simazine + Butisan (Trt B) and Skirmish + Butisan (Trt C) in June 2007.

Ronstar + Stomp (Trt D) gave unexpectedly poor control, as Ronstar is normally good against simazine resistant groundsel. Artist + Stomp (Trt G) gave better control than Artist alone (Trt F), but this was still poor (mean 12.4% and 42.2% cover), and confirmed earlier results that Artist can be weak on groundsel.

Trt J (Flexidor + Butisan) gave much better results than Trt H (Stomp + Butisan) in this assessment. Neither Stomp nor Flexidor are normally very effective against groundsel, so most control is likely to have been from the Butisan in the tank mix. The variable result may have been down to Butisan's short persistence of about 3 months, and it was probably becoming less effective by this time.

Table 5. Trial 2, Site 2, Norfolk. Mean % weed cover on herbicide treated plots 11 June 2007.

Transformed data as arcsine square root. Back-transformed data, as mean % cover, is in brackets.

Treatment (post heading back)	% Cover
A. Untreated	78.9 (96.3)
B. Simazine + Butisan S	18.0 (9.5)
C. Skirmish + Butisan S	**1.4 (0.1)**
D. Ronstar + Stomp lo	21.0 (12.8)
E. Goal	**0.0 (0.0)**
F. Artist	40.5 (42.2)
G. Artist + Stomp hi	20.6 (12.4)
H. Stomp hi + Butisan S	28.3 (22.5)
I. SumiMax (hi rate)	**3.2 (0.3)**
J. Flexidor + Butisan S	**10.9 (3.6)**
K. Chikara	**2.5 (0.2)**
L. Terano	24.4 (17.1)
SED (33 df)	*5.53*
LSD (5%)	*11.3*
Significance, P	*<.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 (transformed data) to be compared.

Summary of herbicide performance 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. Against a high background pressure of simazine resistant groundsel on Site 2, Trt C did not always give total control of this weed, but

performed significantly better than Trt B and most of the other treatments. Likewise simazine resistant willowherb was also better controlled by Trt C than Trt B.

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. At Site 2, Ronstar did not control groundsel as well as would be expected in summer 2007.

Trt E (Goal / Butisan + Stomp) performed better at Site 2 (Norfolk) than Site 1 (Hants) post-planting and post-budding, due to higher levels of couch, dandelion seedlings and some annual meadow grass in this treatment at Site 1. However, Trt E was the cleanest treatment on both sites in June 2007 following the post heading back spray of Goal. As with Ronstar, growers should be aware that Goal must only be applied to dormant crops to avoid leaf scorch, and as this can be potentially more damaging if flowering cultivar shoots are damaged in the maiden year, it would be safest to avoid using Goal as a post-heading back treatment.

Trt F (Artist / Butisan + Flexidor). As in Trial 1, Artist has been one of the better of the new herbicides trialled. 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, and the high population pressure from groundsel at Site 2, particularly in summer 2007, confirmed Artist's weakness against this weed. The addition of Stomp in Trt G (Artist + Stomp / Butisan + Flexidor) improved control of all these weeds, although it is not clear why groundsel should have been better controlled as Stomp is known to be poor against compositae.

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. As with several other treatments, Butisan usefully extends the range of weeds controlled initially, but here Stomp and Flexidor's weakness against compositae was exposed, once Butisan's activity wore off. Mayweed was poorly controlled by these treatments in early summer 2006 at Site 1, and sowthistle in autumn at Site 2. Likewise the poor control of groundsel at Site 2 in autumn 2006 by Trts H and J was confirmed in summer 2007. Willowherb is less susceptible to Flexidor and both treatments were less good against this weed in several assessments.

Trt I (SumiMax / Butisan + Stomp) did not perform well at Site 1, following the equivalent standard product rate for SumiMax used spring 2006 after planting the rootstocks. The product label indicates SumiMax should give good control of AMG

and other grasses, but in our trial it was weak against AMG in particular, and also mayweed and dandelion seedlings at Site 1. Following the 3.3-fold higher rate tried in spring 2007, weed control was good at both sites, including groundsel at Site 2.

Trt K (Chikara / Butisan + Stomp). From the Site 1 results in 2006, black nightshade appeared to be a weakness in Chikara's weed control spectrum, but apart from that, the treatment gave generally good weed control. There remains some concerns about crop safety of Chikara following mixed results during the two year trial across both sites, but this is now largely academic, as UK Approval for Chikara given in October 2007 was granted for Industrial use on non-cropped areas only.

Trt L (Terano / Butisan + Stomp) was one of the poorest treatments overall. Terano did not give good control of redshank, mayweed or dandelion seedlings at Site 1 following spring 2006 and 2007 applications, and the treatments generally was also poor against groundsel at Site 2.

Availability and permitted use of herbicides trialled in HNS 132

Table 6. Summary of recommendations, permitted use and availability of herbicides as at March 2008.

Product	Recommendation for outdoor field rose crop based on HNS 132 results.	Full label approval for HNS	Current use permitted under LTAEU but will require SOLAs in future	Product availability in UK	Comments - e.g. efficacy poorer than alternatives or can be phytotoxic
Artist	**Yes**		Yes	Yes	
Butisan S	**Yes**	Yes		Yes	
Calaris	No		Yes	Yes	Phytotoxicity concerns. Safer alternatives.
Centium 360 CS	No		Yes	Yes	Efficacy
Chikara	No			Yes	Phytotoxicity?. Approval for non-crop areas only
Crystal	No		Yes	Yes	Efficacy
Flexidor 125	**Yes**	Yes		Yes	
Goal	No			**No**	Phytotoxicity concerns & UK availability
Javelin	No		Yes	Yes	Efficacy / phytotoxicity
Liberator	No		Yes	Yes	Efficacy
Ronstar Liquid	**Yes**	Yes		Yes	Crop fully dormant to avoid phytotoxicity
Simazine	(No)			**No**	Horticultural use finally withdrawn December 2007
Skirmish	**Yes**		Yes	Yes	Currently permitted triazine
Stomp 400 SC	**Yes**		Yes	Yes	
SumiMax (212H)	**Yes**		Yes	Yes	Max 0.1 l/ha – recomm. tank mix with e.g. Stomp
Terano	No			**No**	Efficacy. No current plans for UK availability

Table 6 summarises the situation at the time of reporting. Artist, Skirmish, Stomp 400 SC and SumiMax are the four products without full approval for use on nursery stock, which this project has identified as being valuable for use in rose herbicide programs. While their current use is permitted under LTAEU, SOLAs will be required in future once the PSD review process has been completed. As Stomp already has specific off-label approvals (SOLA's) for use on several hand-harvested edible crops, it is expected that Stomp will obtain a SOLA for HNS use relatively easily. The future situation for Skirmish, Artist and SumiMax is less straightforward, and it is important that growers keep on top of developments and check the latest approval status before using these products.

Herbicide costs

Table 7 gives guideline product prices, and Table 8 herbicide costs / ha for some tank mix options. These should be used as an approximate guide only as actual prices will vary between suppliers and quantities ordered etc.

Table 7 Guideline product prices (ex-VAT)[1]

Product	£ per pack	Pack size	£ / litre or kg
Artist	87.82	5 kg	17.56
Butisan S	121.00	5 litre	24.20
Calaris	148.00	5 litre	29.60
Centium 360 CS	100.00	1 litre	100.00
Crystal	85.20	10 litre	8.52
Flexidor 125	53.98	1 litre	53.98
Javelin	57.50	5 litre	11.50
Liberator	180.00	3 litre	60.00
Ronstar Liquid	39.88	1 litre	39.88
Simazine	16.89	5 litre	3.38
Skirmish	112.90	5 litre	22.58
Stomp 400 SC	67.00	10 litre	6.70
SumiMax	133.00	0.5 litre	266.00

[1] Prices supplied by Bartholomews (Chichester) Ltd, except for Javelin (UAP Ltd, Alconbury, Cambs), Calaris and Skirmish (Syngenta Crop Protection UK Ltd), and SumiMax (Interfarm UK Ltd).

Table 8 Cost of herbicide materials for some treatment options[1] based on prices in Table 7

Spring (post planting or post heading back)			Summer (post budding)		
Product	**Rate kg or L/ha**	**Cost £ / ha**	**Product**	**Rate kg or L/ha**	**Cost £ / ha**
Simazine +	3.4	11.49	Simazine +	3.4	11.49
Butisan S	2.5	60.50	Butisan S	2.5	60.50
		Total 71.99			***Total 71.99***
Skirmish +	1.0	22.50	Skirmish +	1.0	22.58
Butisan S	2.5	60.50	Butisan S	2.5	60.50
		Total 83.08			***Total 83.08***
Ronstar Liquid +	4.0	159.52	Flexidor 125 [2] +	1.0	53.98
Stomp 400 SC [3]	3.3	22.11	Butisan S	2.5	60.50
		Total 181.63			***Total 114.48***
Artist +	2.5	43.91	Stomp 400 SC +	5.0	33.50
Stomp 400 SC[4]	5.0	33.50	Butisan S	2.5	60.50
		Total 77.41			***Total 94.00***
Artist +	2.5	43.91			
Butisan S	2.5	60.50			
		Total 104.41			
Flexidor 125 +	2.0	107.96			
Butisan S	2.5	60.50			
		Total 168.46			
Stomp 400 SC[4] +	5.0	33.50			
Butisan S	2.5	60.50			
		Total 94.00			
SumiMax (212 H)	0.1	26.60			
+					

Stomp 400 SC[4]	5.0	33.50	
		Total 60.10	

[1] Simazine can no longer be used so cost of simazine + Butisan treatment included for comparison only.

[2] Flexidor used at lower rate for summer treatment

[3] Stomp used at lower rate when mixed with Ronstar in spring.[4] The 5 L/ha rate is being phased out, all new pendimethalin 400g/L products now have a maximum rate of 3.3 L/ha

The material costs for a combination of two spring applications and one summer spray during the life of a crop could vary from about £200 to £480 / ha. The new herbicides Artist, Skirmish and SumiMax are relatively cheap. The cost of the herbicide materials is, of course, only a proportion of the full cost of applying the programmes. The labour costs of any additional hand weeding or spot treatment necessary to rectify poor weed control, is likely to be much greater than the extra cost of using a more expensive herbicide if that one is the better choice for controlling the weed spectrum present.

Other considerations for effective weed control

The project has concentrated on herbicide options for mainly annual weed control. The following points, while they are basic good practice, are worth re-emphasising to achieve effective weed control.

- Ensure perennial weeds are cleaned up as effectively as possible before planting, as effective herbicide options are limited and spot treatments expensive once the rose crop is present. Perennial weeds such as thistles, common couch, dandelion, perennial sowthistle and creeping cinquefoil were a particular problem at Site 1. A single spray of glyphosate in the autumn prior to rootstock planting suppressed but did not eliminate the perennials present.

- Inspect the site / crop in the year prior to planting and note the predominant weed species present. This will assist choosing the most appropriate herbicide option.

- Ensure the absence of existing weed as far as possible when applying residuals. Butisan S can have some useful contact activity against some early stage seedlings if herbicide application has to be delayed after planting for example.

- Residual herbicides required a good tilth and freedom from clods for best activity, and soil moisture to activate. At least 3 mm of rain or irrigation should occur within a few days of application to wash in the herbicide and

activate it, or efficacy can be affected, especially if herbicides are applied to dry soil.

- Timing and subsequent weather pattern will affect longevity of herbicides. Most rose growers only apply a spring herbicide application in the second (maiden) production year post heading back. This is insufficient to give good weed control up until lifting in the autumn / winter, although late weed growth is tolerated because it may not adversely affect bush development and grade out at that stage. However, perennial weed development can be a significant problem, and it may also be worth applying a second summer residual spray for annuals, particularly if the field is open to prospective customers. To get adequate soil coverage, a sprayer fitted with drop arms or a hand lance between rows may be required, using wide-angle spray nozzles.

Summary of treatment options

Table 9 gives a summary of herbicide mixture options as recommended by this project. As explained previously, these uses are all currently permitted under LTAEU as at March 2008, but approval for some products will require SOLA's in future.

Table 9 Summary of useful herbicide treatment options for field bush roses arising from HNS 132

Product	Rate of use	Comments
Spring - post planting and heading back		
Artist + Stomp 400 SC	2.5 kg/ha 5.0 litres/ha*	Artist weaker on black nightshade, black bindweed, cleavers, AMG and groundsel. Stomp good on cleavers, knotgrass and redshank, charlock moderately resistant, and weak on compositae – e.g. groundsel, sowthistle, mayweed. Mixture, therefore, not best choice if groundsel a major problem, otherwise one of the best non-triazine options, and inexpensive.
Flexidor 125 + Butisan S	2.0 litres/ha 2.5 litres/ha	Flexidor strong on crucifers and polygonums. Weaker on AMG, cleavers, groundsel, willowherb, black nightshade, sowthistle, volunteer cereals. Butisan S good for annual grasses, groundsel, Canadian fleabane, willowherb. Moderate control of black bindweed, cleavers, corn spurrey, fat hen, redshank, small nettle. Weak on fumitory, knotgrass, field penny cress, charlock, pansy, volunteer cereals, wild oat. Mixture therefore likely to be poorer if volunteer cereals, cleavers a problem, and compositae once Butisan runs out of activity. Relatively expensive treatment.
Ronstar + Stomp 400 SC	4.0 litres/ha 3.3 litres/ha	Ronstar good on groundsel including triazine resistant, cleavers, knotgrass, willowherb. Weaker on grasses and does not control chickweed. Mixture in trial was not as good as expected with high levels groundsel, nor against AMG, sowthistle and dandelion seedlings. Relatively expensive treatment.
Skirmish + Butisan S	1.0 litre/ha 2.5 litres/ha	Skirmish weaker on polygonums (e.g. knotgrass, persicaria) and fumitory and black bindweed. Butisan also weaker on fumitory and black bindweed. Mixture was amongst best for triazine resistant groundsel in trial and generally was very good in trial, and inexpensive.
SumiMax + Stomp 400 SC	0.1 litres/ha 5.0 litres/ha*	This mixture not trialled in HNS 132, but SumiMax at this rate likely to need addition to be effective. SumiMax could be good against simazine resistant groundsel, but was weaker on polygonums, AMG and dandelion seedlings in trial. Need tank cleaner after spraying SumiMax. Mixture inexpensive.
Stomp 400 SC + Butisan S	5.0 litres/ha* 2.5 litres/ha	Mixture susceptible to poor control of compositae once Butisan activity runs out. Also poor control of charlock.
Artist + Butisan S	2.5 kg/ha 2.5 litres/ha	Not trialled in HNS 132. Mixture could be poor against black bindweed and cleavers, and also groundsel once Butisan activity fades.
Summer - post budding and optional maiden year summer treatment		
Skirmish +	1.0 litre/ha	See above.

Butisan S	2.5 litres/ha	
Flexidor 125 + Butisan S	2.0 litres/ha 2.5 litres/ha	See above.
Stomp 400 SC + Butisan S	5.0 litres/ha* 2.5 litres/ha	See above.

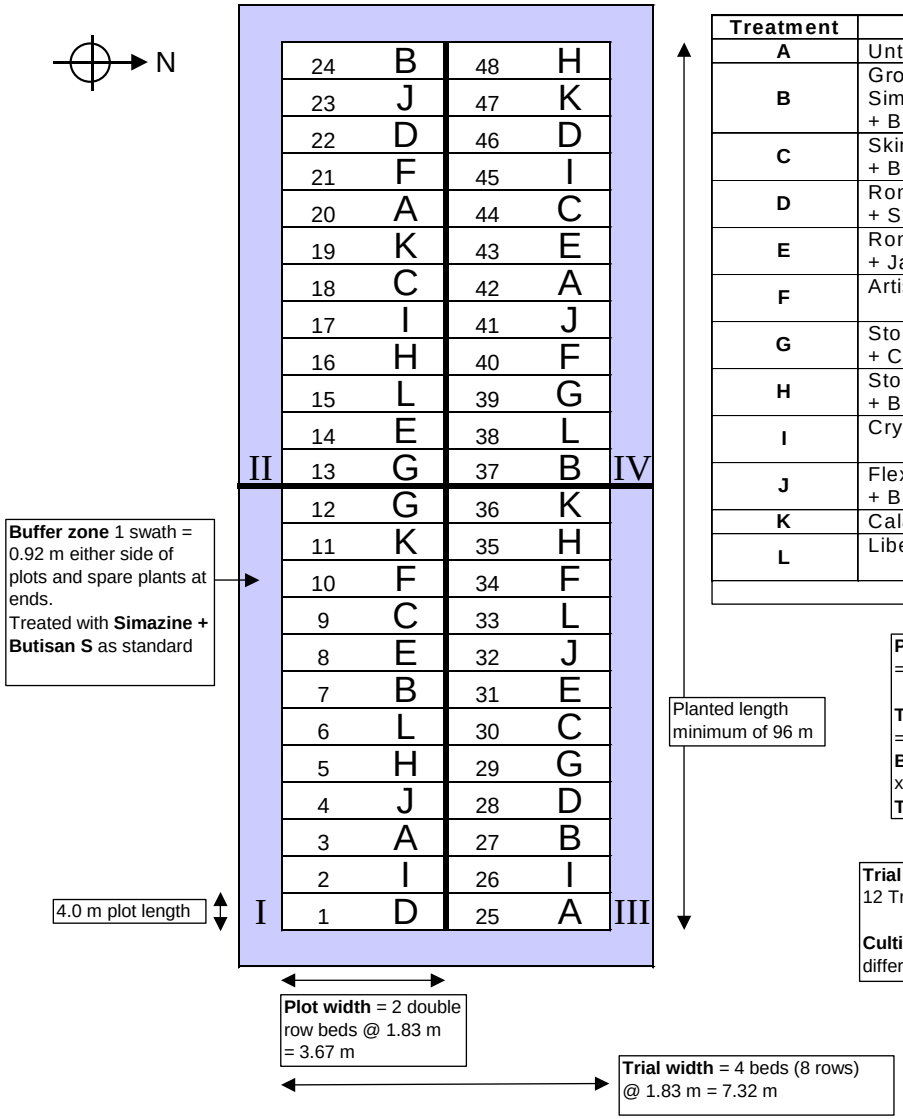
*The 5 L/ha rate is being phased out, all new pendimethalin 400 g/L products now have a maximum rate of 3.3 L/ha. This is likely to affect control of cleavers and knotgrass control, for example, where the partner product in mixtures does not control these weeds well (e.g. Butisan S + Stomp).

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

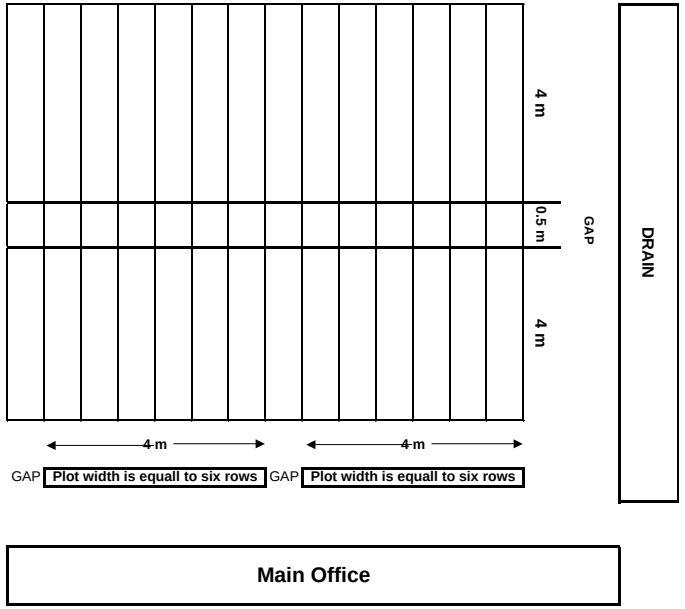
Trial 1 - Planted Spring 2005 Site 2 - Norfolk c/o Wharton's Roses

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

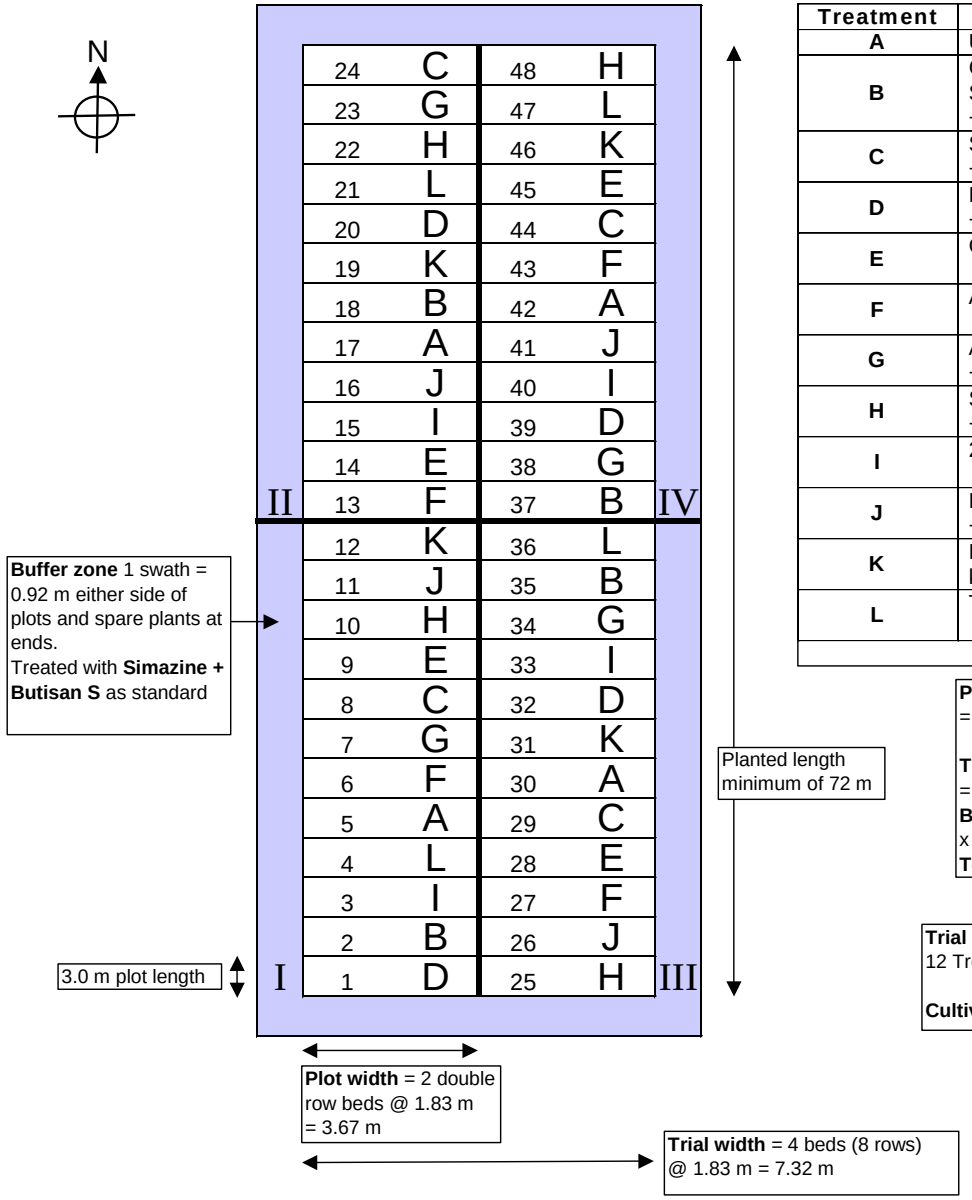
	Treatment - Post planting	Treatment - Post budding	Treatment - Heading back
A	Untreated control	**Untreated control**	**Untreated control**
B	Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha	Simazine 3.4 l/ha + Butisan 2.5 l/ha
C	Skirmish 1 l/ha + Butisan 2.5 l/ha	Skirmish 1 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



Main Office

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

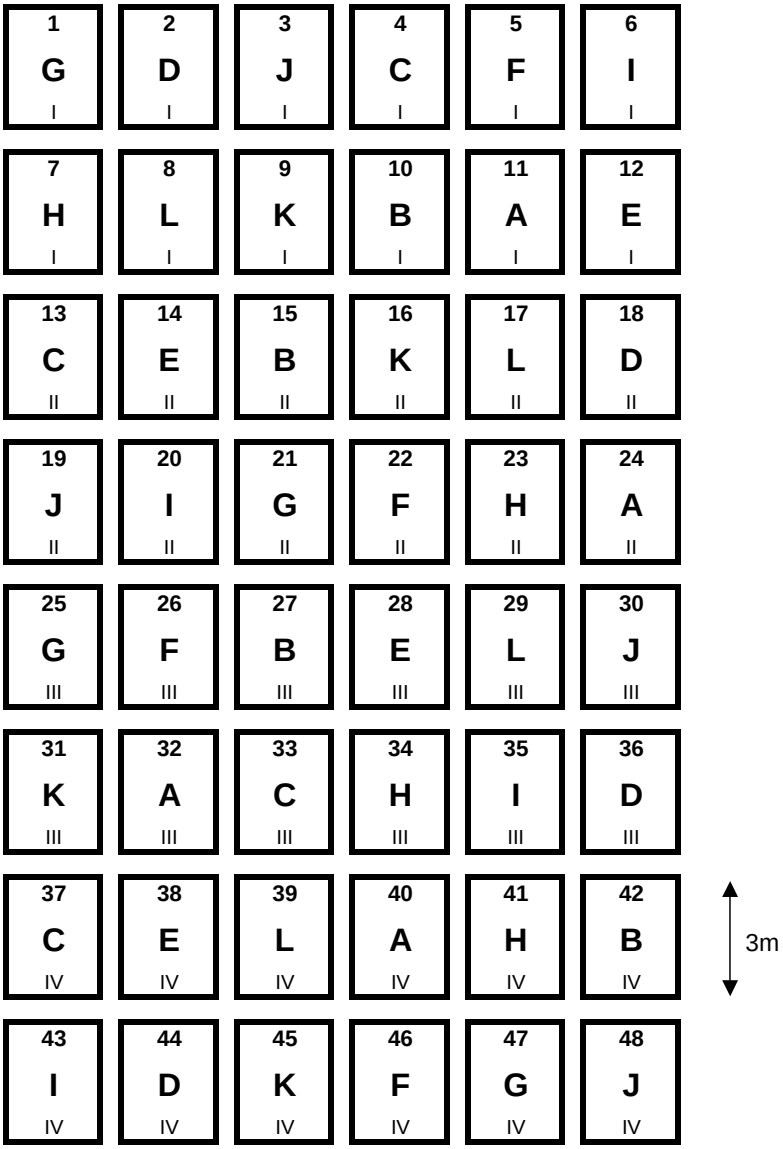
Trial area = 72 m x 7.32 m = 527 m2
Buffer zone = 160 m perimeter x 0.92 m = 147 m2
Total area = 675 **m2**.

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*
Cudweed	*Filago* spp.
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 at stage of final weed record 4 July 2006. The yellow flowering weed in the untreated plots is Hawk's beard (*Crepis spp.*).

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

Photo 3. Trial 2, Site 1. Damage from Trt K, Chikara (left) showing characteristic upcurled leaves and yellowed older leaves on rootstocks. Trt E, Goal (right) showing thinner (delayed) leaf development following severe early scorch. 15 June 2006.

Photo 4. Trial 2, Site 1. First weed assessment 15 June 2006 – most weed on untreated control plots, Trt A.

Photo 5. Trial 2 Site 2, maiden year after heading back. Temporary damage from Goal (left) and Ronstar (right) on scion growth 16 March 2007.

Photo 6. Trial 2 Site 2. Interveinal yellowing on cv. Warm Wishes on Trt K, Chikara, 22 June 2007.

Photo 7. Trial 2 Site 1. Scion growth at 1 May 2007.

Photo 8. Trial 2 Site 1. Growth of maiden crop at final weed record 12 June 2007.

Photo 9. Trial 2 Site 2. Weed at final record, 11 June 2007. Trt A Untreated (left), Trt B simazine + Butisan S (right)

Photo 10. Trial 2 Site 2. Weed at final record, 11 June 2007. Trt C Skirmish + Butisan (left), Trt E Goal (right)

Photo 11. Trial 2 Site 2. Weed at final record, 11 June 2007. Trt F Artist (left), Trt G Artist + Stomp (right).

Photo 12. Trial 2 Site 2. Weed at final record, 11 June 2007. Trt J Flexidor + Butisan S (left), Trt I SumiMax at high rate (right).

APPENDIX 4

ORIGINAL DATA - TRIAL 2
WEED RECORDS FINAL ASSESSMENT
JUNE 2007

Appendix 4 Table 1. Trial 2 Site 1 Hants, Original data 12th June 2007

Recorded 12 June 2007. Weeds per 5 m2

Plot no.	Treatment	Block	AMG	Dandelion	Thistle	Mayweed	Groundsel	Sowthistle	Knotgrass	Cleavers	Spurge	Shep purse	Nightshade	Willowherb	Redshank	Geranium	Bindweed	Can. Fleabane	Kickxia	Buttercup	Fat Hen	Cudweed	Scarlet Pimpernel	Chickweed	Fumitory
5	A	I	40	11		6	12					16		7	12						35	6	3		
17	A	II	19	8		9		30				10		9	18						24				
30	A	III	10	12	1		30	90						5	10								5	2	
42	A	IV		8		1	25			2				5							10				
2	B	I	1	4		2								3	1			1							
18	B	II		3		1	1								1			2					1		1
35	B	III		1										2											
37	B	IV		2														1							
8	C	I					1																		
24	C	II												2	3										
29	C	III	1	1		2		5		1					1			3							
44	C	IV					1								1			1							
1	D	I	3	7	16										1										
20	D	II	1				10								3										
32	D	III	1	1				1																	
39	D	IV		1				9										2							
9	E	I																							
14	E	II																							
28	E	III	1															1							
45	E	IV		4		1												1							
6	F	I		2		1	4						1								1				
13	F	II		2		2																			
27	F	III		3							1														
43	F	IV		4		1	9											1							
7	G	I																							
23	G	II				1				1		1			3				1						
34	G	III					3																		
38	G	IV		1				1																	
10	H	I		1		1				1				3											
22	H	II												1				1							
25	H	III		3		1		10						1			12								
48	H	IV		1		1								2						2					
3	I	I	2	5		2									1										
15	I	II	1	2		2																			
33	I	III	1	4																					
40	I	IV		3																					
11	J	I		1		1				5				2		1		1							
16	J	II				3		1						3	1										
26	J	III	1		1	1								4			9								
41	J	IV		5		1				2				1											
12	K	I		1														3							
19	K	II		1																					
31	K	III		1				5																	
46	K	IV		1									1												
4	L	I		4		10					2			1	4			1							
21	L	II		4		4			1				1	1	3		2	1							
36	L	III		1						1	1														
47	L	IV		2		4								1	9			1			1				

Appendix 4 Table 2. Trial 2 Site 2 Norfolk, Original data 11th June 2007

Recorded 11/06/07 % cover
xx or x indicates predominant or occasional presence.

Plot No	Treatment	Block	% Cover	Groundsel	Willowherb	Sowthistle	Mayweed	AMG	Bittercress	Speedwell	Pansy
11	A	I	100	xx	xx						
24	A	II	95	xx	x		x			x	
32	A	III	95	xx	x	x		xx			
40	A	IV	90	xx	x			xx			
10	B	I	5	xx							
15	B	II	30	xx							
27	B	III	5	xx							
42	B	IV	5	xx							
4	C	I	0								
13	C	II	0.1	x							
33	C	III	0.1	x							
37	C	IV	0.1								
2	D	I	8	xx							
18	D	II	10	xx							
36	D	III	5	xx							
44	D	IV	35	xx				x			
12	E	I	0								
14	E	II	0								
28	E	III	0								
38	E	IV	0								
5	F	I	70	xx							
22	F	II	40	xx							
26	F	III	40	xx							
46	F	IV	20	xx							
1	G	I	10	xx							
21	G	II	20	xx							
25	G	III	30	xx							
47	G	IV	0.5	xx		x					
7	H	I	25	xx							
23	H	II	20	xx							
34	H	III	20	xx	x						
41	H	IV	25	xx							
6	I	I	0								
20	I	II	5						x	xx	
35	I	III	0								
43	I	IV	0								
3	J	I	5	xx							
19	J	II	2	x						x	
30	J	III	10	xx							
48	J	IV	0.5	xx							x
9	K	I	0								
16	K	II	0								
31	K	III	2					x			
45	K	IV	0.1	x							
8	L	I	20	xx							
17	L	II	10	xx							
29	L	III	15	xx							
39	L	IV	25	xx	x						