Grower Summary

CP 086

Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise sustainable weed control strategies

Annual 2014

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Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of this report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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HDC is a division of the Agriculture and Horticulture Development Board.

Project Number:	CP 086
Project Title:	Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise sustainable weed control strategies
Project Leader:	John Atwood, ADAS UK Ltd
Contractor:	ADAS UK Ltd
Industry Representative:	Wayne Brough, HDC
Report:	Annual Report 2014
Publication Date:	16 April 2015
Previous report/(s):	Annual Report 2013
Start Date:	1 April 2011
End Date:	31 March 2016
Project Cost:	£250,000

Progress against Objectives

Objectives

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
1. To develop and mentor four staff in weed biology and control.	March 2016	in progress	
1.1 Train next generation horticulture consultants with an expertise in weed control.	March 2016	in progress	
1.2 Graduate weed biologist recruited.	June 2011	June 2011	
1.2.1 Graduate weed biologist trained and experience in horticultural weed research.	March 2016	In progress	
1.3 Recognises the most common problem weed species associated with field crops (horticulture and arable), protected crops and ornamentals.	Sept 2012	Sept 2012	
1.4 Understands the biology and current control strategies for the common weed species of a range of field crops (horticulture and arable), protected crops and ornamentals.	Sept 2012	Sept 2012	
1.5 Visited at least 10 nurseries with J Atwood or another specialist weed	March 2013	Completed, but recommend that visits should continue where	

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
control expert and discussed/reviewed control strategies for key weeds on each nursery.		thought beneficial	
1.6 BASIS qualified.	Sept 2013	Jan 2013	
1.7 Understands requirements for ORETO standard experimental work.	Sept 2013	Sept 2013	
1.8 Designed experiment and drafted experiment protocol to satisfaction of ADAS Biometrician and ORETO Study Manager.	Sept 2013	Sept 2013	
1.9 Organised and managed successful delivery of two experiments from agreed work packages.	Sept 2013	Sept 2013	
1.10 Delivered consultancy advice to growers on control on weeds of the individuals' specialist work area protected crops and ornamentals on at least five problems.	Sept 2014	In progress	
1.11 Drafted HDC Project Reports on at least two projects.	Sept 2013	Sept 2013	
1.12 Submitted to HDC or elsewhere at least three proposals on R&D topics supported by growers.	March 2014	Dec 2013	
1.13 Drafted an HDC Factsheet on biology and control of specific weed	March 2013	At present, no specific requirement - will review in future	March 2016

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
species of horticultural crops in specialist work area.			
1.14 Delivered at least three talks on weed control to nursery staff, grower groups or an HDC sponsored conference.	Sept 2014	Sept 2013	
2. Deliver applied research and KT work packages.	March 2016	In progress	
2.1.1 First pot screening for horticulture weeds set up.	Oct 2011	May 2012 (1st set) Feb 2013 (2nd set)	
2.1.2 First pot screening completed.	Aug 2012	March 2013	
2.1.3 Second pot screening for horticulture weeds set up.	Oct 2014		May 2014
2.1.4 Second pot screening completed.	Aug 2015		Aug 2014
2.2.1 First container plant screening trial set up.	Oct 2012	July 2012	
2.2.2 First container plant screening trial completed.	Sep 2013	Nov 2012	
2.2.3 Second container plant screening trial set up.	Oct 2013	June 2013	
2.2.4 Second container plant screening trial completed.	Sep 2014	Nov 2013	
2.2.5 Third container plant screening trial set up.	Oct 2015		June 2014

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
2.2.6 Third container plant screening trial completed.	Sep 2016		Nov 2014
2.3.1 First tree field herbicide trial set up.	April 2012	April 2012	
2.3.2 First tree field herbicide trial completed.	June 2013	Sept 2013	
2.3.3 Second tree field herbicide trial set up.	April 2013	Replaced with herbicide trial in stocks for cut flowers completed Sept 2013	
2.3.4 Second tree field herbicide trial completed	June 2013	Replaced with herbicide trial in stocks for cut flowers	
2.4.1 First vegetable herbicide trial set up.	May 2013	March 2013	
2.4.2 First vegetable herbicide trial completed.	Aug 2013	Sept 2013	
2.4.3 Second vegetable herbicide trial set up.	May 2014		
2.4.4 Second vegetable herbicide trial completed.	Aug 2014		
2.4.5 Third vegetable herbicide trial set up.	May 2015		
2.4.6 Third vegetable herbicide trial completed.	Aug 2015		
2.5.1 Top fruit herbicide trial set up.	April 2015		
2.5.2 Top fruit herbicide trial completed.	Sept 2015		
2.6.1 Ground cover	April 2013	In progress (initial	

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
trial set up.		trial run in 2012)	
2.6.2 Ground cover trial completed.	Aug 2015		
2.7.1 Perennial weed trial set up.	March 2013	Delayed due to late spring	April 2013
2.7.2 Perennial weed trial completed.	Sept 2015		
3. Set up a working group within the European Weed Research Society.	March 2012	Not fully functional yet	March 2016

Summary of Progress

A training programme has continued in 2013 with both general ADAS courses and more specific technical training. As the trainees have gained experience and are all now BASIS qualified, training has switched to some extent from more formal training events to individual coaching on specific aspects of the job. For the trainees based at Boxworth there continues to be the opportunity to gain further experience by working on a wide range of weed control projects not just those specifically planned through the fellowship. With increasing experience and confidence the trainees have been able to plan and run weed control experiments, present results at events across all sectors and, more recently, develop project proposals outside of the weeds fellowship.

Jessica Sparkes has been on maternity leave since August 2013 but intends to return during the latter half of 2014. Maria Tzortzi was been promoted from scientific officer to replace Jessica initially on a temporary basis. She has participated fully in the fellowship training activities and experiments and her appointment as weed researcher has now been made permanent.

The nursery stock experiments for 2013 were successfully planned and written up by David Talbot in the West Midlands. The second container nursery experiment (Objective 2.2) was concluded in November 2013 as was the budded tree herbicide experiment (Objective 2.3). A follow up container nursery experiment is being planned by David Talbot for 2014, further developing some treatments first tested in 2013 and introducing new experimental compounds.

Possible species to be grown as living mulches with potential for use within the crop rows of bush and top fruit were examined for growth parameters and nitrogen balance (Objective 2.6) in pot experiments by Jessica Sparkes, Maria Tzortzi and Harriet Roberts in 2013. Field sowings were made in an apple plantation at a commercial top fruit holding in autumn 2013. This work will be continued in 2014 with growth studies, water and nitrogen usage and apple yields.

Following liaison with the industry, Angela Huckle ran a programme of herbicide trials for improved control of groundsel in salad leaf rocket (Objective 2.4) during 2013. These trials were based on growers' holdings. Further work on salad crops is planned for 2014 with both herbicide screening and weed reducing green manure treatments.

At the request of the cut flower industry, an additional project was included in the programme of work for 2013. Angela Huckle managed an herbicide trial on stocks for cut flowers at the Cut Flower Centre (CFC) Spalding in liaison with CFC manager Lyndon Mason. This trial was be run instead of a second field tree herbicide trial, as it was thought that sufficient information was gained from the first tree trial which covered two seasons. Further herbicide screening work on cut flowers will be managed by Angela Huckle outside the fellowship project.

The control of perennial weeds is being covered by several experiments investigating different aspects. An experiment investigating control of perennial weeds (Objective 2.7) by the allelopathic effects of cover crops started in 2013, managed by Jessica Sparkes and Maria Tzortzi and follows a research area initially developed by Lynn Tatnell. It is hoped to develop this further in 2014 with field trials but will be dependent on finding a suitable site. An herbicide screening on perennial thistle control in peony for cut flowers was carried out during 2013. Further work on perennial control includes a fallow year herbicide trial started in autumn 2013 and a literature review on non-chemical methods for perennial weed control is being undertaken in 2014.

Liaison with researchers in other European countries is proceeding (Objective 3.0). Lynn Tatnell presented posters on cover crops and herbicide resistance, respectively, at a European Weed Research Society Symposium in Turkey in June 2013.

Initially through contacts made at the minor crops working group Brussels March 2012, John Atwood has made contact with researchers in the Netherlands and Germany and set up a SharePoint web site to share outline details of current

research projects. Currently we have access to horticultural research reports from Germany (some can be accessed at http://www.hortigate.de) and these have proved useful in developing treatments for the salad leaf rocket experiments. Further contacts were made during 2013 through meetings with Peter Hartvig Aarhus University, Denmark, and Heinrich Loesing LWK Schleswig-Holstein, Germany.

European contacts

The Netherlands

Wageningen University and Research Centre, Wageningen Campus, Droevendaalsesteeg 4, 6708 PB Wageningen, Netherlands

Ornamentals: Fons van Kuik

Vegetables: Rommie van der Weide, Marleene Riemens

Fruit: Bart Heijne

General (Principal contact): Corne Kempenaar

Germany

Dienstleistungszentrum Ländlicher Raum - Rheinpfalz -(DLR), Berufsbildende Schule für Wein- und Gartenbau, Breitenweg 71, 67435 Neustadt/Weinstrasse (Germany)

Vegetables (Principal contact): Ingeborg Koch

Fruits: Michael Glas

Vines: Friedrich Louis

Ornamentals: Bernd Böhmer

LWK Schleswig-Holstein, Aussenstelle, Baumschulberatung, 25421 Pinneberg, Germany

Ornamentals: Heinrich Loesing

Denmark

Aarhus University, Department of Agroeconomy- Crop Health, Forsogsvej 1, 4200 Slaelse, Denmark

All crops: Peter Hartvig

Eire

Tillage Crops KT and Horticulture Development

Teagasc Kildalton College, Piltown, Co Kilkenny

Ornamentals and foliage: Andy Whelton

USA

North Carolina State University, Raleigh, 27695, North Carolina

Ornamentals: Joe Neal

Contacts from France are being sought. The most active interest so far has come from researchers in the Netherlands and Germany. Good links also exist with researchers in Eire and the US working on ornamentals and foliage crops.

Milestones not being reached

The working group of European weed control researchers was not set up by March 2012 as planned. The timing of this target was too optimistic but progress is being made in building links with researchers from the Netherlands, Denmark and Germany. It is planned to continue building links with researchers in continental Europe through the life of the project by attendance at EWRS workshops and informal contacts, so a revised target of March 2016 is proposed.

Do remaining milestones look realistic?

1.10. Consultancy advice. This should be broadened beyond protected crops and ornamentals.

1.13. Drafting HDC factsheets. This will depend on HDC requirements. Nothing is planned at present, but there are possible gaps that could be filled such as weed control in cut flowers.

2.3.3. Second field tree herbicide trial. This experiment was replaced with an herbicide trial on column stocks grown for cut flowers at the request of the industry.

Training undertaken

During the year the four fellowship trainees undertook a range of training activities and "on-the-job" work experience in the field of weed control research and consultancy. Activities included formal training courses, internal seminars, attendance at conferences and field visits with experienced consultants. The trainees' training activities are listed in Appendix 1.

Expertise gained by trainees

In addition to the formal non-technical ADAS training programme, the trainees have gained practical experience of drafting protocols to the ADAS standard, setting up and managing experiments and drafting experimental reports. The main experience gained during the three years of the fellowship is summarised below:

Jessica Sparkes

- Improved background knowledge of UK agriculture and horticulture
- Experience in weed resistance testing
- Seedling weed identification
- Providing consultancy advice
- Research on non-chemical weed control methods
- Gained BASIS qualification for Horticulture
- Delivered a weed control presentation at a grower meeting (HDC Narcissus technical seminar, Cornwall)

Harriet Roberts

- Technical writing improved
- Experience in contract management, protocol development, managing herbicide trials and drafting reports
- Experience in new project development, drafting proposals and presentation of concepts
- Weed seedling identification
- Trained in aspects of herbicide advice in fruit and nursery stock crops
- Gained BASIS qualification for Horticulture
- Presented fruit weed control research results at SCEPTRE project management meeting
- Presented weed control research results at HDC hardy ornamentals panel meeting
- Presented weed control research results at amenity forum meeting, Lancaster

Angela Huckle

- Networking with European researchers
- Staff management and quality systems
- Gave seminar to staff following visit to EWRS workshop in Spain
- Trained in weed control in nursery stock and fruit
- Gained BASIS qualification for Horticulture
- Developed experiment protocols for vegetable weed control projects in consultation with industry leading producer

David Talbot

- Confident and skilled in giving “on-nursery” advice on weed control programmes in nursery stock and protected ornamentals
- Gaining experience in ADAS quality management systems when running “off-site” experiments
- Consolidated existing skill in identification of seedling weeds

Other achievements in the last year not originally in the objectives

Harriet Roberts has taken the lead in drafting protocols, setting up experiments and drafting reports under John Atwood’s supervision for several important weed control projects outside of the fellowship including SCEPTRE projects on perennial weed control in bush and cane fruit. She has developed new herbicide proposals for the HDC soft panel including the use of Shark (carfentrazone-ethyl) as a winter treatment for strawberries. These proposals were well received and are being funded.

Jessica Sparkes, guided by Lynn Tatnell has undertaken a comprehensive economic review of electrical weed control methods for CRD. She has also worked with ADAS colleagues running a commercial programme of screening for herbicide resistance in grass weeds such as black-grass.

Changes to project

Are the current objectives still appropriate for the Fellowship?

Broadly speaking the current objectives remain appropriate for the fellowship but some adjustments to the timing of the milestones have been requested.

Grower Summary - Objective 2.2 – Second container plant screening trial

Headline

- HDC H18 proved safe to the majority of crop species tested and will be taken forward for further crop safety assessments and detailed weed control spectrum testing.
- Wing-P was promising in terms of safety to the crop species tested but subsequently proved too difficult to gain an authorisation for use over crop foliage, an EAMU for pre-emergence use remains available.

Background

Weed control in container-grown nursery stock continues to rely on an increasingly limited range of active ingredients following the loss of key active ingredients in recent years. The loss of Ronstar 2G (oxadiazon) which has a final use date of 30 June 2015 has serious implications for the UK horticultural industry.

The focus of this project was to find alternative herbicides that would be safe to apply over foliage immediately after potting and to follow up with later in the summer. At present the main herbicide for this period is Flexidor 125 (isoxaben). Hitherto Flexidor 125 has been used as a supplementary treatment to follow up Ronstar 2G, however it will now be the main treatment. The problems with relying on Flexidor 125 are however:

Some shrub species and even more herbaceous species are sensitive to it.

Groundsel, willowherb, moss and liverwort are not controlled.

Only two applications per year are permitted and in any case reliance on one herbicide will lead to resistance problems.

The main objective of the trial was to assess the crop safety of two new herbicides: Wing-P (pendimethalin + dimethenamid) and HDC H18 (experimental product) to a range of container-grown nursery stock species.

Summary

A weed control trial was carried out on container-grown nursery stock at Wyevale Container Plants, Hereford. The main objective of the trial was to assess the crop safety of two new herbicides: Wing-P (pendimethalin + dimethenamid) alone, and in mixtures with Flexidor 125 (isoxaben) in order to broaden the weed control spectrum, and HDC H18 (experimental product) to a range of container-grown nursery stock

species. A commercial standard treatment; Flexidor 125 was included for comparison. Wing-P was included in the trial carried out in 2012 and appeared to be relatively safe so was included again in 2013, to broaden the knowledge of the products' performance on different plant species. The Wing-P treatment proved to be more damaging on the species tested in 2013 than those tested in 2012. In 2013 damage was still evident on *Buddleja, Hydrangea* and *Perovskia* 12 weeks after treatment. Mixing Wing-P with Flexidor 125 resulted in similar levels of damage with *Buddleja* and *Perovskia,* in addition damage was noted on *Spiraea* 12 weeks after treatment. HDC H18 initially proved to be more damaging than Flexidor 125, however most species recovered; with the exception of *Buddleja* and *Perovskia* where damage was still visible 12 weeks after treatment. If authorisation can be obtained, HDC H18 has potential for use on a range of hardy nursery stock species. Unfortunately, subsequent to these experiments it proved too difficult to obtain an authorisation for the use of Wing-P over the crop at a rate high enough to be effective; the existing Extension of Authorisation for Minor Use (EAMU 0253/13) for Wing–P in outdoor ornamental plant production limits use to seed-grown and bulb crops, as the product has to be applied prior to crop emergence, this EAMU also prohibits application via hand held equipment.

Phytotoxicity was recorded on a 0–9 Scale with 0 representing plant death, 9 being comparable with controls and 7 being commercially acceptable damage. Table 2.2.1 lists the treatments and approval status and Table 2.2.2 summarises phytotoxicity scores 12 weeks after treatment.

Table 2.2.1. Approval status of herbicides used in the container HNS experiment

Treat no.	Product name	Active ingredient	Rate (L/ha or kg/ha)	Approval status
1	Untreated			
2	Flexidor 125	Isoxaben (125 g/L)	1.0 L/ha	Label
3	Wing P	Pendimethalin (250g/L) + dimethenamid – p (212.5 g/L)	4.0 L/ha	Not approved
4	Wing P + Flexidor 125	Pendimethalin (250g/L) + dimethenamid – p (212.5 g/L) isoxaben (125 g/L)	4.0 L/ha 1.0 L/ha	Not approved + Label
5	HDC H18	Confidential		Not approved

Table 2.2.2. Mean phytotoxicity scores (9 = similar to untreated, 7 = acceptable slight damage, 0 = plant death) 12 weeks after treatment

Treatment Number	Scores											
	Buddleja	***Ceratostigma***	***Cistus***	***Cornus***	***Escallonia***	***Hebe***	***Hydrangea***	***Perovskia***	***Physocarpus***	***Santolina***	***Sorbaria***	***Spiraea***
1	9	9	9	9	9	9	9	9	9	9	9	9
2	7	9	9	9	9	9	9	7	9	9	9	8.50
3	7	9	9	9	9	9	7.50	6	9	9	9	8.75
4	7	9	9	9	9	9	7.75	6.50	9	9	9	7.50
5	6.50	9	9	9	9	9	8.75	7	9	9	9	8.25
F pr.	<.001	-	-	-	-	-	<.001	<.001	-	-	-	0.045
l.s.d (19 d.f)	0.398	0.000	0.000	0.000	0.000	0.000	0.703	0.398	0.000	0.000	0.000	0.964

Financial benefits

There are no financial benefits as yet from this experiment. If it is possible to obtain authorisation for use of HDC H18 on container-grown nursery stock then it is likely that hand weeding costs of up to £43,000 per hectare (based on three rounds of hand weeding) will be saved. The likely cost of the herbicide is not known, but it will be significantly less than any hand weeding costs.

Action points

- If HDC H18 becomes available it will be a useful treatment for post-potting summer treatment of hardy nursery stock species.
- *Buddleja* and *Perovskia* are sensitive to HDC H18 and should not be treated when or if the product becomes commercially available.

Grower Summary - Objective 2.3 - Tree field herbicide trial

Headline

- HDC H30 was the best weed control treatment when used in addition to the nursery standard herbicide programme, but caused some stunting to rootstocks especially *Malus* in the unusually wet growing season of 2012.

Background

Weed control programmes in field-grown nursery stock have relied upon a limited number of active ingredients for a number of years. The gradual withdrawal of the Long Term Arrangements for Extension of Use (LTAEU) has also impacted upon the herbicides that HNS growers are able to utilise.

During 2013 it was announced that the authorisation for Ronstar Liquid (oxadiazon) would be withdrawn, with use up of existing stocks allowed until June 2015. The loss of Ronstar Liquid will further reduce weed control options in field-grown production. Although relatively expensive, Ronstar Liquid is a reliable herbicide used both in the field and around nurseries on container beds (before standing down). A number of alternatives which could potentially be used in field-grown stock were selected for testing in this herbicide screening.

Summary

The trial commenced in 2012 investigating weed control on field-grown *Malus, Prunus, Quince* and *Sorbus* at Frank P Matthews Ltd, Tenbury Wells, with treatments applied after planting in April 2012 and again after heading back in March 2013. Nine herbicide treatments were assessed, seven of which were novel treatments. All March 2012 treatments were applied after planting in addition to a standard programme of Devrinol (napropamide) + Flexidor 125 (isoxaben), and also applied post-heading back the following spring to dormant budded trees added to the nursery standard treatment of Flexidor 125 (isoxaben) + Stomp Aqua (pendimethalin). The treatment programmes are summarised in Table 2.3.1.

When recorded 12 weeks after treatment in 2013 the standard treatment had weed cover of 13.2%, with predominant weeds groundsel *(Senecio vulgaris),* white clover *(Trifolium repens)* and common chickweed *(Stellaria media).* The best additional treatments for weed control were HDC H30, Ronstar Liquid (oxadiazon) and Gamit 36 CS (clomazone) with 0.8%, 1% and 7% weed cover respectively. Only HDC H30 and Ronstar Liquid persisted sufficiently to give improved weed control by 16 weeks after treatment. It is now known that the authorisation for the use of Ronstar Liquid will cease from 30 June 2015. No stunting

was noted on any species treated with HDC H30 during 2013; it is thought that the excessive summer rainfall washed this herbicide into the crops rooting zone in 2012 and root uptake occurred resulting in some stunting. No carry over effect was noted in the maiden year 2013.

Phytotoxicity was recorded on a 0–9 Scale with 0 representing plant death, 7 commercially acceptable damage and 9 being comparable with controls, however, no phytotoxicity symptoms were noted in the trial. Table 2.3.2 lists treatments and their approval status and Table 2.3.3 summarises percentage weed cover.

Table 2.3.1. Treatment programmes used in the field tree herbicide experiments

Treat no	**After planting**	**After heading back**
1	Devrinol + Flexidor 125	Stomp Aqua + Flexidor 125
2	Devrinol + Stomp Aqua + Flexidor 125	Devrinol + Stomp Aqua + Flexidor 125
3	Ronstar Liquid + Devrinol + Flexidor 125	Ronstar Liquid + Stomp Aqua + Flexidor 125
4	HDC H30 + Devrinol + Flexidor 125	HDC H30 + Stomp Aqua + Flexidor 125
5	Gamit 36 CS + Devrinol + Flexidor 125	Gamit 36 CS + Stomp Aqua + Flexidor 125
6	HDC H13 + Devrinol + Flexidor 125	HDC H13 + Stomp Aqua + Flexidor 125
7	HDC H14 + Devrinol + Flexidor 125	HDC H14 + Stomp Aqua + Flexidor 125
8	HDC H15 + Devrinol + Flexidor 125	HDC H15 + Stomp Aqua + Flexidor 125
9	HDC H28 + Devrinol + Flexidor 125	HDC H28 + Stomp Aqua + Flexidor 125
10	Wing P + Devrinol + Flexidor 125	Wing P + Stomp Aqua + Flexidor 125

Table 2.3.2. Approval status of herbicides used in the field tree herbicide experiments

Product name	Active ingredient	Rate (L/ha or kg/ha)	Approval Status
Stomp Aqua	Pendimethalin	2.9 L/ha	EAMU
Flexidor 125	Isoxaben	2.0 L/ha	Label
Devrinol	Napropamide (450 g/L)	9.0 L/ha	Label
Ronstar Liquid	Oxadiazon (250 g/L)	4.0 L/ha	Label
HDC H30	Confidential		Not approved
Gamit 36 CS	Clomazone (360 g/L)	0.25 L/ha	LTAEU
HDC H13	Confidential		Not approved
HDC H14	Confidential		Not approved
HDC H15	Confidential		Not approved
HDC H28	Confidential		Not approved
Wing P	Dimethenamid-p + pendimethalin (212.5:250g/L)	4.0 L/ha	Not approved

Table 2.3.3. Mean percentage weed cover 4, 8, 12 & 16 weeks after treatment (WAT)

Treatment	Percentage weed cover 4 WAT	Percentage weed cover 8 WAT	Percentage weed cover 12 WAT	Percentage weed cover 16 WAT
1	0.25	1.0	13.2	79.2
2	1.0	1.0	23.5	86.2
3	0.0	0.50	1.0	5.5
4	0.25	0.50	0.8	2.8
5	0.50	1.0	7.0	68.8
6	0.25	1.0	9.2	50
7	0.75	1.0	10	55
8	0.50	1.0	16	85
9	0.50	1.0	8.2	65
10	0.25	1.0	9.8	54.5
F pr.	ns	0.023	0.027	<.001
l.s.d (39 d.f)	0.784	0.375	12.14	23.17

Financial benefits

There are no financial benefits from the results regarding HDC H30 because the product has yet to get approval for use on nursery stock. The additional use of Gamit 36 CS however has the potential to improve weed control with standard herbicide programmes giving additional control of groundsel, willowherb and cleavers which can be costly to remove by hand weeding/machine or by directed contact herbicide applications.

Action points

- If HDC H30 gains authorisation for use on outdoor nursery stock it could be a valuable additional treatment to include in an herbicide programme but care should be taken with *Malus* as leaching under exceptional rainfall conditions at the trial site caused significant stunting in 2012.
- Gamit 36 CS could be readily developed as an addition to the tank mix of standard herbicides such as Stomp Aqua + Flexidor 125 to add control of groundsel, willowherb and cleavers.

Grower Summary - Objective 2.4 - Vegetable herbicide trial: rocket

Headline

- Devrinol (napropamide) was confirmed as a crop safe treatment when incorporated pre-drilling or irrigated in post-drilling.
- A low rate of Goltix Flowable (metamitron) improved control of groundsel when added as a tank mix to the Devrinol incorporation treatment. It was crop safe at one site but reduced emergence by around 10 or 20% at a second site depending on whether primed or un-primed seed was used.
- A range of alternative herbicides were tested but none proved crop safe even where primed seed was used.

Background

The control of weeds in short season baby leaf salad crops can be difficult, especially in crops such as wild rocket which are sensitive to a number of commercially available herbicides. Crop rotations and soil sterilants such as dazomet (Basamid) are used to reduce the weed spectrum before drilling a crop of wild rocket. However, a number of weeds can still be problematic, including groundsel which is a particular problem as, due to its similar appearance to rocket, it can be missed during hand weeding leading to contamination and rejections by retailers. Hand weeding is also expensive (c. £150/ha) and with the threat of the possible loss of soil sterilants in the future, alternative herbicides for use in wild rocket are needed. The aim of the trial was to test alternatives to the current standard Devrinol, for crop safety and efficacy.

Summary

The main objective of the trial was to assess the crop safety of a range of new herbicides to be used alone or as an addition to the standard Devrinol treatment to improve control of groundsel in drilled wild rocket grown for salad leaf. Supplementary objectives were to see if the use of primed seed would enable more aggressive herbicide treatments to be used safely and to examine the efficacy and crop safety of different methods applying the standard Devrinol treatment.

Table 2.4.1. Approval status of herbicides used in the wild rocket experiments

Product name	Active ingredient	Rate (L/ha or kg/ha)	Approval Status
Devrinol	napropamide (450 g/L)	0.85 L/ha	EAMU
Dow Shield 400	clopyralid (400 g/L)	0.25 L/ha	EAMU
Goltix Flowable	metamitron (700 g/L)	1.0 L/ha	EAMU
Dual Gold	s-metolachlor (960 g/L)	1.4 L/ha	EAMU
Butisan S	metazachlor (500 g/L)	1.5 L/ha	Not approved
Wing-P	dimethenamid-p + pendimethalin (212.5:250g/L)	1.25 L/ha	Not approved

Site 1–Kent

The experiment was carried out on a commercial field crop in Kent, between June and July 2013. The variety 'Napoli' was used, and was drilled into non–sterilised soil containing four major weeds; common fumitory *(Fumaria officinalis)*, volunteer oil seed rape (*Brassica napus* ssp. *Oleifera)*, annual mercury *(Mercurialis annua)* and black bindweed *(Fallopia convolvulus)*. There were two trials situated side by side, one using non-primed seed, and the other using primed seed. Eight main treatments (including an untreated control) using six different pre-emergence applications of herbicides were tested and, as sub treatments, the effect of Dow Shield (clopyralid) was tested post-emergence with each pre-emergence herbicide treatment (for a complete treatment list see the Science Section of the report). Pre–drilling treatments were applied on 3 June and the trial was drilled immediately after treatment. Post-drilling treatments were also applied on the same day. Post-emergence treatments were applied on 25 June.

Phytotoxicity was first assessed in the crop on 25 June, 3 weeks after the pre and post drilling treatments. Levels of damage varied, with the most severe effects seen in Dual Gold, Butisan S and Wing-P plots (Figure 2.4.1). A final phytotoxicity assessment was carried out on 9 July, just prior to harvest.

Plots were also assessed for percentage of crop emergence, and percentage weed cover. Crop emergence was significantly reduced in plots treated with Dual Gold, Butisan S and Wing-P, and percentage weed cover also increased in these treatments, likely due to the reduced competition by the crop. Weed species included common fumitory *(Fumaria officinalis)*, volunteer oil seed rape (*Brassica napus* ssp. *Oleifera)*, annual mercury *(Mercurialis annua)*, black bindweed *(Fallopia convolvulus)* and fathen (*Chenopodium album*).

Results (Figure 2.4.2) indicate that Devrinol is the most crop safe treatment, and although weed germination was not fully controlled, the area covered by weeds was reduced. At this site, the addition of Goltix Flowable as a tank mix to the Devrinol treatment did not significantly affect emergence.

Figure 2.4.1. Plots treated with Dual Gold, Butisan S and Wing P can be clearly picked out due to the phytotoxic effect of these herbicides on the crop – 2013 (Site 1, Kent)

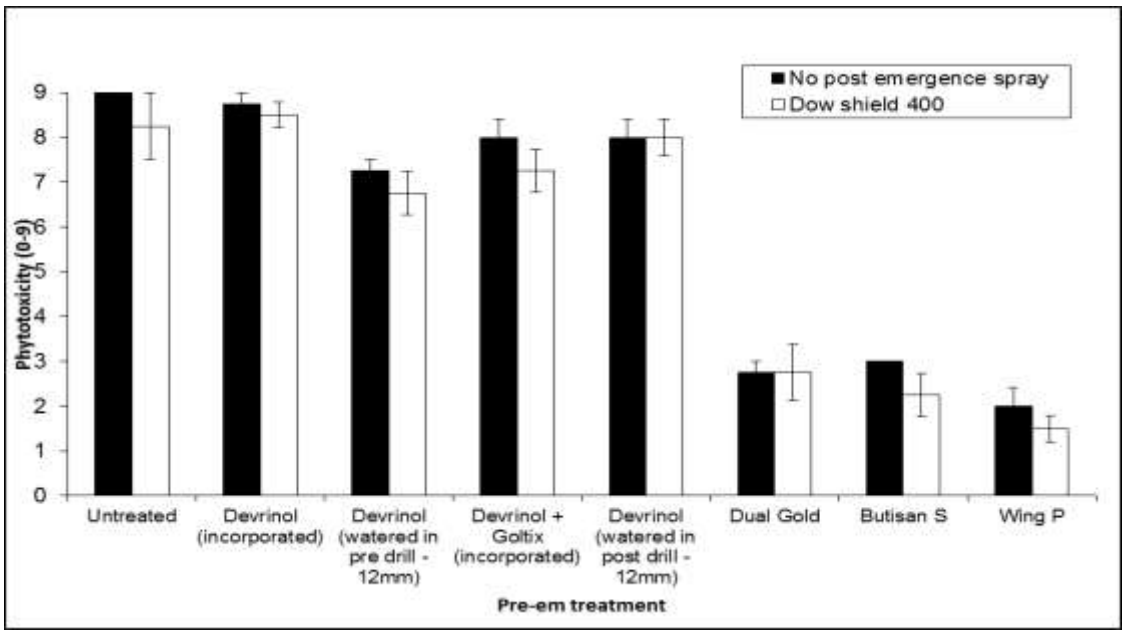

Figure 2.4.2. Phytotoxicity scores on non-primed seed – 2013 (Site 1, Kent). Error bars indicate standard errors. Treatments on the x axis show the pre-emergence applications (either pre drilling or post). White bars show plots which received Dow shield 400 as a post-emergence spray on top of the pre-emergence applications

Primed seed lead to a slight reduction in phytotoxicity, but did not decrease the damage to a point where the crop would become commercially acceptable in the most severely affected treatments.

Incorporation into the soil pre–drilling was the most crop safe method on non-primed seed. Also, Devrinol watered in post-drilling, as per current commercial practice, showed less phytotoxicity than Devrinol watered in pre-drilling, on non-primed seed. There was little difference between the Devrinol treatment application methods for primed seed at this site.

When Devrinol was tank-mixed with Goltix and incorporated pre-drilling this combination caused some very slight phytotoxic and crop emergence effects, but were of an acceptable commercial standard, therefore there is a possibility that this combination could potentially be crop safe at lower rates of Goltix.

Site 2 – Wiltshire

The experiment was carried out on a commercial field crop in Wiltshire, between May and June 2013. The variety 'Napoli' was used, and was drilled into soil sterilised with Basamid (dazomet). The two trials were situated side by side, one using non–primed seed, and the other using primed seed. Seven main treatments (including an untreated control) using five different pre-emergence applications of herbicides were tested and, as sub treatments, the effect of Dow Shield was tested post-emergence with each pre-emergence herbicide treatment. Pre–drilling treatments were applied on 7 May and the trial was drilled immediately after. Post-drilling treatments were then applied on 8 May. Post-emergence treatments were applied on 7 June.

Phytotoxicity was first assessed in the crop on 7 June, four weeks after the pre- and post-drilling treatment. Levels of damage varied, with the most severe effects seen for Dual Gold, Butisan S and Wing-P. A final phytotoxicity assessment was carried out on 20 June, just prior to harvest.

The trial was also assessed for percentage of crop emergence, and percentage weed cover. Emergence was significantly reduced by Dual Gold, Butisan S and Wing-P, and percentage weed cover increased in the Butisan S treatment as a result of poor crop cover. There was a wide variety of weed species on this site including knotgrass (*Acronicta rumicis*), groundsel (*Senecio vulgaris)*, field pansy (*Viola arvensis*) and spear thistle (*Cirsium vulgare*). Results (Figure 2.4.3) indicate that Devrinol was the most crop safe treatment, and although weed germination was not fully controlled, percentage weed area cover was reduced.

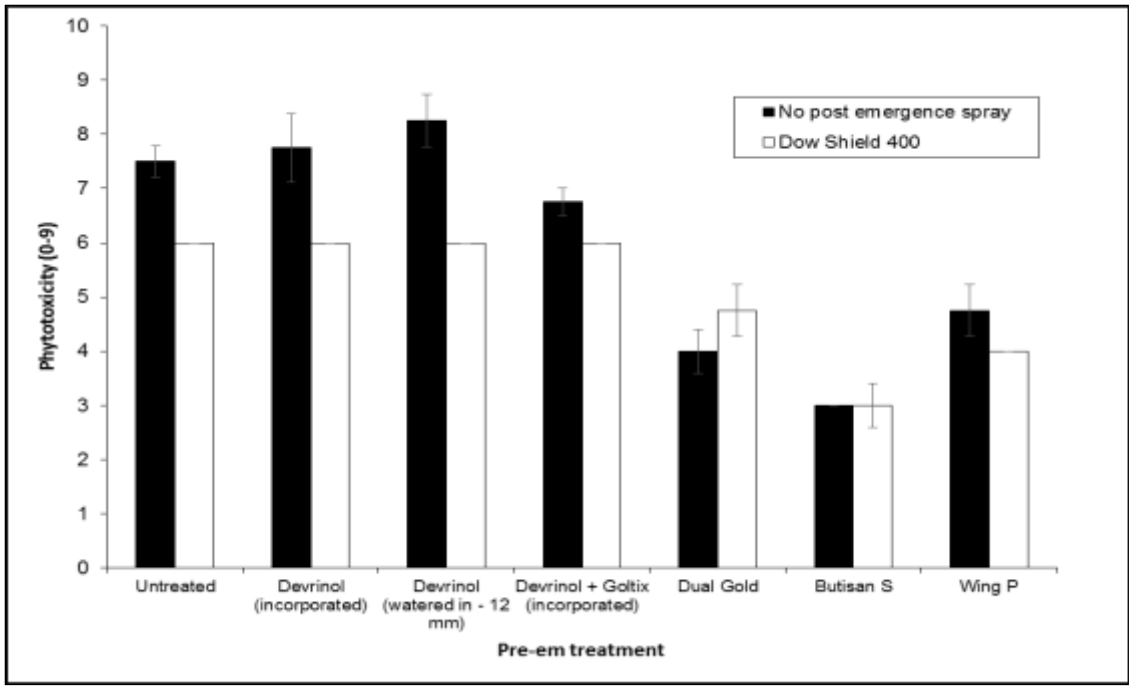

Figure 2.4.3. Phytotoxicity scores on non-primed seed – 2013 (Site 2, Wiltshire). Treatments on the x axis show the pre emergence applications (either pre-drilling or post). White bars show plots which received Dow shield 400 as a post-emergence spray on top of the pre-emergence applications

Where Devrinol incorporated and Devrinol watered in pre–drilling were used the primed seed showed the highest percentage of crop emergence. The use of primed seed also increased the percentage emergence in the plots treated pre-emergence with Dual Gold, Butisan S and Wing-P, compared with non-primed but emergence was still significantly supressed compared with the untreated. Unlike the Kent site in Wiltshire, the addition of Goltix to the Devrinol treatment did not appear as crop safe with a reduction of 20% emergence in the non-primed, but with the use of primed seed the reduction in emergence was only around 10%.

Financial benefits

Devrinol was confirmed as being the most suitable herbicide for use in wild rocket production. The addition of a low rate of Goltix Flowable as a tank mix with the treatment has the potential to improve control of groundsel and reduce hand weeding costs and the risk of crop rejection.

Action points

The current commercial standard, Devrinol is still the most crop safe treatment used in the trials, either incorporated into the soil pre–drilling, or watered in post-drilling.

Goltix Flowable has the potential to improve control of groundsel when used as a tank mix with Devrinol. At 1 L/ha it slightly reduced the percentage crop emergence at one site but the effect was minimal where primed seed was used.

Dual Gold, Butisan S and Wing-P are not crop safe to use on wild rocket.

Dow Shield 400 is slightly phytotoxic to wild rocket, and no appreciable benefits were seen in reduction of weed cover when compared to treatments that did not receive a post-emergence spray.

Grower Summary - Objective 2.6 - Ground cover trial: living mulches

Headline

- Creeping red fescue alone and as a mixture with birdsfoot trefoil were the most suppressive for both perennial and annual weeds.
- Other living mulch species efficiently suppressed the annual weeds but were less effective on perennial weeds, however most reduced levels compared with the untreated control.

Background

The main objective of the trial was to investigate the suitability of a range of living mulch species for weed control within the rows of top fruit and blackcurrants by evaluating the growth rate of the mulch, and the soil nitrogen level following one growing season.

Summary

A container trial was carried out at ADAS Boxworth to investigate the suitability of a range of living mulch species for weed control in top fruit and blackcurrants. The trial was separated in two parts: (1) Living mulches being sown in two different sowing densities alone with no weeds and the ground cover of each living much species assessed (2). The same living mulch species as part one plus two weed types, annuals and perennials (sown separately from each other). The annual species were chickweed, groundsel and mayweed and the perennials were broad-leaved dock and common couch. The information presented in Tables 2.6.1 and 2.6.2, sets out the treatments and species used for each part of the trial.

Table 2.6.1. Treatment list part 1

Treatment	Common name	Scientific name	Sowing density (g/m²)	Seeds per container (g)
1	White clover	*Trifolium repens*	0.70	0.50
2	White clover	*Trifolium repens*	1.40	1.00
3	Black medic	*Medicago lupulina*	0.80	0.60
4	Black medic	*Medicago lupulina*	1.60	1.20
5	Creeping red fescue	*Festuca rubra*	3.75	2.70
6	Creeping red fescue	*Festuca rubra*	7.50	5.40
7	Birdsfoot trefoil	*Lotus corniculatus*	0.70	0.50
8	Birdsfoot trefoil	*Lotus corniculatus*	1.40	1.00
9	Creeping red fescue + birdsfoot trefoil	*Festuca rubra* + *Lotus corniculatus*	3.75 + 0.70	2.70 + 0.50
10	Creeping red fescue + birdsfoot trefoil	*Festuca rubra* + *Lotus corniculatus*	7.50 +1.40	5.40 + 1.00
11	Untreated	-	-	

Table 2.6.2. Treatment list part 2

Treatment	Common name	Sowing density (g/m^2)	Weed type
1	White clover	0.70	Annuals
2	White clover	1.40	Annuals
3	Black medic	0.80	Annuals
4	Black medic	1.60	Annuals
5	Creeping red fescue	3.75	Annuals
6	Creeping red fescue	7.50	Annuals
7	Birdsfoot trefoil	0.70	Annuals
8	Birdsfoot trefoil	1.40	Annuals
9	Creeping red fescue + birdsfoot trefoil	3.75 + 0.70	Annuals
10	Creeping red fescue + birdsfoot trefoil	7.50+1.40	Annuals
11	Untreated	-	Annuals
12	White clover	0.70	Perennials
13	White clover	1.40	Perennials
14	Black medic	0.80	Perennials
15	Black medic	1.60	Perennials
16	Creeping red fescue	3.75	Perennials
17	Creeping red fescue	7.50	Perennials
18	Birdsfoot trefoil	0.70	Perennials
19	Birdsfoot trefoil	1.40	Perennials
20	Creeping red fescue + birdsfoot trefoil	3.75 + 0.70	Perennials
21	Creeping red fescue + birdsfoot trefoil	7.50 + 1.40	Perennials
22	Untreated	-	Perennials

There were no measured differences between the two living mulch sowing densities for ground cover and efficacy of weed suppression. All of the cover crop species suppressed the perennial weeds to some extent compared with the untreated control creeping red fescue alone and in a mixture with birdsfoot trefoil were the most suppressive for both perennial and annual weeds. This could be explained by the dense ground cover that creeping red fescue provides. Some of the living mulch species also efficiently supressed the annual weed species. The most effective included the creeping red fescue alone and in mixture with birdsfoot trefoil and also the white clover at the higher sowing density for groundsel and mayweed and black medic for the mayweed alone. However it is important to note that, creeping red fescue reduced the nitrogen availability in the soil in

contrast to the leguminous species. Potentially, a mixture of creeping red fescue and a species which provides high nitrogen availability should be considered for future research. These experiments will be repeated in field conditions to further validate the results.

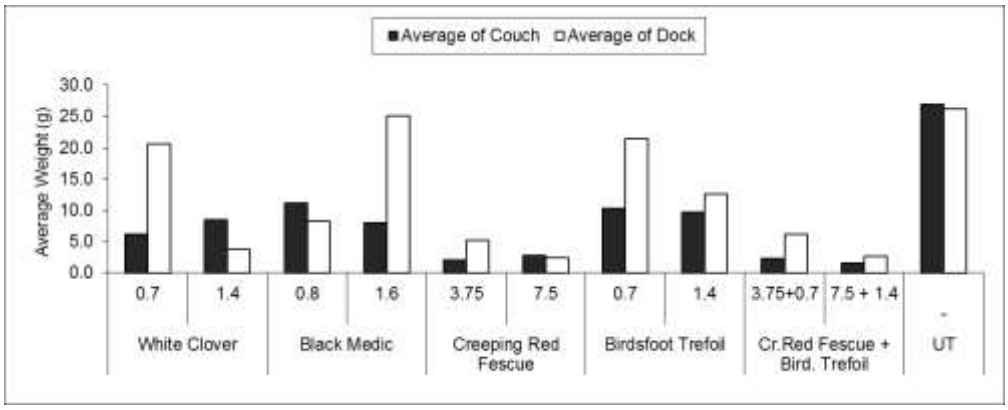

Figure 2.6.1. Perennial weeds - average fresh weed weight (g) at the destructive assessment five months after planting

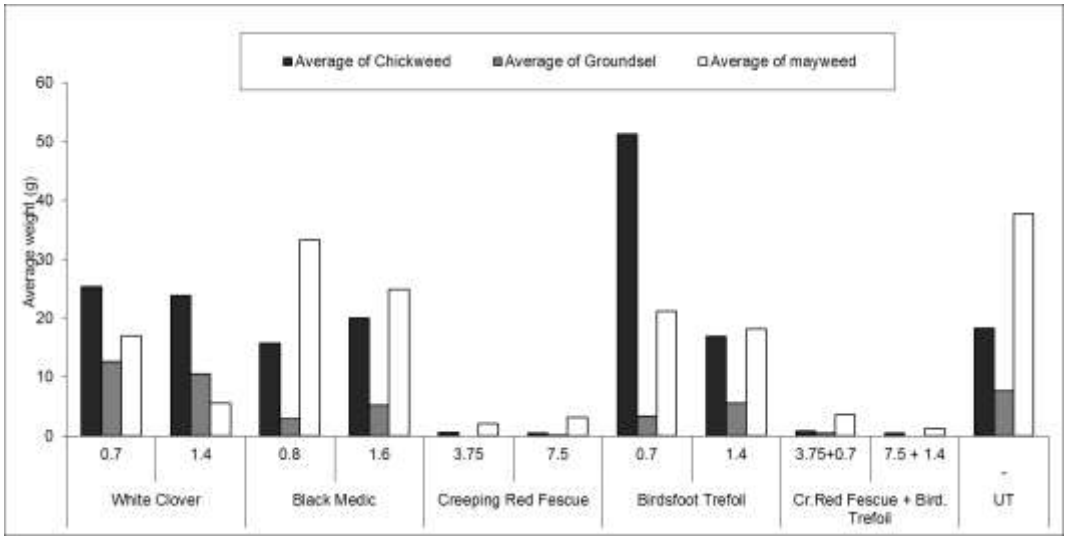

Figure 2.6.2. Annual weeds – average fresh weed weight (g) at the destructive assessment five months after sowing

Financial benefits

There are no financial benefits as yet from this project. The field work needed for an economic assessment will continue through 2014 and 2015.

Action points

- Creeping red fescue alone or grown in combination with birdsfoot trefoil could be used to suppress both perennial and annual weeds.
- The legume living mulch species could be used to suppress the annual weeds, but were less effective on perennials.
- Creeping red fescue alone and in a mixture decreased the nitrogen availability in contrast to the leguminous species. As a result additional nitrogen application may be required when using these species as a living mulch.

Grower Summary - Objective 2.7 - Perennial weed trial: green manures

Headline

- Buckwheat was the most suppressive green manure for both perennial and annual weeds.

Background

The main objective of the trial was to investigate the suitability of a range of species grown as a green manure cover crop for perennial weed control prior to planting the main crop.

Summary

A container trial was carried out at ADAS Boxworth to investigate the control of perennial weeds including broad-leaved docks, creeping thistles and field bindweed from various cover crop species as green manures. Untreated containers with weeds only, were used as reference to compare any weed suppression from the different cover crops. The table below shows the investigated weed species and treatments (Table 2.7.1). A fresh weight assessment of the weed species took place after flowering and a second assessment a month later.

Table 2.7.1. Treatment list

Treatment no.	Cover crop species	Sowing density	Seed needed per pot	Perennial weed species
1	Buckwheat (*Fagopyrum esculentum*)	120 kg/ha	8.6g	Creeping Thistle
2	Buckwheat (*Fagopyrum esculentum*)	120 kg/ha	8.6g	Broad-leaved dock
3	Buckwheat (*Fagopyrum esculentum*)	120 kg/ha	8.6g	Field bindweed
4	Caliente 119R	11 kg/ha	0.79g	Creeping Thistle
5	Caliente 119R	11 kg/ha	0.79g	Broad-leaved dock
6	Caliente 119R	11 kg/ha	0.79g	Field bindweed
7	Caliente 61	8 kg/ha	0.57g	Creeping thistle

Treatment no.	Cover crop species	Sowing density	Seed needed per pot	Perennial weed species
8	Caliente 61	8 kg/ha	0.57g	Broad-leaved dock
9	Caliente 61	8 kg/ha	0.57g	Field bindweed
10	Caliente 99	10 kg/ha	0.72g	Creeping thistle
11	Caliente 99	10 kg/ha	0.72g	Broad-leaved dock
12	Caliente 99	10 kg/ha	0.72g	Field bindweed
13	-	-		Creeping thistle
14	-	-		Broad-leaved dock
15	-	-		Field bindweed

The results show that the cover crops are capable of suppressing the weed growth as well as weed re-growth when used as green manures. Buckwheat was the most suppressive cover crop of all the weed species as it had the densest mass of foliage over the soil. Buckwheat and Caliente 61 were the most suppressive cover crops on the thistle population after being mulched. The use of the green manure species in general appeared to be less effective in reducing the growth of docks. Caliente 99 did not significantly control the dock re-growth. Field bindweed had a poor establishment and results were too difficult to accurately conclude from this experiment.

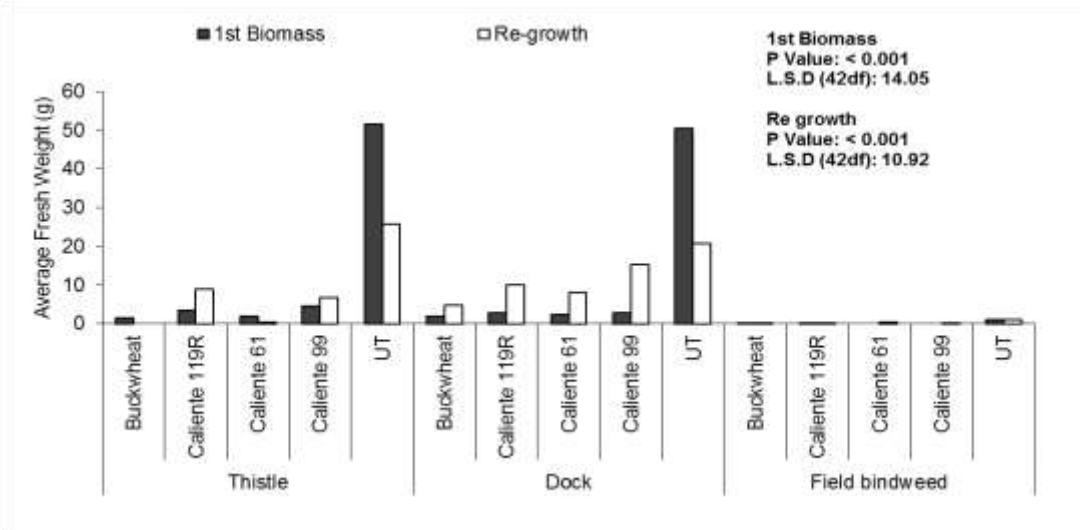

Figure 2.7.1. First biomass assessment 1 August 2013 and re-growth assessment 5 September 2013

Financial benefits

There are no financial benefits as yet from this project. The economic benefits will depend on the persistence of control achieved and this is yet to be assessed.

Action points

- Buckwheat has the best potential as a suppressive cover crop for perennial and annual weed species.

Grower Summary - Column stocks herbicide screen

Headlines

- Dual Gold appears to be safe to use with column stocks when applied post-planting but it currently only has approval for use during May on crops which are uncovered at the time of application.

Background

There are a limited range of herbicides which are safe for use on column stocks, and there is a need for crop safety information on current and new herbicides for use on the newer 'Figaro' varieties desired by the retailers.

Summary

The objective of the trial was to assess the crop safety of a range of herbicides pre and post-planting in column stocks for cut flower production. The trial re-evaluated herbicides with approval for use in ornamental plant production: HDC H29 and Butisan S, alongside newer herbicides recently developed for brassica production such as Wing-P and Dual Gold. The newer stocks varieties are thought to be more susceptible to herbicide damage than the older varieties and so both were compared in the trials.

The experiment was carried out on a commercial crop of column stocks at the National Cut Flower Centre, Holbeach St Johns, Spalding within a polythene tunnel, between April and July 2013. Two varieties were used in the trial; 'Figaro Lavender', a variety of limited vigour, and 'Fedora Deep Rose', which is more vigorous. The trial was planted into soil which had been sterilised two or three years previously, two of the four trial blocks were situated in each area. There were seven treatments, including an untreated control (Table (stocks) 1).

Table (stocks) 1. Detail of herbicide treatments applied pre- or post-planting on stocks - 2013

Treatment	Pre-planting	Post-planting	
1	Untreated	Untreated	
2	HDC H29	Butisan S	1.5 L/ha
3	HDC H29	Wing-P	3.5 L/ha
4	HDC H29	Dual Gold	0.78 L/ha
5	-	Wing-P	3.5 L/ha
6	-	Butisan S	1.5 L/ha +
		HDC H31	
7	-	Butisan S	1.5 L/ha +
		Dual Gold	0.78 L/ha

Table (stocks) 2. Approval status of herbicide treatments used on stocks 2013

Product	Active ingredient	Approval status	
		Outdoor	Protected
Butisan S	Metazachlor (500 g/L)	Approved	Not approved*
Dual Gold	S-metolachlor (960 g/L)	Approved	Not approved
HDC H29	Confidential	Approved	Not approved
HDC H31	Confidential	LTAEU	Not approved
Wing-P	Dimethenamid-p (212.5 g/L) + pendimethalin (250 g/L)	Approved pre-planting only	Not approved

*Some metazachlor products can be used on protected crops as unlike Butisan S they do not contain a label warning stating not to use on protected crops.

Pre–planting treatments were applied on the 25 April, and the trial was planted on 26 April. Post-planting treatments were applied on the 2 May. Phytotoxicity was first assessed in the crop approximately two weeks after treatment on 15 May, and then fortnightly until 10 weeks after treatment. Levels of damage varied, with the most severe effects after applications of HDC H29 + Wing-P, Wing-P post-planting and Butisan S + HDC H31 post-planting. A final assessment was carried out on 8 July, just prior to harvest.

At each phytotoxicity assessment, the trial was also assessed for crop vigour. HDC H29 + Wing-P, Wing-P post-planting and Butisan S + HDC H31 post-planting also caused a reduction in crop vigour

Figure (stocks) 1. Effect of Wing-P on column stocks 10 weeks after treatment

At harvest, on 9 July, plots were assessed by Cut Flower Centre staff for the percentage of marketable stems. For all treatments, 'Fedora Deep Rose' had a higher number of marketable stems, and treatments of Ronstar liquid followed by Butisan S or Dual Gold and Butisan S + Dual Gold post-planting had a higher percentage of marketable stems relative to the crops that did not receive the HDC H29 pre-planting treatment (Figure (stocks) 2).

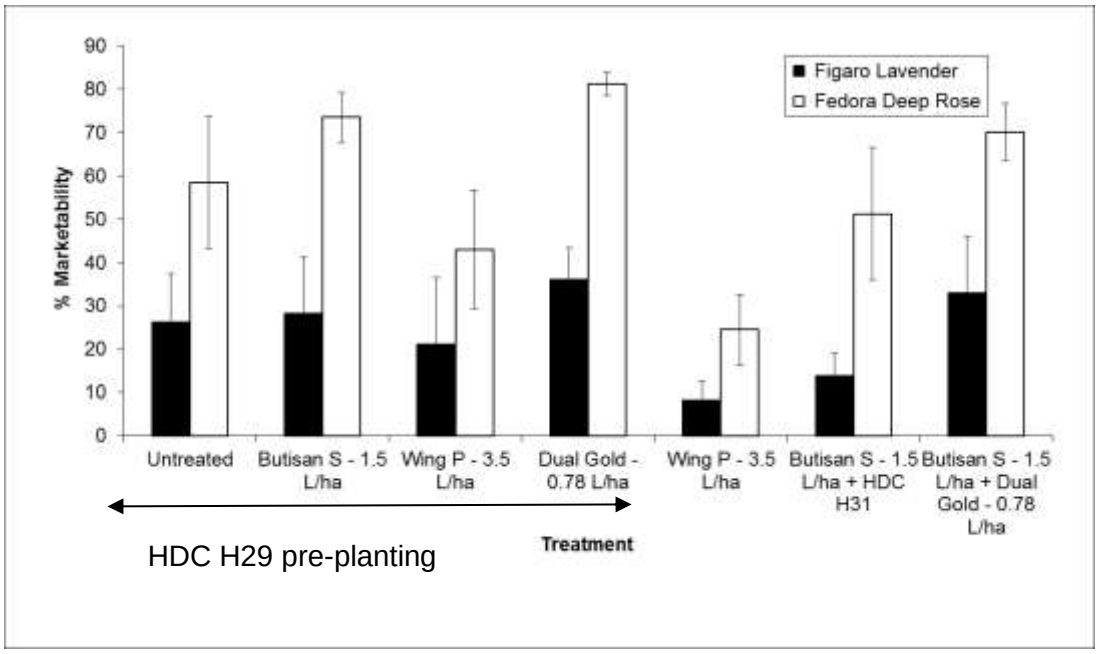

Figure (stocks) 2. Percentage of marketable stems at harvest - 2013

During the course of the project it was announced that the approval for HDC H29 would be revoked with use up of existing stock by 30 June 2015. Alternative herbicides such as Dual Gold and Butisan S do not have as wide a range of activity, although they do control chickweed which was resistant to HDC H29. Dual Gold which was found to be crop safe may need to be tank mixed depending upon the anticipated weed spectrum, and this product is only approved for application during May. Although Butisan S was crop safe in this trial when used post planting as a tank mix with Dual Gold or after pre-planting HDC H29,

caution must be advised with its use as damage has been known to occur in some commercial situations. The revocation of approval for HDC H29 will be a great loss, and further work on crop safe alternatives is still needed.

Financial benefits

There are no financial benefits as yet from this project. The use of Dual Gold may save some hand weeding costs compared to untreated but the situations under which it can be used (outdoor during May only) will be too limiting.

Action points

- **Dual Gold can be used as a post-planting treatment on column stocks provided application is made during May on crops which are uncovered at the time of application**

Grower Summary - Peony herbicide screen

Headlines

- Dow Shield 400, HDC H15, Peak + Butryflow, HDC H30 and a repeated treatment of HDC H21 all reduced the spread of creeping thistle compared with the untreated control.
- Of the most effective treatments Dow Shield 400 was the least damaging when applied over the Peony foliage.

Background

Weed control within a long lived perennial crop such as peony is a considerable challenge, and with few herbicide options available to growers, the control of weeds such as creeping thistle (*Cirsium arvense*) growing within and between the rows is virtually impossible without damaging the crop, requiring manual removal. Control currently relies on directed sprays of Roundup (glyphosate) and hand removal. The objective of this project was to compare directed herbicide treatments for peonies for crop safety and control of creeping thistles.

Summary

The objective of the trial was to assess the efficacy and crop safety of a range of herbicides applied as directed sprays against creeping thistle (*Cirsium arvense*) in peony grown for cut flower production.

Table (peony) 1. Treatments applied to peony trial site – Winchester growers 2013

Trt no.	Treatment	Active ingredient	Rate	Approval
1	Untreated			
2	HDC H19 *	Confidential		Not approved
3	HDC H20 *	Confidential		Not approved
4	HDC H21 + adjuvant *	Confidential		Not approved
5	Dow Shield 400	Clopyralid (400 g/L)	0.5 L/ha	On label
6	HDC H29	Confidential		Not approved
7	HDC H15	Confidential		Not approved
8	Callisto	Mesotrione (100g/L)	1.5 L/ha	Not approved
9	Titus	Rimsulfuron (25% w/w)	50 g/ha	Approved
10	Callisto + Titus	Mesotrione (100g/l) rimsulfuron (25% w/w)	1.5 L/ha + 50 g/ha	Not approved EAMU
11	Peak + Butryflow	Prosulfuron (75% w/w) bromoxynil (402g/l)	20 g/ha + 1.0 L/ha	Not approved Not approved[1]
12	Florasulam	Florasulam (4.54% w/w)	0.15 L/ha	Not approved[2]

*** Applied twice, initially same timing as all the other treatments then again 14 days after**

[1]Approved post-flower harvest for bulbs

[2]Similar product Barton has an EAMU for use on outdoor ornamentals

No one treatment reduced thistles to a commercially acceptable level. Dow Shield 400, HDC H15, Peak + Butryflow, HDC H29 and HDC H21 all reduced the spread of thistle to some extent. HDC H21 and Callisto + Titus caused the most lasting damage to the peony foliage, causing necrosis and chlorosis respectively. Further screening is required to help develop strategies for effective thistle control in this crop.

Financial benefits

There are no financial benefits as none of the treatments tested provided a commercially acceptable level of creeping thistle control.

Action points

- Although not full effective in situations with high infestation, Dow Shield 400 can be used as the safest and most effective directed spray treatment for thistle control in peony.

Grower summary –Hot foam application in horticulture: scoping trials

Headlines

- The Foamstream system is a potentially viable alternative to chemical and hand weeding options for container standing ground preparation before standing down container plants.
- For soft fruit or vegetable production the Foamstream system is not yet in a form that can be readily adopted in these sectors.

Background

Foamstream is a new thermal weeding technology which has been developed for weed control in the amenity sector. The technology works by denaturing proteins and destroying enzymes within the target plant using hot water with foam. The natural foaming agents provide an insulating layer to retain heat for longer and provide a greater level of weed control.

Summary

Trials were carried out in summer 2013 to investigate the potential of using Foamstream technology in three different horticultural situations:

Hardy nursery stock: container plant standing areas in glasshouse, polytunnels and outdoors - containers on sand, gravel and mypex, over empty beds and in, around and over containers.

Strawberry: established crop post-harvest - runner control, a newly planted crop – general weed control and a headland area – general weed control.

Organic field vegetables: inter-plant and inter-row application to control annual and perennial weeds which cannot be mechanically removed in calabrese – non-cropped and cropped area and leeks – within row and headland plot treated.

For each situation the host grower was consulted on where the Foamstream technology may be of most use in their sector and this was used to help decide upon where would be best to trial the technology.

Figure (Foamstream) 1. Foamstream technology supplied by Weedingtech

Hardy nursery stock

Foamstream provided very effective weed control for up to four weeks controlling virtually all weed, moss and liverwort species it came in contact with. The water and foam flowed well around the containers and caused no damage to the plants in them. As a result of the speed of foliage kill, the ability to use it in any weather and its safety from an environmental and health and safety point of view the host grower was very keen to replace conventional herbicides with this equipment. However, Foamstream lacked persistence, and was slower than conventional spray systems to apply. Changes that could help improve the product would include a lance head that was adaptable to the right situation (i.e. a narrower head) and if the equipment allowed the flow of the foam to be adjustable. A faster flow of foam could be used to increase speed of application and reduce labour cost. Finally, if the equipment could be downsized, a smaller version would be more suitable to treat smaller areas as small and medium sized nurseries wouldn't have large enough bed areas for the current sized equipment. From conversation with our host grower if the cost of application was similar to or less than hand weeding (£6.93/hour) then he would be interested in trialling on a larger scale in combination with residual herbicides.

During

1 WAT

Before

1 WAT

2 WAT

4 WAT

2 WAT

4 WAT

Sand pot standing area | **Sand tree pot standing area**

Figure (Foamstream) 2. Effects of foam stream on sand container standing area, and tree container standing area at 1, 2, and 4 weeks after treatment (WAT)

Strawberries

Foamstream provided very effective weed control up to four weeks. Six weeks after treatment however, annual weeds had begun to germinate in addition to thistles, fine grasses and cow parsley re-growing from rhizomes. There were still however many more weeds in the untreated rows than in the treated. For the inter-row area treatment, application of Foamstream caused runners to immediately wilt and provided good control of weeds. After six weeks no regrowth from runners was visible. The Foamstream also offered good control of cereals, shepherd's purse, nettle, poppy and wild oats. There was some recovery from the deliberately treated strawberry crop plants, the plant where the hot foam was applied directly over the crown was cut open and showed some vascular staining and a corky outer cuticle but overall remained a fairly healthy looking. This could mean that Foamstream has potential as a dormant season treatment or even as a post-harvest treatment to the crop.

The comment from the host grower was that the technology killed the weeds present regardless of species or size, however it would need repeating regularly, therefore either a lower dose or higher speed, or the introduction of a residual herbicide element to the program would be needed. To make this technology into a commercially viable operation, the steam boiler, tanks, mixer etc. would need to be tractor mounted and automated to provide for one man operation.





During | 1 WAT | 1 WAT UTC | 2 WAT | 2 WAT UTC





During | 1 WAT | 1 WAT UTC | 2 WAT | 2 WAT UTC

Figure (Foamstream) 3. Strawberry plots during then one and two weeks after treatment (WAT) compared with the untreated controls (UTC). Top row mainseason strawberries, bottom row 60 day.

Organic field vegetables

For the non-cropped brassica field, a similar outcome was observed, the Foamstream worked very well killing some fairly large weeds including polygonums, fat hen and creeping thistle. For the cropped brassica field with calabrese in situ, the foam flowed nicely around the crop plants but needed careful application to ensure the treatment reached all the surrounding weeds. Initially most of the weeds in the treated plot were killed but by six weeks there were quite a few species of weeds that were germinating. There was also some damage to brassicas where the plants were treated close to the stem; approximately 10% of plants were affected.

In the cropped leek field, it was hard to get between leeks because of the spacing and so as a result the weeds within the rows remained un-touched.

Over both vegetable situations the equipment was not really at a stage to be able to make a direct comparison with standard methods, but there was an impressive level of knock-down of a large and dense weed population. The crop damage observed was a concern and the tractor mounting and speed of application would need to be improved.

During 1 WAT 2 WAT 4 WAT

Brassica crop damage

Brassica crop damage

Before

1 WAT

2 WAT

4 WAT and leek crop damage

Figure (Foamstream) 4. Calabrese and leek plots before, during, one, two and four weeks after Foamstream treatment

In conclusion:

- Foamstream provided immediate weed control to all species tested.
- Application was possible in any weather, no toxicity or residues were associated.
- Weed control was not long lived for thistles, liverwort (four to six weeks) and had no effect on surface germinating seeds.
- Investigation of optimal timing and integration with herbicide programs could make this a very useful tool as herbicide options become more limited.
- In the long-term, adaptations to flow rates and application equipment would be necessary to commercialise it for intensive horticulture.

Financial benefits

For nursery stock production the Foamstream kit is fairly well suited to the production systems however at present there is not enough information on the cost of the equipment and time and frequency of application required to provide an accurate financial appraisal.

Further development of the Foamstream technique is required before it can be used for commercial application with soft fruit and vegetable crops.

Action points

- The Foamstream system is a potentially viable alternative to chemical and hand weeding options for container standing ground preparation before standing down container-grown plants.