PROJECT REPORT

To:
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FV 256

Vegetables: Solutions to the loss of active ingredients for weed control in vegetable crops

Final report for the 2005 trial

August 2005

Commercial - in Confidence

FV 256 FINAL REPORT 2005

Project title:	Vegetables: Solutions to the loss of active ingredients for weed control in vegetable crops
Project number:	FV 256
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Report:	Final report completed September 2005
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Location:	Warwick HRI, Kirton, Lincolnshire
Project co-ordinator:	HDC Vegetable Panel Members
Date project started: **Date project completed**:	1 April 2005, 31 August 2005
Keywords:	Drilled: bulb Onion, Leek, Carrot, Parsnip, Coriander, Swede, Vining peas, Baby leaf spinach, Dwarf French beans, Transplants: Celery, Cauliflower, Lettuce; Crop safety, herbicides

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Headline

Vegetable crops tested: drilled bulb onion, leek, carrot, parsnip. coriander, vining pea, dwarf French bean, swede, baby leaf spinach; transplants celery, cauliflower and lettuce. *Active substances in italics not yet registered in the UK and it will take time before they are available to the grower*. Potential alternative herbicides for the future, which appear to be safe (non-phytotoxic) to some crops have been identified and are worth further evaluation. All herbicides evaluated in 2005 were very effective and controlled a wide weed spectrum.

- *Imazamox*/pendimethalin N 3.0 L/ha (50/750g a.i./ha) was very safe to peas (UK registration is being sought by the company) and dwarf beans; 1.5L/ha applied pre-transplanting appeared safe to cauliflower.
- *Oxyfluorfen* N 1.0 L/ha (240 g a.i./ha) applied after transplanting pre-weed-emergence and later, caused initial damage to cauliflower (scorch to the leaves and growing point) but plants recovered; *oxyfluorfen* ½ N 0.5 L/ha (120g a.i./ha) post-weed-emergence was safe to drilled bulb onions, ¼ N to leek
- *Dimethachlor* N 3.0 L/ha (500g a.i./ha): was very safe to cauliflower transplants; 1.5 L/ha appeared safe to swedes, peas and, surprisingly, to lettuce
- *LB1* ½ N 0.125 L/ha (30g a.i./ha) appeared safe to cauliflower.
- Bacara (flurtamone/diflufenican) ½ N 0.5 L/ha (125/50g a.i./ha) appeared safe in pea, celery, onion, possibly carrots and parsnip; at ¼ N 0.25 L/ha to leek
- Spinach, coriander were not tolerant of any of the herbicides tested

Background and commercial objectives

Herbicide screening trials on a range of vegetable crops were funded by the Agrochemical Industry and carried out by NVRS/HRI until 1990. Information on crop tolerance was made available to relevant crop sectors for further development and was extremely useful. Agrochemical Companies no longer screen new herbicides on minor crops. Since then important herbicides for vegetable growers: terbutryn, fenuron, fomesafen, terbacil, cyanazine, sodium monochloroacetate, metoxuron, prometryn, pentanochlor were not supported in the EC Review; simazine and atrazine failed to achieve Annex 1 status. There are derogations for "Essential Uses" in some crops, but these will be lost 31 December 2007. Alternatives are therefore sought - this trial is to screen "new" herbicides for crop tolerance.
The overall aim of this project is to:

- identify candidate herbicides after consultation with crop protection companies, a search of literature and previous data at Wellesbourne, and discussion with vegetable sectors in other European Member States. Only herbicides with a future (on Annex 1 or supported in the EC Review) will be selected.
- establish a screening system to test a range of vegetables for crop tolerance to new herbicides available for major crops or vegetables in other European Member States but whose development cannot be justified by the manufacturers for UK minor crop use.
- find new solutions for weed control as rapidly as possible by further development and through HDC obtain Specific Off-Label Approvals (SOLAs)
- demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so they can continue until the end of 2007.

Summary of Results

Herbicides were applied at 2x Normal, Normal, ½ Normal dose rates in all crops, except onion and leek Normal, ½ Normal, ¼ Normal dose rates. Assessments were made for any crop damage (phytotoxicity). Weed control was also monitored to identify the potential of each product to control the target weeds.

Crop Safety

The following information is based on only one trial, on an irrigated, light silt loam soil. For safety there should no or negligible/transient damage at a recommended dose rate and no, or acceptable, effects at the overlap dose.

Table 1. Pre-weed-emergence herbicides 3 safe; x not safe; all gave very good weed control # applied pre-transplanting.

Herbicide 'Normal' dose/ha	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Pea**	**Swede**	**Spinach**
imazamox/ pendimethalin # 3.0 L	X	X	X	X	X	X	3 ½N	X	3	3	X	X
dimethachlor 3.0 L	X	X	X	X	X	X	3	3 ½N	X	3 ½N	3 ½N	X
oxyfluorfen 1.0 L	X	X	X	X	X	X	3	X	X	X	X	X

Green text on Annex 1 (positive list) as of August 2005

Table 2. Post-weed-emergence herbicides 3 safe; x not safe, (in parentheses marginally safe); all gave very good weed control, BAS 635H covered the widest weed spectrum.

Herbicide 'Normal' dose	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Pea**	**Swede**	**Spinach**
LB1 0.25L/ha	X	X	X	X	X	X	3 ½N	X	X	X	X	X
oxyfluorfen 1.0 L	3 ½N	3 ¼N	X	X	X	X	3	X	X	X	X	X
BAS 635H 70 g	X	X	X	X	X	X	X	X	X	X	X	X
Bacara 1.0 L flurtamone/diflufenican	3 ½N	3 ¼N	(3 ½ N)	(3 ½ N)	X	3 ½N	X	X	X	3 ½N	X	X

Green text on Annex 1 (positive list) as of August 2005

Weed species controlled

Weed populations were very high on this Kirton site. The predominant species were shepherd's purse, small nettle, mayweeds, chickweed, smooth sowthistle, and groundsel. There were also a few pale persicaria, knotgrass, fat-hen, creeping thistle and common poppy. BAS 635H and oxyfluorfen controlled a very wide weed spectrum.

Table 3. Pre-weed-emergence herbicides: weed species controlled √; poor control or not controlled X by the herbicides at various dose rates, - weeds not present on untreated plots

Pre-weed-emergence Herbicide	**Shepherd's purse**	**Scentless mayweed**	**Small nettle**	**Pale persicaria**	**Chickweed**	**Smooth sowthistle**	**Groundsel**	**Redshank**	**Common poppy**	**Fumitory**	**Fat-hen**
imazamox/pendimethalin 2 N	√	√	√	√	√	√	√	√	-	-	-
imazamox/pendimethalin N 3 L	√	√	√	√	√	√	√	√	-	(X)	-
imazamox/pendimethalin ½ N	X	X	X	√	√	X	X	-	-	-	-
imazamox/pendimethalin ¼ N	X	X	X	√	√	X	X	-	X	-	-
dimethachlor 2N	√	√	√	√	√	√	√	-	√	-	-
dimethachlor N 3 L	√	√	√	√	√	√	√	-	√	-	-
dimethachlor ½ N	X	√	X	√	√	√	√	-	X	-	(X)
dimethachlor ¼ N	X	X	X	√	√	√	X	-	X	-	-
oxyfluorfen 2N	√	√	√	√	√	√	√	√	√	-	-
oxyfluorfen N 1.0 L	√	√	√	√	X	√	√	√	√	-	-
oxyfluorfen ½ N	√	√	√	√	X	√	√	√	√	-	-
oxyfluorfen ¼ N	√	√	√	√	X	√	√	-	√	-	-

Table 4. Post-weed-emergence herbicides: √ weed species controlled; √ or # controlled at cotyledon stage; X poor control or not controlled by the herbicides at various dose rates ( ) low population on area; - weeds not present on untreated plots,

Post-weed-emergence Herbicide	**Shepherd's purse**	**Scentless mayweed**	**Small nettle**	**Chickweed**	**Smooth sowthistle**	**Common poppy**	**Groundsel**	**Redshank**	**Pale persicaria**	**Speedwells**	**Knotgrass**	**(Fat-hen)**	**(Fumitory)**	**(Creeping thistle)**
LBI 2 N	X	√	√	√	√	√	√	-	√	-	√	-	-	√
LBI N 0.25L	X	√	√	√	√	√	√	-	√	(X)	√	-	-	√
LBI ½ N	X	√	X	X	√	√	√	-	√	(X)	√	-	-	√
LBI ¼ N	X	X	X	X	-	-	-	-	-	(X)	-	-	-	-
oxyfluorfen 2N	√	√	√	X #	√	√	√	√	√	-	-	-	-	√
oxyfluorfen N 1.0L	√	√	√	X#	√	√	√	√	√	-	-	-	-	-
oxyfluorfen ½ N	√	√	√	X#	√	√	√	√	√	-	-	(X)	-	-
oxyfluorfen ¼ N	X	X	-	X	-	-	-	X	X	-	-	-	-	-
BAS 635H 2N	√	√	√	√	-	-	√	√	√	-	√	√	-	√
BAS 635H N 70 g	√	√	√	√	-	-	√	√	√	-	√	X	-	√
BAS 635H ½ N	√	√	√	√	-	-	√	√	√	-	X	X	-	√
BAS 635H ¼ N	√	-	-	-	-	-	-	-	-	-	-	-	-	-
Bacara 2N	√	√	√	√	√	-	√	-	-	-	-	-	√	-
Bacara N 1.0 L	√	X#	√	√	√	-	√	-	X	-	-	-	√	-
Bacara ½ N	√	X#	X#	√	√	-	X	(X)	X	-	(X)	-	(√)	-
Bacara ¼ N	√	X	X	-	-	-	X	(X)	X	-	(X)	-	-	-

Appendix 2 gives limited data for the weed spectra of herbicides in the trial.

Herbicides: Current Approval Status

Herbicide Product#	**Company**	**active substance (formulation)**	**N product rate /ha Light soil**	**Registered now *or in future***
Pre-weed-emergence				
(Nirvana)	BASF	imazamox/pendimethalin (16.7/250 g/L) SC	3.0 L	France peas
(Teridox)	Syngenta	dimethachlor (500 g/L SC)	3.0 L	*? oilseed rape*
(Goal)	Makhteshim	oxyfluorfen (24% EC)	1.0 L	Spain, onions, brassicas
Post-weed-emergence				
LB1	confidential	confidential WG	0.25 L	*in future*
(Goal)	Makhteshim	oxyfluorfen (24% EC)	1.0 L	Spain onions, brassicas
BAS 635H + wetter 0.6% final vol	BASF	confidential WG	70 g	*Maize, cereals*
Bacara	Bayer CropScience	flurtamone/diflufenican (250/100 g/L) SC	1.0 L	UK cereals

product name in another country; Green text on Annex 1 as of August 2005

Action Points for Growers

- growers need to be aware that there may be further losses if actives fail to achieve Annex 1 listing.
- establish an early stage screening system for test new herbicides when available.
- need to review their current weed control strategy for many vegetable crops because "Essential Uses" for important herbicides metoxuron, prometryn, terbutryn, fomesafen, cyanazine, pentanochlor expire 31 December 2007.
- some potential alternative herbicides which appear to be safe (non-phytotoxic) to some crops have been identified and further work is needed to assess crop safety of residual herbicides on very light soils/sands and to evaluate efficacy and programmes for oxyfluorfen, Bacara, dimethachlor.
- where no data are available, two years residues trials may be required for a SOLA (Specific Off-Label Approval) application.
- demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so that these uses can continue. (Action already taken through HDC)

Practical and Financial Benefits from this Study

The safety of a range of vegetable crops to some alternative herbicides and the potential for SOLAs has been identified in this early stage screening trial. However, some herbicides are not yet registered in the UK *and it will take time before they are available to the grower.* The herbicides in the 2005 screen controlled a wide weed spectrum.
The study also identified herbicides that are too damaging, and the type of symptoms (e.g. bleached spotting) that would render leaf crops coriander, baby-leaf spinach unmarketable.
Weeds cause yield loss, harvesting difficulties and, importantly, contamination of produce with weedy parts (some toxic) that could result in crop rejection thus incurring considerable financial loss. All conventionally grown outdoor field vegetables are dependent on herbicides. Without a range of herbicides to control a wide weed spectrum vegetable growing could become uneconomic. A recent Pesticide Usage Survey 2003, showed the % area of crops in Great Britain receiving herbicide sprays (see below).

Comparison of herbicide treated areas and GB crop area (Pesticide Usage Survey 2003), crop value and gross margins (* J Nix, Farm Management Pocketbook, 2004) for a range of some important vegetable crops

Crop	***Crop area ha last survey***	***% Herbicide treated area last survey***	***Crop value £/ha *2005***	***Gross Margin £/ha * 2005***
Brassicas	32,424	195	3,150 cauliflower	825
Peas & Beans	46,211	263	1,000 vining peas	750
Onions & leeks	12,397	1101(split doses)	3,500 bulb onions	1,225
Carrots, parsnips, celery	13,062	594 (split doses)	6300 maincrop	1,775

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As a result of the EC pesticide review programme, growers will lose key herbicides. Some examples of important losses are: prometryn to control fumitory in onions and carrots; cyanazine for charlock in brassicas, metoxuron for mayweeds (and + linuron to suppress potato volunteers) in carrots; fomesafen for broad-leaved weeds and potato volunteer suppression in dwarf beans; pentanochlor for knotgrass in celery and parsley. Three of the top ten most popular herbicides used in vegetables: cyanazine, terbutryn/terbuthylazine, metoxuron, for broad-leaved weeds will soon be lost. The areas sprayed (Pesticide Usage Survey 2003 Defra, CSL) are shown below. Alternatives are urgently needed.

List of active substances permitted for **vegetables** in the UK, for the following herbicide 'Essential Uses' only, until 31 Dec 2007. Area sprayed 2003; * 1999data

Active Substance	**Crop Use**
Atrazine 1252 ha	Sweetcorn
Cyanazine 40,424 ha	Vining pea; Calabrese/Broccoli, Cauliflower, Cabbage, Bulb Onion, Salad Onion, Leek
Fenuron small	Runner beans, Spinach
Fomesafen 2,766ha	Vining Pea (spring sown), Broad Bean (spring sown), Dwarf French bean, Runner bean
Metoxuron 14,389ha	Carrots, parsnips
Pentanochlor 4,144ha	Celeriac, Celery, Carrot, Parsnip Parsley & Herbs (outdoor & protected)
Prometryn 6,327 ha	Bulb & Salad Onion (outdoor), Leek (direct drilled & transplanted), Carrot, Parsnip Celery, Parsley, Herbs, all (outdoor & protected)
Simazine small	Asparagus
Sodium mono-chloroacetate 1,764 ha*	Bulb & Salad Onion, Leek, Cabbage, Brussels sprout, Calabrese/ Broccoli, Cauliflower
Terbacil small	Herbs (outdoor & protected)
Terbutryn 16,433ha	Vining, Edible Podded Pea, Broad Bean,

SCIENCE SECTION

Introduction

Herbicide screening trials on a range of vegetable crops were funded by the Agrochemical Industry and carried out by NVRS/HRI until 1990. Information on crop tolerance was made available to relevant crop sectors for further development and was extremely useful. Agrochemical Companies no longer screen new herbicides on minor crops.
The overall aim of this project is to create a system for preliminary herbicide screening on a range of horticultural crops chosen by the HDC Vegetable Panels. The first HDC screening trial began in 2004. New active substances for arable crops or used in vegetables in other Member States are selected a) if they are already on Annex 1 or supported in the EC Review although they may not be registered yet in the UK; b) after discussions with the Crop Protection Companies, and the vegetable sectors in other parts of Europe. The screening trial provides information on crop phytotoxicity to active substances so that they can be evaluated further in commercial crops or in residue trials to support on-label or SOLA use (by the HDC through the SOLA programme).
Important herbicides for vegetable growers: terbutryn, fenuron, fomesafen, terbacil, cyanazine, sodium monochloroacetate, metoxuron, prometryn, pentanochlor were not supported in the EC Review, simazine and atrazine failed to achieve Annex 1 status. The derogations for their "Essential Uses" will be lost 31 December 2007 and alternatives are therefore sought. This work allows the industry to demonstrate to the European Commission that action has been taken to find alternatives so that these uses can continue.

Objectives

- To assess crop safety ('phytotoxicity') to herbicides tested
- To assess where possible, efficacy against weeds that are common problems in vegetables
- To identify suitable candidates for further development and for SOLAs
- To demonstrate to the European Commission that action has been taken to find alternatives to replace the 'Essential Uses' so that they can continue until 31 Dec 2007

Sowing date and herbicide application date

Crop & Variety	Drill/ Transplant Date	Spray Date Pre-weed-emergence
Onion Hystar	8 April	11 April
Leek Roxton	8 April	11 April
Celery transplants Victoria	5 May	5 May#; 11 May*
Cauliflower transplants Fremont	5 May	5 May#; 11 May*
Lettuce transplants Challenge	5 May	5 May#; 11 May*
Dwarf French Bean Laguna	11 May	11 May
Pea Cabree	11 May	11 May
Swede Magres	10 May	11 May
Spinach baby leaf Whale	10 May	11 May
Coriander Santos	10 May	11 May
Carrot Nairobi	10 May	11 May
Parsnip Javelin	10 May	11 May

#imazamox/pendimethalin **pre-transplanting**; *dimethachlor & oxyfluorfen **post-transplanting pre-weed-emergence**

Crop & Variety	Spray Date Post-weed-emergence & Growth Stage	
Onion Hystar	7 June	2 Leaves
Leek Roxton	7 June	2 Leaves
Celery transplants Victoria	17 May	established
Cauliflower transplants Fremont	17 May	established
Lettuce transplants Challenge	17 May	established
Dwarf French Bean Laguna	7 June	1 Trifoliate Leaf
Pea Cabree	7 June	4 node
Swede Magres	7 June	2 True Leaves
Spinach baby leaf Whale	7 June	2 True Leaves
Coriander Santos	18 June	3 True Leaves
Carrot Nairobi	18 June	2 True Leaves
Parsnip Javelin	18 June	1 – 2 True Leaves

Site: Warwick HRI Kirton

Soil type (ADAS scale): Silt Loam (light)

Herbicides
This trial is to screen herbicides for crop tolerance. Herbicides were applied at 2x Normal, Normal, ½ Normal dose rates in all crops, except onion and leek Normal, ½ Normal, ¼ Normal dose rates. Pre-emergence dose rates appropriate for the light soil type.

No. Product	Active ingredient * (g a.i. / L & formulation)	"Normal" N Rate Product/ha (g a.i./ha)
1. (Nirvana) #	imazamox/pendimethalin (16.7/250 g/L)	3.0 L (50/750 g)
2. (Teridox)#	dimethachlor (500 g/L SC)	3.0 L (1500 g)
3. (Goal) #	oxyfluorfen (24% EC)	1.0 L (240 g)
4. LB1#	Confidential WG	0.25 L
5. (Goal) #	oxyfluorfen (24% EC)	1.0 L (240 g)
6. BAS 635H# + wetter 0.6% vol	Confidential WG	70 g
7. Bacara	flurtamone/diflufenican (250/100) g/L SC	1.0 L (250/100 g)

* green text active ingredient achieved Annex 1 status; all other active ingredients are supported in the EC Pesticide Review; # no UK product yet

Crop details
Crops were sown with a Stanhay Singulaire drill, on a 1.83 m bed of 4 rows/plot on 40 cm row width at high populations, except for peas and beans sown with a Planet push drill in double rows. Press wheels on drills ensured a fine, firm seedbed – plots were not rolled. Celery, lettuce and cauliflower transplants planted with a Michigan planter on 3 rows per plot.

Trial Design
Plot size 2 m long x 1 bed width (1.83 m) with 2 replicates of each treatment (total 672 plots).

Records/Assessments
The following records and assessments were undertaken at, or following application of the various experimental treatments.

- Crop and weed growth stage recorded at the times of application and crop assessment
- Weather during and after application.
- Estimates of reduction in crop emergence or delay after pre-emergence applications
- Observations on any phytotoxicity symptoms, crop scores for damage (0=complete kill; 7=acceptable damage depending on the market; 10=no damage) at appropriate intervals
- Weeds present on control plots.
- Weeds present on herbicide treated plots and overall weed control scores (0=no control; 7= acceptable control; 10=complete control)

Application Data

Sprays were applied using an Oxford precision sprayer with a 2 m boom and four 110º flat fan nozzles (BCPC code F110/0.80/3) delivering 200 L/ha water volume at 2 bar pressure to give fine spray quality.

Pre-weed-emergence Herbicide Trial

Date applied	Weather	Crop; Soil	GS weeds
Pre-emergence Onion & Leek (sown 8 April)			
11 April 1/4N, ½ N, N dose only tr 1 to 3	10ºC; 81% RH; cloud cover 7; wind 2mph irrigation 12 April; rain after application 12-13 April 3.5mm	Pre-em crop Sowing depth 1 cm; seedbed fine surface dry	-
Pre-transplant Celery, Lettuce & Cauliflower (planted 5 May)			
5 May Tr 1 imazamox/ pendimethalin	12.3ºC; 11% RH; cloud cover 7; wind 3mph rain after application 6 & 7 May 13mm	Pre-transplanting seedbed fine surface moist	-
Post-transplant Celery, Lettuce & Cauliflower (planted 5 May) Pre-weed-emergence			
11 May trs 2 & 3	9.3ºC; 61% RH; cloud cover 5; wind 1mph no rain after application; irrigation 13 May	Pre-transplanting seedbed fine surface moist	-
Pre-emergence (Peas, Dwarf Beans, Swede, Spinach, Carrot, Parsnip, Coriander sown 11/12 May)			
11 May trs 1, 2 & 3	9.3ºC; 61% RH; cloud cover 5; wind 1mph no rain after application; irrigation 13 May	Pre-transplanting seedbed fine surface moist	-

Post-weed-emergence Herbicide Trial

Date applied	Weather	GS crop; Soil	GS weeds
Pre-emergence Standard *Onion & Leek (sown 8 April),			
11 April Standard only	10ºC; 81% RH; cloud cover 7;wind 2mph irrigation 12 April; rain after application 12-13 April 3.5mm	Pre-em crop Sowing depth 1 cm; seedbed fine, surface dry	-
Pre-emergence Standard **Carrot & Parsnip (sown 11 May)			
12 May Standard only	10ºC; 69% RH; cloud cover 4; wind 3mph; no rain after application; irrigation 13 May	Pre-transplanting seedbed fine, surface moist	-
Post-emergence Celery, Lettuce & Cauliflower (planted 5 May)			
17 May tr 4 to 7	8.7ºC (12ºC later); 56% RH; cloud cover 5; wind 4mph; no rain after application	Celery, Lettuce & Cauliflower established; seedbed fine, surface moist	Cotyledon stage
Post-emergence Onion & Leek (sown 8 April) Dwarf Beans, Peas, Swede, Spinach, (sown 11 May)			
7 June tr 4 to 7	11.8ºC (16ºC later); 61% RH; cloud 5; wind 3mph; no rain after application	GS Onion, Leek, Swede, Spinach 2 True Leaves, GS Dwarf Beans 1 Trifoliate Leaf; Peas 4 node; seedbed fine, surface moist	2 true leaves; small plant on onion & leek plots
Post-emergence Coriander, Carrot, Parsnip (sown 11 May)			
18 June tr 4 to 7	22.1ºC (29ºC later); 88% RH; cloud 8; wind 3mph; no rain after application	GS Coriander 3 True Leaves; Carrot 2 True Leaves, Parsnip 1 - 2 True Leaves; seedbed fine, surface dry	Small plant on coriander; none on carrot & parsnip

standard pre-emergence herbicide at ½ Normal dose was applied: *Ramrod + Stomp (4.5 + 0.65) L/ha
**Stomp + Linuron (500 g/L formulation) (1.6 + 1.0) L/ha

Results Crop tolerance (more detail in the following Tables)

Phytotoxicity symptoms pre-weed-emergence herbicides

Rainfall and irrigation increased damage from residual soil acting herbicides and damage was greater for the earlier drilled onions and leeks, where too much irrigation reduced emergence on untreated plots.
Carrots and parsnips took 23 days to emerge.

Imazamox/pendimethalin (Nirvana) 3.0 L/ha: appeared very safe to peas and dwarf beans even at 6.0 L/ha. Applied pre-transplanting of cauliflower it was marginally safe at 1.5 L/ha Pendimethalin alone is safe in many of the vegetables tested except swede and spinach; but imazamox can cause gradual, slow, stunting of some crops. The combination caused reduced emergence and death of swede and spinach; lettuce transplants died within 2 weeks. There was gradual stunting and vigour loss for coriander, celery, onion, leek, carrots and parsnips.

Dimethachlor (Teridox) 3.0 L/ha: applied after transplanting was very safe to cauliflower, the 1.5 L/ha appeared safe to swede and surprisingly to lettuce where all plants survived. The first pea leaves were severely crinkled and distorted and plants were stunted, but the ½ N dose appeared safe. Celery leaves were scorched and distorted/stuck together although later growth was normal. The leaves of dwarf beans suffered slight distortion and the margins became necrotic and died. It caused delayed and reduced emergence of coriander, and carrot, parsnip, onion and leek failed to emerge. There was stunting followed by complete death of spinach.

Oxyfluorfen (Goal) 1.0/ha: applied after transplanting was safe to cauliflower but initially the growing point was scorched and a growth check followed. Emergence was poor on untreated areas of onion and leek after a lot of irrigation and this may have exacerbated damage – there was a complete kill - even at ¼ N dose. Lettuce was killed within a few days. The leaves of celery transplants were severely scorched and distorted but plants recovered 2 months later. Drilled crops emerged but carrot, parsnip, swede and spinach soon died. Coriander emerged quickly and was slightly more tolerant than carrot, but plants became chlorotic and lost vigour. The first pea leaves were severely crinkled and distorted and plants stunted, dwarf beans suffered similar damage.

Phytotoxicity symptoms post-weed-emergence herbicides

These herbicides were applied on 17 May and 7 June under cool conditions, but carrots, parsnip and coriander were sprayed on 18 June and temperatures later that day rose above 29ºC and this may have increased damage.

LB1 0.25L/ha/ha: a foliar-acting translocated herbicide, caused wilting and leaf distortion. Damage was particularly severe on coriander, carrot, parsnip, celery, dwarf beans, peas, spinach and lettuce - the growing point was affected and several crops died. Small wart-like growths on any remaining carrot roots appeared for the N dose, at 2N the roots were brittle and disintegrated. Onion and leek survived but leaves remained curled over and the 2N dose appeared to advance maturity in comparison with untreated onions. Cauliflower initially suffered slight wilting and leaf distortion but plants recovered 3 weeks later although for the 2N dose, leaf veins became chlorotic. The N and 2N dose appeared to advance maturity and

produce loose, open curds. No effects appeared on swedes until 3 weeks after application when there was some stunting and leaf-cupping.

Oxyfluorfen (Goal) 1.0 L/ha: has residual activity and is also a very fast-acting contact herbicide. It severely scorched crop species that were not well protected by leaf wax, but it also killed well-waxed peas. Coriander, carrot, parsnip, celery, lettuce, swede, dwarf bean and spinach were severely damaged, suffering leaf loss, severely affected growing points and/or plant death. In onion it caused slight leaf distortion and white leaf tips, with more effect on leeks, but there was recovery later. Oxyfluorfen was applied to cauliflower early, (14 days after transplanting) - the older leaves were scorched and the growing point was affected by the 2N dose. However, the plants recovered 3 weeks later.

BAS 635H 0.07kg/ha: caused wilting and curled leaves initially, followed by severe stunting and death of all crops except onion and leek, where some survived but leaves remained wilted. Symptoms were typical of a sulfonylurea but it was very fast-acting. In addition onions, leeks, and lettuce were chlorotic; swede and cauliflower assumed a purple colouration.

Bacara 1.0 L/ha (flurtamone/diflufenican): caused bleaching on those leaves present at application, symptoms typical of diflufenican. Flurtamone also causes bleaching – this is why effects were more severe than for diflufenican alone in the 2004 trial. Effects on crops (and weeds) were quick to develop. Severity of bleaching ranged from slight spotting (peas), bands (onions, leeks) to the total leaf area (swedes, lettuce). New growth was unaffected. Lettuce and cauliflower eventually died. Effects were unacceptable in short season crops where there was no time to recover, and where leaves are marketed – coriander, baby-leaf spinach. Bacara appeared to be safe in pea, onion, celery and possibly carrot and parsnip at 0.5 L/ha and leek at 0.25 L/ha

Crop Safety Scores (mean of two replicates) pre-weed-emergence herbicides

Table 5. Onion and leek: pre-emergence herbicides applied 11 April (sown 8 April). assessment date, crop damage score (0 total kill; 7 acceptable; 10 no damage). **Too much irrigation was applied – and soil capped – this may have increased herbicide damage therefore these data should be treated with caution**

Product ***Assessment Date:*** ***Untreated GS:***	**Rate**	**Onion** **13/5** **post crook**	 **26/5** **1 TL**	 **7/6** **2 TL**	**Leek** **13/5** **post crook**	 **26/5** **1 TL**	 **7/6** **2 TL**
imazamox/pendimethalin N 3 L	N	10	3 st	2 st del	10	3 st	2 st
imazamox/pendimethalin	1/2N	10	6 st	4 st	10	5 st	3 st
imazamox/pendimethalin	1/4N	10	7 st	5 st	10	6 st	4 st
dimethachlor N 3 L	N	0 no em	0	0	0	0	0
dimethachlor	1/2N	1	3	2 del	1	1	1
dimethachlor	1/4N	5	5	3 del	3	3	2
oxyfluorfen N 1.0 L	N	0	0	0	0	0	0
oxyfluorfen	1/2N	0	0	0	0	0	0
oxyfluorfen	1/4N	1 del	0	0	0	1	0

No em none emerged, del delayed; st stunting

Table 6. Carrot, parsnip emerged 3 June: coriander emerged 26 May: pre-emergence herbicides applied 11 May: assessment date, growth stage (cot cotyledon, TL true leaf), crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment date:*** ***Untreated GS:***	**Rate**	**Carrot** **7/6** **cotyledon**	 **3/7** **4 TL**	 **18/7** **6 TL**	 **30/7** **harvest**	**Parsnip** **7/6** **cotyledon**	 **3/7** **3 TL**	 **18/7** **5 TL**	 **30/7**	**Coriander** **26/5** **cotyledon**	 **7/6** **1 TL**	 **3/7** **bolting**
imazamox/pendimethalin	2N	6 red em cl	0	0	0	6 cl	0	0	0	8 st del	8	3
imazamox/pendimethalin N 3 L	N	7 cl	1	1	1	7 cl	0	0	0	9	8	5
imazamox/pendimethalin	1/2N	10	3	3	3	10	2	2	2	10	9	7
dimethachlor	2N	0	0	0	0	0	0	0	0	4 red em del	4 red em del	3 st dist
dimethachlor N 3 L	N	0	0	0	0	0	0	0	0	6	6 loss	5
dimethachlor	1/2N	2	0	0	0	1	1	1	0	8	9	9
oxyfluorfen	2N	3	0	0	1	0 em dead	0	0	0	8	7 st	3 nec
oxyfluorfen N 1.0 L	N	4	1	1	3	1 loss	0	0	0	9	8 st	6 st sc
oxyfluorfen	1/2N	5	2	2	3	2 loss	1	1	1	10	9 del	7 st sc

red em reduced emergence, del delayed emergence; st stunting; vig red vigour reduction; loss plant loss; cl chlorosis; dist distortion; nec necrosis; sc scorch

Table 7. Vining peas, dwarf French beans: pre-emergence herbicides applied 11 May: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Pea** **31/5** **2 node**	**7/6** **3 node**	**3/7** **flat pod**	**18/7** **canning**	**DF Beans** **31/5** **simple L**	**7/6** **1 trifoliate L**	**3/7** **yellow bud**	**18/7** **pods set**	**31/7** **freezing**
imazamox/pendimethalin	2N	10	9 st	9	10	10	8 st	8 st	10	10
imazamox/pendimethalin N 3 L	N	10	10	10	10	10	10	10	10	10
imazamox/pendimethalin	½ N	10	10	10	10	10	10	10	10	10
dimethachlor	2N	6 dist	5 dist	4	5	3 sc dist	3	3 st loss	3	4
dimethachlor N 3 L	N	8	7	7	7	5 sc	4 sc	4 del	4	5
dimethachlor	½ N	10	10	10	10	8	7 sc	7	8	9
oxyfluorfen	2N	5#	3#	2#	2	5 #	3#	2#	2	2
oxyfluorfen N 1.0 L	N	6	4 st	3	3	7	5	4	4	4
oxyfluorfen	½ N	8	6 st	6 del	7del	9	6 st	6	7	8

severe crinkling and distortion of new leaves, sc scorch; st stunting; dist distortion; nec necrosis; del delay; loss plant loss

Table 8. Swede and spinach: pre-emergence herbicides applied 11 May: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Swede** **23/5** **cotyledon**	**31/5** **1TL**	**7/6**	**3/7**	**Spinach** **23/5** **cotyledon**	**31/5** **2TL**	**7/6** **4TL harvest**	**3/7** **bolted**
imazamox/pendimethalin	2N	7 st cl	2 cl	0	0	5 red em st	2 st del	0	0
imazamox/pendimethalin N 3 L	N	8 st cl	3 cl	0	0	7 red em st	3 del	0	0
imazamox/pendimethalin	½ N	9 st cl	4 del	3	3	8 st	4 del	2	1
dimethachlor	2N	8 st	5	4	4	6	0	0	0
dimethachlor N 3 L	N	10	8	8	9	8 st	4	4	4
dimethachlor	½ N	10	10	9	10	10	8	7	7
oxyfluorfen	2N	0 red em nec	0	0	0	0 red em nec	0	0	0
oxyfluorfen N 1.0 L	N	0 red em nec	0	0	1	0 red em nec	0	0	0
oxyfluorfen	½ N	4	3	1	2	0 red em nec	0	0	0

red em reduced emergence, del delay; cl chlorosis; st stunting; dist distortion; nec necrosis

Table 9. Celery, cauliflower and lettuce transplants: pre-weed-emergence herbicide imazamox/pendimethalin applied pre-transplanting 5 May: dimethachlor and oxyfluorfen applied post-transplanting pre-weed-emergence 11 May, assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***Untreated GS:***	**Rate**	**Celery** **23/5** **2 new lves**	**31/5**	**7/6**	**3/7**	**Cauliflower** **23/5**	**31/5**	**7/6**	**3/7**	**23/7** **mature**	**Lettuce** **23/5**	**31/5**	**7/6**	**3/7** **over** **mature**
imazamox/pendimethalin	2N	10	9	8 st	0	8	7 st	5 st	3 st death	5	2	1	1	1st
imazamox/pendimethalin N 3 L	N	10	10	9 st	2 st	9	8	6 st	5 st	7	4	2	2	2st
imazamox/pendimethalin	½ N	10	10	10	3 st	10	10	10	10	10	6	3	3	3st
dimethachlor	2N	7 sc	6	5 st	4 st dist	10	10	10	10	10	8	6	6	5 dist
dimethachlor N 3 L	N	9 sc	8	7	6 st dist	10	10	10	10	10	9	8	8	9
dimethachlor	½ N	10	9	8	8	10	10	10	10	10	10	9	9	10
oxyfluorfen	2N	3 sc dist	3	3	5	7 sc gpt	8 st	10	10	10	0	0	0	0
oxyfluorfen N 1.0 L	N	5 sc	5	5	7	8	9	10	10	10	1	1	1	3 del
oxyfluorfen	½ N	6 sc	6	6	9	9	10	10	10	10	2	3	3	4 del

del delayed maturity, dist distorted, sc scorch, gpt growing point, st stunted

Crop Safety Scores (mean of two replicates) post-weed-emergence herbicides

Table 10. Onion, leek: post-emergence herbicides applied 7 June at 2 L stage: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Onion** **13/6** **2 L**	**20/6** **3 L**	**10/7** **6 L**	**27/7**	**Leek** **13/6** **2 L**	**20/6** **3 L**	**10/7** **5 L**	**27/7**
LBI N 60 g	N	7 w cl	5	3	3 cl curled down	7 w cl	4	2	2 cl curled down
LBI	½ N	8 dist	7	5	6 cl curled down	7	5	3	4 cl curled down
LBI	¼ N	9	8	6	7 cl curled down	9	6	4	5 cl curled down
oxyfluorfen N1.0 L	N	6 dist sc	6 white tip	5 st white tip	7 st white tip	6 dist sc	6	4 st	6 st white tip
oxyfluorfen	½ N	8	7 kink	10	10	7	7 kink	6	7 white tip
oxyfluorfen	¼ N	10	9	10	10	9	8	9	9
BAS 635H N 70 g	N	5 w cl	4 w cl	3 w	3 w	4 w severe cl	3	2 w	2 w
BAS 635H	½ N	5	5 w cl	4 w	4 w	5	4	3 w	3 w
BAS 635H	¼ N	7	6 w cl	4 w	5 w	6	5	3 w	4 w
Bacara N 1.0 L	N	9	5 band	7 band	8	8 cl	5	4 band	6
Bacara	½ N	10	7	8	9	9	7	7 band	8
Bacara	¼ N	10	9	10	10	10	9	9	10

w wilt cl chlorosis; st stunting; bl bleached spots; band bleached bands; nec necrosis; sc scorch; dist distortion

Table 11. Carrot, parsnip post-emergence herbicides applied 18/6 at 2 TL stage carrot, 1 – 2 TL parsnip; coriander 3 TL: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Carrot** **23/6** **3 TL**	 **10/7** **4- 5 TL**	 **26/7** **6-7 TL**	**Parsnip** **23/6** **2 TL**	 **10/7** **3 TL**	 **26/7** **5 TL**	**Coriander** **23/6** **4 - 5TL**	 **10/7** **flowering**
LBI	2N	2 dist	1 dead	1	1 dist, cl, w	1 death	0	1 w dist cl	0
LBI N 60 g	N	4	4 gr	4	1	1 death	1	1	0
LBI	½ N	7	6 thin	6	2	3 dist	3	2	0
oxyfluorfen	2N	1 sc sc (loss 2 leaves)	1 death	2	1 sc	1 death	2	2 severe sc sc (loss 2 leaves)	1
oxyfluorfen N1.0 L	N	2 sc	2	3	2 sc	2	3	3 sc (loss 1-2 leaves)	2
oxyfluorfen	½ N	4 sc	3	4	3 sc	3	4	4 sc	3
BAS 635H	2N	2 w dist	0	0	2 w dist	0	0	2 w dist	0
BAS 635H N 70 g	N	2	0	0	2	0	0	3	0
BAS 635H	½ N	3	0	0	2	0	0	4	0
Bacara	2N	5 (10% bl)	3 (100% bl)	3	5 (10% bl)	3 (50% bl)	3	3 (10% bl)#	2 bl
Bacara N 1.0 L	N	6 (1% bl)	4 (50% bl)	7	6 (5% bl)	4 (30% bl)	5	6 (2–5% bl)#	5 bl
Bacara	½ N	9	7 (10% bl)	9	9 slight bl	7 (10% bl)	9	7 (0.5% bl)#	6 bl

gr several wart-like growths on roots, dist distortion, sc scorch; st stunting; cl chlorosis; bl bleaching, w wilt, # bleaching caused quality loss for leaf herb

Table 12. Peas, dwarf French beans, swede, spinach: post-emergence herbicides applied 7/6 peas 4 nodes; swede 2TL; spinach 2TL; dwarf French beans one trifoliate L; assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment:*** ***Untreated GS:***	**Rate**	**Peas** **13/6** **5 node**	**20/6** **1st flower**	**10/7** **freezing**	**DFBeans** **13/6** **1trifoliate L**	**20/6** **2 trifol L**	**10/7** **pod set**	**Swede** **13/6** **4TL**	**20/6** **5-6 TL**	**10/7** **100% cover**	**Spinach** **13/6** **5 TL**	**20/6** **harvest**	**3/7** **bolted**
LBI	2N	3 w dist	0	0	3 dist	0	0	10	10	5 st #	2 w cl	2	1 st
LBI N 60 g	N	4 w dist	0	0	4 dist	1	0	10	10	7 st #	4 w cl	3.5	2 cl gpt dead
LBI	½ N	5 dist	1	0	5 dist	2	0	10	10	10	6 w cl	5	3 cl gpt dead
oxyfluorfen	2N	2 sc gpt	0	0	2 sc	0	0	1 nec	0	0	0 nec	0	0
oxyfluorfen N1.0 L	N	3 sc	1	1	2 sc	2	1	2 sc	2	5	1 nec	0	0
oxyfluorfen	½ N	4 sc	2	3	3 sc	3	3	3	4 leaf loss	8	2 nec	1	1
BAS 635H	2N	2 w dist	0	0	3 dist	0	0	2 w cl	1	0	2 w	0	0
BAS 635H N 70 g	N	3w dist	0	0	4 dist	1	0	4 w	1	0	3 w	1	0
BAS 635H	½ N	5 w dist	0	0	5 dist	1	0	5	1	1	5 w	2	0
Bacara	2N	4 bl	5	5	4 bl	1	0	2 bl	2	5 st (20% bl)	3 bl	3	2
Bacara N 1.0 L	N	6 bl	7	7	5 bl	3	2 st del	4 bl	2	6 st (10% bl)	5 bl	5	4
Bacara	½ N	7 bl	9	9	6 bl	4	4 del	5 bl	3	7 st (5% bl)	6 bl	6	5

w wilting; sc scorch; st stunting; cl chlorosis; bl bleaching; dist distortion, nec necrosis; del delay; # leaf cupping and stunting – became more severe later on 23/7

Table 13. Celery, cauliflower, lettuce: post-emergence herbicides applied 17/5 to established transplants: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***Untreated GS:***	**Rate**	**Celery** **31/5** **3 new leaves**	**20/6** **5-6 new lves**	**10/7** **mature**	**Cauliflower** **31/5**	**20/6**	**10/7**	**23/7** **mature**	**Lettuce** **23/5**	**7/6**	**20/6** **mature**
LBI	2N	2 w dist nec	0	0	8 w dist	6 st vc	4 am	4 am	4 w dist cl	0	0
LBI N 60 g	N	2 w dist nec	0	0	10	8 vc	6 am	6 am	5.5 w dist cl	0	0
LBI	½ N	3 w dist nec	0	0	10	10	9	9	6.5 w dist	0	0
oxyfluorfen	2N	2 sc	1 st dist	1 sc st#	5.5 nec gpt	9 st	9 st del	9	0 nec	0	0
oxyfluorfen N1.0 L	N	4 sc	3 st	3 st #	7 nec gpt	10	10	10	0 nec	0	0
oxyfluorfen	½ N	5 sc	4 st	4 st	9	10	10	10	2	1	1
BAS 635H	2N	0	0	0	0	0	0	0	2 dist	0	0
BAS 635H N 70 g	N	0	0	0	0	0	0	0	3 dist	0	0
BAS 635H	½ N	0	0	0	0	0	0	0	4 dist	0	0
Bacara	2N	7 bl	5 bl	5 bl st	1 cl gpt	0	0	0	4 cl bl	0	0
Bacara N 1.0 L	N	7 bl	6 bl	7 bl	2	1 st bl	0	0	5	1	1
Bacara	½ N	9	8	9	3	3 st bl	3 st del	4 del	7	3	3del

crinkled leaves; am advanced maturity loose open florets, vc vein clearing, bl bleached spots/areas, del delay, nec necrosis g pt growing point affected, st stunting
Initial effects on cauliflower and celery from BAS 635H (23/5 were wilting, distortion and leaves curling down

Crop Safety (summary)

The following information is based on only one trial, on an irrigated, light soil. For safety there should be no or negligible/transient damage at a recommended dose rate and no or acceptable effects at the overlap dose.

Table 1. Pre-emergence herbicide 3 safe; X not safe; all gave very good weed control. # applied pre-transplanting

Herbicide 'Normal' dose/ha	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Pea**	**Swede**	**Spinach**
imazamox/ pendimethalin # 3.0 L	X	X	X	X	X	X	3 ½N	X	3	3	X	X
dimethachlor 3.0 L	X	X	X	X	X	X	3	3 ½N	X	3 ½N	3 ½N	X
oxyfluorfen 1.0 L	X	X	X	X	X	X	3	X	X	X	X	X

Table 2. Post-emergence herbicide 3 safe; X not safe, (in parentheses marginally safe); all gave very good weed control, BAS 635H covered the widest weed spectrum.

Herbicide 'Normal' dose	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Pea**	**Swede**	**Spinach**
LB1 0.25L/ha	X	X	X	X	X	X	3 ½N	X	X	X	X	X
oxyfluorfen 1.0 L	3 ½N	3 ¼N	X	X	X	X	3	X	X	X	X	X
BAS 635H 70 g	X	X	X	X	X	X	X	X	X	X	X	X
Bacara 1.0 L	3 ½N	3 ¼N	(3 ½ N)	(3 ½ N)	X	3 ½N	X	X	X	3 ½N	X	X

Results Weed Control (predominant species in bold type, low population limited data in parentheses)

Table 14. Pre-weed-emergence herbicides applied 11 April: weed species remaining after treatment, weed species controlled, weed species on untreated plots of onion and leek drilled early on 8 April. A lot of irrigation applied. Assessed 28 May and 16 June. Related weed counts see below.

Herbicide	Weeds not controlled	Weeds controlled
imazamox/pendimethalin N 3 L	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
imazamox/pendimethalin ½ N	mayweeds*	shepherd's purse small nettle sowthistle groundsel poppy chickweed pale persicaria
imazamox/pendimethalin ¼ N	shepherd's purse poppy mayweeds groundsel	small nettle sowthistle chickweed pale persicaria
Untreated**: shepherd's purse mayweeds small nettle smooth sowthistle** groundsel common poppy chickweed pale persicaria		
dimethachlor N 3 L	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
dimethachlor ½ N	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
dimethachlor ¼ N	shepherd's purse poppy	mayweeds small nettle sowthistle groundsel chickweed pale persicaria
Untreated: **shepherd's purse mayweeds small nettle smooth sowthistle pale persicaria** groundsel common poppy chickweed		
oxyfluorfen N 1.0 L	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
oxyfluorfen ½ N	chickweed	shepherd's purse mayweeds small nettle sowthistle groundsel poppy pale persicaria
oxyfluorfen ¼ N	chickweed	shepherd's purse mayweeds small nettle sowthistle groundsel poppy pale persicaria
Untreated: **shepherd's purse mayweeds smooth sowthistle common poppy small nettle** groundsel chickweed pale persicaria		

* mayweed all Scentless mayweed

Number of weed species / m^2 on 17 May on untreated (pre-weed-emergence) for each herbicide area (mean 4 counts in 0.33 m^2 quadrat) and overall (mean 12 counts) in two replicates of onion and leek

	Shepherd's purse	Mayweeds	Small nettle	Sowthistle, smooth	Chickweed	Common poppy	Pale persicaria	Groundsel	TOTAL
Untreated (imazamox/pendimethalin)	258	194	30	48	6	14	9	9	568
Untreated (dimethachlor)	316	168	63	18	10	12	21	14	622
Untreated (oxyfluorfen)	218	170	6	28	18	8	3	8	470
Untreated	*264*	*177*	*33*	*32*	*12*	*11*	*11*	*10*	*550*

Table 15. Pre-weed-emergence herbicides applied 12 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of dwarf French beans, peas, swede, baby leaf spinach, coriander, carrot, parsnip. Assessed 16 June. Related weed counts see below

Herbicide	**Weeds not controlled**	**Weeds controlled**
imazamox/pendimethalin 2N	-	shepherd's purse mayweeds small nettle sowthistle chickweed pale persicaria redshank groundsel
imazamox/pendimethalin N 3 L	(fumitory)	shepherd's purse mayweeds small nettle sowthistle chickweed pale persicaria redshank groundsel
imazamox/pendimethalin ½ N	shepherd's purse mayweeds pale persicaria sowthistle small nettle groundsel	chickweed redshank
Untreated**: shepherd's purse mayweeds small nettle smooth sowthistle chickweed pale persicaria** redshank groundsel		
dimethachlor 2N	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
dimethachlor N 3 L	-	shepherd's purse mayweeds small nettle sowthistle groundsel poppy chickweed pale persicaria
dimethachlor ½ N	small nettle shepherd's purse chickweed (poppy fat-hen fumitory)	mayweeds groundsel pale persicaria sowthistle
Untreated: **shepherd's purse mayweeds small nettle smooth sowthistle chickweed** fat-hen pale persicaria		
oxyfluorfen 2 N	-	shepherd's purse mayweeds small nettle sowthistle pale persicaria chickweed redshank groundsel
oxyfluorfen N 1.0 L	chickweed	shepherd's purse mayweeds small nettle sowthistle pale persicaria redshank groundsel
oxyfluorfen ½ N	chickweed	shepherd's purse mayweeds small nettle sowthistle pale persicaria redshank groundsel
Untreated: **shepherd's purse mayweeds small nettle smooth sowthistle pale persicaria chickweed** redshank groundsel		

Number of weed species / m^2 on 7 June on untreated (pre-weed-emergence) for each herbicide area (mean 14 counts in 0.33 m^2 quadrat) and overall (mean 42 counts) in 2 replicates of coriander, carrot, parsnip, pea, dwarf bean, swede and spinach

	Shepherd's purse	Mayweeds	Small nettle	Sowthistle, smooth	Chickweed	Redshank	Pale persicaria	Fat-hen	Common poppy	Black-bindweed	Knotgrass	Field speedwell	Fumitory	Groundsel	TOTAL
Untreated (imazamox/pendimethalin)	30	17	13	14	6	1	3	0	<1	0	<1	0	1	1	86
Untreated (dimethachlor)	39	32	33	10	9	2	5	6	1	2	1	1	<1	1	142
Untreated (oxyfluorfen)	43	22	26	32	8	4	22	<1	1	2	0	<1	0	2	163
Untreated overall	*35*	*24*	*24*	*19*	*8*	*2*	*10*	*3*	*1*	*1*	*<1*	*<1*	*<1*	*1*	*129*

Table 16. Pre-weed-emergence herbicides imazamox/pendimethalin applied 5 May pre-transplanting, dimethachlor and oxyfluorfen post-transplanting 12 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of lettuce, cauliflower and celery. Assessed date 12 June. Related weed counts see below

Herbicide	**Weeds not controlled**	**Weeds controlled**
imazamox/pendimethalin 2N	-	shepherd's purse small nettle pale persicaria mayweeds sowthistle groundsel chickweed
imazamox/pendimethalin N 3 L	-	shepherd's purse small nettle pale persicaria mayweeds sowthistle groundsel chickweed
imazamox/pendimethalin ½ N	shepherd's purse mayweeds small nettle sowthistle groundsel	pale persicaria chickweed
Untreated**: shepherd's purse small nettle pale persicaria** mayweeds smooth sowthistle groundsel chickweed		
dimethachlor 2N	-	shepherd's purse small nettle mayweeds chickweed groundsel
dimethachlor N 3 L	-	shepherd's purse small nettle mayweeds chickweed groundsel
dimethachlor ½ N	shepherd's purse small nettle chickweed (common poppy fat-hen)	groundsel mayweeds
Untreated: **shepherd's purse small nettle mayweeds chickweed** groundsel		
oxyfluorfen 2N	-	shepherd's purse small nettle mayweeds pale persicaria chickweed sowthistle groundsel
oxyfluorfen N 1.0 L	chickweed	shepherd's purse small nettle mayweeds pale persicaria sowthistle groundsel
oxyfluorfen ½ N	chickweed	shepherd's purse small nettle mayweeds pale persicaria sowthistle groundsel
Untreated: **shepherd's purse small nettle mayweeds pale persicaria chickweed** smooth sowthistle groundsel		

Number of weed species / m^2 on 4 June on untreated (pre-weed-emergence) for each herbicide area (mean 6 counts in 0.33 m^2 quadrat) and overall (mean 18 counts) in 2 replicates of lettuce, cauliflower and celery

	Shepherd's purse	Mayweeds	Small nettle	Sowthistle, smooth	Chickweed	Common poppy	Pale persicaria	Fat-hen	Groundsel	TOTAL
Untreated (imazamox/pendimethalin)	35	7	28	4	9	0	27	1	5	115
Untreated (dimethachlor)	33	10	31	1	10	1	1	5	4	96
Untreated (oxyfluorfen)	41	11	22	2	6	1	13	0	2	98
Untreated overall	*36*	*9*	*27*	*2*	*9*	*1*	*14*	*2*	*4*	*104*

Table 17. Pre-weed-emergence herbicides: weed control score (0 no control; 7 acceptable; 10 complete control) assessment date 16 June (35 DAT drilled; 42 DAT Nirvana applied pre- transplants; 30 DAT applied post transplants)

Herbicide	Peas enclosed bud	D Beans 1 ½trifoliate	Celery	Cauliflower	Lettuce	Swede 5TL	Spinach 5 TL	Carrot 2TL	Parsnip 1TL	Coriander 3TL	Onion 2-3L	Leek 2-3L
imazamox/pendimethalin 2N	10	10	10	10	10	10	10	10	10	10	-	-
imazamox/pendimethalin N 3 L	10	10	10	10	10	10	10	10	10	10	10	10
imazamox/pendimethalin ½ N	6	6	9.5	9.5	9.5	9.9	9.9	9.2	9.2	9.5	9.2	9.2
imazamox/pendimethalin ¼ N	-	-	-	-	-	-	-	-	-	-	5	5
dimethachlor 2N	10	10	10	10	10	10	10	10	10	10	-	-
dimethachlor N 3 L	10	10	10	10	10	10	10	10	10	10	10	10
dimethachlor ½ N	9.9	9.9	9.5	9.5	9.5	10	10	9.9	9.9	9.7	9	9
dimethachlor ¼ N	-	-	-	-	-	-	-	-	-	-	4	4
oxyfluorfen 2N	10	10	10	10	10	10	10	10	10	10	-	-
oxyfluorfen N 1.0 L	9.9	9.9	9.5	9.5	9.9	10	10	9.5	9.5	9.9	9	9
oxyfluorfen ½ N	9.9	9.9	9.2	9.2	9.5	9.9	9.9	9	9	9.5	9	9
oxyfluorfen ¼ N	-	-	-	-	-	-	-	-	-	-	5	5

Results Weed Control **(predominant species bold, low population limited data in parentheses)**

Table 18. Post-weed-emergence herbicides applied 7 June: weed species controlled, weed species on untreated plots of onion and leek. Area treated pre-weed-emergence with ½ dose rate of Stomp + propachlor (0.75 + 4.5) L/ha but a few weeds remained. Assessed 20 June. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
LBI N 60 g	shepherd's purse (ivy-leaved speedwell)	mayweeds (small nettle chickweed groundsel)
LBI ½ N	shepherd's purse (chickweed ivy-leaved speedwell fumitory)	mayweeds (small nettle black-bindweed knotgrass groundsel)
LBI ¼ N	shepherd's purse mayweeds (small nettle chickweed black-bindweed groundsel)	some mayweeds
Untreated: **shepherd's purse** mayweeds (small nettle chickweed black-bindweed groundsel)		
oxyfluorfen N 1.0 L	(chickweed))	shepherd's purse mayweeds (small nettle)
oxyfluorfen ½ N	(chickweed redshank)	shepherd's purse mayweeds
oxyfluorfen ¼ N	chickweed shepherd's purse mayweeds (pale persicaria redshank)	
Untreated: **shepherd's purse pale persicaria** (mayweeds chickweed)		
BAS 635H N 70 g	-	shepherd's purse
BAS 635H ½ N	-	shepherd's purse
BAS 635H ¼ N	-	shepherd's purse
Untreated: **shepherd's purse**		
Bacara N 1.0 L	-	shepherd's purse mayweeds (chickweed small nettle knotgrass)
Bacara ½ N	mayweeds (redshank)	shepherd's purse (chickweed small nettle)
Bacara ¼ N	mayweeds shepherd's purse (knotgrass small nettle)	
Untreated: **shepherd's purse mayweeds** (redshank knotgrass small nettle chickweed)		

Number of weed species / m^2 remaining on 7 June after pre-emergence ½ N dose Stomp + Ramrod on two replicates (mean of 16 counts in 0.33 m^2 quadrat) in onion and leek

	Shepherd's purse	Mayweeds	Small nettle	Chickweed	Black-bindweed	Pale persicaria	Groundsel	TOTAL
Untreated	*13*	*6*	*2*	*1*	*2*	*2*	*<1*	*26*

Table 19. **Post-weed-emergence herbicides** applied 7 June to dwarf French beans, peas, swede, baby leaf spinach; 18 June coriander: weed species controlled, weed species on untreated. Assessed 13 June.

Herbicide	**Weed species not controlled**	**Weed species controlled**
LBI 2 N	shepherd's purse	mayweeds groundsel sowthistle small nettle pale persicaria chickweed
LBI N 60 g	shepherd's purse (speedwells)	mayweeds groundsel sowthistle small nettle pale persicaria chickweed
LBI ½ N	shepherd's purse chickweed small nettle (speedwells)	mayweeds groundsel sowthistle pale persicaria
Untreated: **shepherd's purse small nettle pale persicaria chickweed mayweeds** groundsel smooth sowthistle		
oxyfluorfen 2N	chickweed	shepherd's purse small nettle mayweeds pale persicaria redshank groundsel sowthistle
oxyfluorfen N 1.0 L	chickweed	shepherd's purse small nettle mayweeds pale persicaria redshank groundsel sowthistle
oxyfluorfen ½ N	chickweed shepherd's purse	small nettle mayweeds pale persicaria redshank groundsel sowthistle
Untreated: **shepherd's purse small nettle mayweeds chickweed** pale persicaria redshank groundsel sowthistle		
BAS 635H 2N		shepherd's purse small nettle chickweed mayweeds pale persicaria redshank groundsel knotgrass
BAS 635H N 70 g	(fat-hen)	shepherd's purse small nettle chickweed mayweeds pale persicaria redshank groundsel knotgrass
BAS 635H ½ N	(fat-hen annual meadow-grass) knotgrass	shepherd's purse small nettle chickweed mayweeds pale persicaria redshank groundsel
Untreated: **shepherd's purse small nettle chickweed mayweeds** pale persicaria redshank groundsel knotgrass		
Bacara 2N		small nettle shepherd's purse mayweeds chickweed groundsel sowthistle
Bacara N 1.0 L	mayweeds	small nettle shepherd's purse chickweed groundsel sowthistle
Bacara ½ N	mayweeds groundsel small nettle (redshank knotgrass)	shepherd's purse chickweed sowthistle (fumitory)
Untreated: **small nettle shepherd's purse mayweeds chickweed** groundsel smooth sowthistle		

Number of weed species/m^2 on untreated (post-weed-emergence) for each herbicide area (mean 10 counts in 0.33 m^2 quadrat) and overall (mean 40 counts) in 2 replicates of areas on dwarf French beans, peas, swede, baby-leaf spinach on 13 June; on coriander 18 June

	Shepherd's purse	Mayweeds	Small nettle	Sowthistle, smooth	Chickweed	Common poppy	Knotgrass	Field speedwell	Pale persicaria	Redshank	Fumitory	Groundsel	TOTAL
Untreated (LB1)	55	13	47	3	13	1	2	1	47	0	1	3	186
Untreated (oxyfluorfen)	84	22	32	4	12	1	<1	1	4	4	0	4	168
Untreated (BAS 635H)	90	8	79	1	13	<1	4	<1	4	4	1	4	208
Untreated (Bacara)	39	10	80	4	14	1	1	1	<1	0	<1	4	154
Untreated overall	*67*	*13*	*60*	*3*	*13*	*1*	*2*	*1*	*13*	*2*	*1*	*4*	*180*

Table 21. Post-weed-emergence herbicides applied 17 May to small (cotyledon stage) weeds celery, lettuce & cauliflower transplants: weed species not controlled, weed species controlled, weed species on untreated. Assessed 13 June

Herbicide	**Weed species not controlled**	**Weed species controlled**
LBI 2 N	shepherd's purse	chickweed mayweeds common poppy groundsel knotgrass small nettle
LBI N 60 g	shepherd's purse (ivy-leaved and field speedwell)	chickweed mayweeds common poppy groundsel knotgrass small nettle
LBI ½ N	shepherd's purse chickweed small nettle (ivy-leaved and field speedwell)	mayweeds common poppy groundsel knotgrass
Untreated: **shepherd's purse chickweed mayweeds common poppy** groundsel knotgrass small nettle		
oxyfluorfen 2N	-	shepherds purse mayweeds chickweed small nettle groundsel common poppy
oxyfluorfen N 1.0 L	-	shepherds purse mayweeds chickweed small nettle groundsel common poppy
oxyfluorfen ½ N	-	shepherds purse mayweeds chickweed small nettle groundsel common poppy
Untreated: **shepherds purse mayweeds chickweed small nettle** groundsel common poppy		
BAS 635H 2N	-	shepherds purse small nettle mayweeds chickweed groundsel common poppy
BAS 635H N 70 g	-	shepherds purse small nettle mayweeds chickweed groundsel common poppy
BAS 635H ½ N	-	shepherds purse small nettle mayweeds chickweed groundsel common poppy
Untreated: **shepherds purse small nettle mayweeds chickweed** groundsel common poppy		
Bacara 2N	-	shepherds purse small nettle mayweeds chickweed
Bacara N 1.0 L	-	shepherds purse small nettle mayweeds chickweed
Bacara ½ N	-	shepherds purse small nettle mayweeds chickweed
Untreated: **shepherds purse small nettle mayweeds chickweed**		

Number of weed species/m^2 on 13 June on untreated (post-weed-emergence) for each herbicide area (mean 6 counts in 0.33 m^2 quadrat) and overall (mean 24 counts) on 2 replicates of celery, cauliflower and lettuce

	Shepherd's purse	Mayweeds	Small nettle	Sowthistle,	Chickweed	Common poppy	Knotgrass	Field speedwell	Fumitory	Groundsel	TOTAL
Untreated (LB1)	26	11	2	1	12	6	3	1	1	3	66
Untreated (oxyfluorfen)	43	13	8	0	10	2	<1	1	0	2	79
Untreated (BAS 635H)	49	6	10	0	10	2	<1	0	0	2	79
Untreated (Bacara)	36	8	26	0	12	<1	2	0	<1	1	85
Untreated overall	*38*	*10*	*12*	*0*	*12*	*3*	*2*	*<1*	*<1*	*2*	*77*

Table 22. Post-weed-emergence herbicides applied early 17 May to celery, cauliflower, lettuce transplants; on 7 June to dwarf French beans, peas, swede, baby leaf spinach; 18 June to coriander. Assessed 20 June (3 July coriander). Weed control score (0 no control; 7 acceptable; 10 complete control)

Herbicide	DFBeans	Peas	Swede	Spinach	Coriander	Celery	Cauliflower	Lettuce
LBI 2 N	6	8	9	9	9.5	9.5	9.5	9.5
LBI N 60 g	4	8	9	8	9	9	9	9
LBI ½ N	2	6	5	5	7	5.5	5.5	5.5
oxyfluorfen 2N	9	10	10	10	10	10	10	10
oxyfluorfen N 1.0L	8	9.5	10	10	10	10	10	10
oxyfluorfen ½ N	5	6	7.5	7	9	10	10	10
BAS 635H 2N	10	10	10	10	10	10	10	10
BAS 635H N 70 g	10	10	10	10	10	10	10	10
BAS 635H ½ N	10	10	9	7	10	10	10	10
Bacara 2N	9.5	10	10	10	10	10	10	10
Bacara N 1.0 L	9	9	10	10	10	10	10	10
Bacara ½ N	5	5	9	9	6	10	10	10

Table 23. **Post-weed-emergence herbicides** applied 7 June to onion and leek. A ½ dose of standard pre-emergence Stomp + Ramrod (0.75 + 4.5) L/ha applied 11 April and main weeds remaining were: shepherd's purse, mayweeds, and small nettle. Weed control score for the **programme** (0 no control; 7 acceptable; 10 complete control) assessed 20 June

Herbicide	Onion	Leek
LBI N 60 g	7	8
LBI ½ N	5	5
LBI ¼ N	4	4
oxyfluorfen N 1.0 L	10	10
oxyfluorfen ½ N	7	8
oxyfluorfen ¼ N	5	5
BAS 635H N 70 g	10	10
BAS 635H ½ N	10	10
BAS 635H ¼ N	10	10
Bacara N 1.0 L	9.5	9.5
Bacara ½ N	7.5	7.5
Bacara ¼ N	5.5	5.5

Table 24. Post-weed-emergence herbicides applied 18 June to carrot and parsnip but no weeds were present and none emerged later. . A ½ dose of standard pre-emergence herbicide Stomp + Linuron (1.6 + 1.0) L/ha controlled all species. Assessed 23 June and 18 July. Weed control score for the **programme** (0 no control; 7 acceptable; 10 complete control).

Herbicide	**Carrots**	**Parsnips**
LBI 2 N	10	10
LBI N 60 g	10	10
LBI ½ N	10	10
oxyfluorfen 2N	10	10
oxyfluorfen N 1.0 L	10	10
oxyfluorfen ½ N	10	10
BAS 635H 2N	10	10
BAS 635H N 70 g	10	10
BAS 635H ½ N	10	10
Bacara 2N	10	10
Bacara N 1.0 L	10	10
Bacara ½ N	10	10

Weed species controlled (summary)

Table 3. Pre-weed-emergence herbicides: √ weed species controlled; X poor control or not controlled by the herbicides at various dose rates; - weeds not present on untreated plots

Pre-weed-emergence Herbicide	**Shepherd's purse**	**Scentless mayweed**	**Small nettle**	**Pale persicaria**	**Chickweed**	**Smooth sowthistle**	**Groundsel**	**Redshank**	**Common poppy**	**Fumitory**	**Fat-hen**
imazamox/pendimethalin 2 N	√	√	√	√	√	√	√	√	-	-	-
imazamox/pendimethalin N 3 L	√	√	√	√	√	√	√	√	-	(X)	-
imazamox/pendimethalin ½ N	X	X	X	√	√	X	X	-	-	-	-
imazamox/pendimethalin ¼ N	X	X	X	√	√	X	X	-	X	-	-
dimethachlor 2N	√	√	√	√	√	√	√	-	√	-	-
dimethachlor N 3 L	√	√	√	√	√	√	√	-	√	-	-
dimethachlor ½ N	X	√	X	√	√	√	√	-	X	-	(X)
dimethachlor ¼ N	X	X	X	√	√	√	X	-	X	-	-
oxyfluorfen 2N	√	√	√	√	√	√	√	√	√	-	-
oxyfluorfen N 1.0 L	√	√	√	√	X	√	√	√	√	-	-
oxyfluorfen ½ N	√	√	√	√	X	√	√	√	√	-	-
oxyfluorfen ¼ N	√	√	√	√	X	√	√	-	√	-	-

Table 4. Post-weed-emergence herbicides: √ weed species controlled; √ or # controlled at cotyledon stage; ( ) low population on area; X poor control or not controlled by the herbicides at various dose rates; - weeds not present on untreated plots,

Post-weed-emergence Herbicide	**Shepherd's purse**	**Scentless mayweed**	**Small nettle**	**Chickweed**	**Smooth sowthistle**	**Common poppy**	**Groundsel**	**Redshank**	**Pale persicaria**	**Speedwells**	**Knotgrass**	**(Fat-hen)**	**(Fumitory)**	**(Creeping thistle)**
LBI 2 N	X	√	√	√	√	√	√	-	√	-	√	-	-	√
LBI N 0.25L	X	√	√	√	√	√	√	-	√	(X)	√	-	-	√
LBI ½ N	X	√	X	X	√	√	√	-	√	(X)	√	-	-	√
LBI ¼ N	X	X	X	X	-	-	-	-	-	(X)	-	-	-	-
oxyfluorfen 2N	√	√	√	X #	√	√	√	√	√	-	-	-	-	√
oxyfluorfen N 1.0L	√	√	√	X#	√	√	√	√	√	-	-	-	-	-
oxyfluorfen ½ N	√	√	√	X#	√	√	√	√	√	-	-	(X)	-	-
oxyfluorfen ¼ N	X	X	-	X	-	-	-	X	X	-	-	-	-	-
BAS 635H 2N	√	√	√	√	-	-	√	√	√	-	√	√	-	√
BAS 635H N 70 g	√	√	√	√	-	-	√	√	√	-	√	X	-	√
BAS 635H ½ N	√	√	√	√	-	-	√	√	√	-	X	X	-	√
BAS 635H ¼ N	√	-	-	-	-	-	-	-	-	-	-	-	-	-
Bacara 2N	√	√	√	√	√	-	√	-	-	-	-	-	√	-
Bacara N 1.0 L	√	X#	√	√	√	-	√	-	X	-	-	-	√	-
Bacara ½ N	√	X#	X#	√	√	-	X	(X)	X	-	(X)	-	(√)	-
Bacara ¼ N	√	X	X	-	-	-	X	(X)	X	-	(X)	-	-	-

Conclusions

The aim of this trial was to screen herbicides for crop safety, with a view to further development and applications for SOLAs. *Active substances in italics are not yet registered in the UK and it will take time before they are available to the grower.*

Crop safety
At Kirton the irrigation applied (and the above average rainfall in April and the beginning of May) provided a stringent test of safety of residual soil acting herbicides.
This study has identified potential alternative active substances (Tables1 and 2) which, on limited data on a silt loam (light soil type), would appear to be safe (non-phytotoxic), at the timing and rates of product/ha or (a.i.)/ha suggested. The most promising safe, effective herbicides, rate product/ha (a.i./ha) were for:

- Bulb onion – post-weed-emergence *oxyfluorfen* ½ N 0.5 L/ha (120g) [*oxyfluorfen* is registered in Spain for pre-emergence application in drilled onions and sets but it was too damaging in this trial where there was too much irrigation on the onion and leek area – it may possibly be safe with no irrigation]; post-weed-emergence Bacara ½ N 0.5 L/ha (flurtamone/diflufenican 125/50g)

- Leek – post-weed-emergence *oxyfluorfen* ¼ N 0.25 L/ha (60g); post-weed-emergence Bacara ¼ N 0.25 L/ha (flurtamone/diflufenican 62.5/25g)

- Carrot and parsnip - post-weed-emergence possibly Bacara ½ N 0.5 L/ha (flurtamone/diflufenican 125/50g)

- Vining peas – pre-emergence *imazamox/pendimethalin* N 3.0 L/ha (50/750g) UK registration is being sought for peas; *dimethachlor* 1.5 L/ha (250g); post-weed-emergence Bacara ½ N 0.5 L/ha (flurtamone/diflufenican 125/50g)

- Dwarf French beans – pre-emergence *imazamox/pendimethalin* 3.0 L/ha (50/750g)

- Celery transplants – after transplanting post-weed-emergence Bacara 0.5 L/ha (flurtamone/diflufenican 125/50g)

- Cauliflower transplants – *oxyfluorfen* N 1.0 L/ha (240 g a.i./ha) applied after transplanting pre-weed-emergence and later post-weed-emergence caused initial damage to cauliflower (scorch to the leaves and growing point) but plants soon recovered; application after transplanting pre-weed-emergence *dimethachlor* 3.0 L/ha (500g); after transplanting post-weed-emergence. LB1 N dose appeared to advance maturity and produce loose, open curds but the ½ N 0.125 L/ha (30 g) may be safe.

- Lettuce transplants – post-transplanting pre-weed-emergence *dimethachlor* 1.5 L/ha (250g)

- Swede - pre-weed-emergence *dimethachlor* 1.5 L/ha (250g)

- Spinach, coriander – nothing safe

Rainfall and irrigation increased damage from residual soil acting herbicides and damage was greater for the earlier drilled onions and leeks, where too much irrigation followed by soil capping reduced emergence on untreated plots.

The trial was on a light, silt loam soil. Promising herbicides also need to be tested on very light soils/sands where appropriate for the crop

Post-emergence herbicides were applied on 17 May and 7 June under cool conditions, but carrots, parsnip and coriander were sprayed on 18 June and later that day temperatures rose above 29ºC and this may have increased damage.

Imazamox/pendimethalin at 3.0 L/ha may be worth further investigation in dwarf beans. The dose rate of pendimethalin is low but application must be immediately after sowing.

It may be some time before dimethachlor becomes available in the UK.

Oxyfluorfen severely scorched crop species that were not well protected by leaf wax. Oxyfluorfen was applied to cauliflower early, (14 days after transplanting) - the older leaves were scorched and the growing point was affected by the N 1.0 L/ha and 2N dose. However, the plants recovered 3 weeks later. In onion it caused slight leaf distortion and white leaf tips, with more effect on leeks, but there was recovery later and it is worth further development in the UK in these crops. It is effective on a wide weed spectrum and severely damaged volunteer potatoes in a 2005 cauliflower trial FV 240. Early sprays allow more time for recovery and water volumes and droplet size may influence crop safety. Based on this years' work the leaf presentation of cauliflower appeared to have more effect on safety than leaf wax, i.e. erect onion leaves trapped less spray than horizontal ones.

BAS 635H 0.07kg/ha: caused wilting and curled leaves initially, followed by severe stunting and death of all crops except onion and leek, where some survived but leaves remained wilted. Symptoms were typical of a sulfonylurea but it was very fast-acting.

Bacara (flurtamone/diflufenican) caused bleaching on those leaves present at application, symptoms typical of diflufenican. Flurtamone also causes bleaching – this is why effects were more severe than for diflufenican alone in the 2004 trial. Effects were unacceptable in short season crops where there was no time to recover, and where leaves are marketed – coriander, baby-leaf spinach. It could be evaluated in the HDC carrot and parsnip trials (FV 236b)

The 'Essential Uses' of important herbicides expire 31 December 2007. This work allows the industry to demonstrate to the European Commission that action has been taken to find alternatives, so that these uses can continue.

Weed control

Many of the lost herbicides are for post-emergence use on weed species that escape pre-emergence control, however a pre-emergence residual herbicide is essential for slow-emerging crops, such as parsnips, or in a quick growing crop (coriander, lettuce, baby-leaf spinach) where the time from planting/sowing to harvest is short. All herbicides screened in the 2005 trial controlled a wide weed spectrum and had few weaknesses.

Residual herbicides applied pre-weed-emergence:
imazamox/pendimethalin at 3.0 L/ha controlled all weeds at the Kirton site but may be less effective on fumitory and at low rates did not control mayweeds or groundsel; dimethachlor at doses of 1.5 L/ha or less did not control common poppy, shepherd's purse or small nettle; oxyfluorfen controlled all weed species present, even at 0.25 L/ha, but chickweed appeared to be resistant.

Post-weed-emergence herbicides:
LB1 was particularly effective on Compositae – mayweeds, groundsel and creeping thistle, but shepherds purse, and possibly speedwell was not controlled. Oxyfluorfen was very effective on all species except chickweed, although this was controlled at cotyledon stage.
BAS 635H at all dose rates tested killed all weeds, including creeping thistle, with the exception of fat-hen (and completely killed all crops except onion and volunteer wheat). Bacara appeared to control fumitory, but was ineffective on mayweeds and groundsel at 0.5 L/ha.

A Table given in Annex 2 shows data on UK labels and from trials or labels in other countries for weed susceptibility, for all herbicides in the trials.

Herbicides: Current Approval Status

Product	**Active ingredient * (g a.i. / L & formulation)**	**Manufacturer/ Company**	**Approval/Registration status now *or in future***
Pre-emergence			
(Nirvana) #	imazamox/pendimethalin (16.7/250 g/L)	Bayer CropScience	No UK approval, France peas
(Teridox)#	dimethachlor (500 g/L SC)	BASF	*? oilseed rape*
(Goal) #	oxyfluorfen (24% EC)	Syngenta	No UK approval, Spain, onions, brassicas
Post-emergence			
LB1#	confidential	confidential	confidential
(Goal) #	oxyfluorfen (24% EC)	Makhteshim	No UK approval, Spain, onions, brassicas
BASF635H#	confidential	BASF	No UK approval, ? *Maize, cereals*
Bacara	flurtamone/diflufenican (250/100) g/L	Bayer CropScience	UK cereals

 # product name in another country; Green text on Annex 1 positive list August 2005

Recommendations

Some of the herbicides identified as potentially useful are not yet available to UK growers. The EC Review process is also slower than anticipated. Close co-operation with Crop Protection Companies is needed to encourage Mutual Recognition as soon as herbicides are registered for minor uses. UK registration is sought for *imazamox/pendimethalin* for peas.

Further work is needed:

- on the irrigated site at Kirton evaluate other herbicides not included in the 2005 trial
- to evaluate oxyfluorfen in onions and leeks on very light soils/sands, and to continue work in cauliflower and cabbage.
- to evaluate Bacara in onion and leek; and include in 2006 carrot and parsnip trials (FV 236b),
- if possible assess efficacy against fumitory which has become a problem in some crops and was not present on the trial site
- to evaluate dimethachlor (depending on it's future) in cauliflower, swede and lettuce
- to evaluate imazamox/pendimethalin in dwarf French beans (but discuss with France first)
- to obtain residues data, if available from other countries, to support SOLA applications by HDC (already being done), and to set up trials where they are not available

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Appendix 1: Weeds found on the untreated trial areas

Latin name	Common name
Capsella bursa-pastoris	Shepherd's purse
Chenopodium album	Fat-hen
Cirsium arvense	Creeping thistle
Fumaria officinalus	Common fumitory
Matricaria spp.	Mayweeds
Papaver rhoeas	Common poppy
Persicaria maculosa	Redshank
Polygonum aviculare	Knotgrass
Polygonum convolvulus	Black-bindweed
Polygonum lapathifolium	Pale persicaria
Senecio vulgaris	Groundsel
Sonchus oleraceus	Smooth sowthistle
Stellaria media	Common chickweed
Tripleurospermum inodorum	Scentless mayweed
Urtica urens	Small nettle
Veronica persica	Common field speedwell
Veronica hederifolia	Ivy-leaved speedwell

Appendix 2

Herbicides applied pre- and post-weed-emergence

Weed susceptibility data from labels UK and other countries, this trial in red text and other information – please treat with caution

Key: S = Susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant

Common name	Latin name	imazamox/ pendimethalin Pre 3L/ha	dimethachlor Pre 2.5L/ha	oxyfluorfen Pre 1L/ha	LB1 Post 0.25L/ha	oxyfluorfen Post 1L/ha	BAS365H Post 70g/ha	Bacara Post 1L/ha
Bindweed, black	*Fallopia convolvulus*	MS	MS					
Bugloss	*Anchusa arvensis*							
Charlock	*Sinapis arvensis*			S		S		
Chickweed, common	*Stellaria media*	S S	S S	R	S	MR	S S	S S
Cleavers	*Galium aparine*	R	MR				S	S
Corn marigold	*Chrysanthemum segetum*							
Corn spurrey	*Spergula arvensis*			S		S		S
Crane's-bill, cut-leaved	*Geranium dissectum*		MR					
Deadnettle, henbit	*Lamium amplexicaule*							
Dead-nettle, red	*Lamium purpureum*	S		S			S	S
Dock, broad-leaved	*Rumex obtusifolius*			S	S			
Fat-hen	*Chenopodium album*	MS	MS	S	S	S	S MR	
Fool's parsley	*Aethusa cynapium*	S						
Forget-me-not, field	*Myosotis arvensis*		S				S	S
Fumitory, common	*Fumaria officinalis*	MS (MR)		S	S?	S		S
Gallant -soldier	*Galinsoga parviflora*					S		
Groundsel	*Senecio vulgaris*	MS S	S	S S	S	S	S	S
Hemp-nettle, common	*Galeopsis tetrahit*							
Knotgrass	*Polygonum aviculare*	S	MS	S	S S	S	S S	
Mayweed, scented	*Matricaria recutita*	S	S	S	S		S	S
Mayweed, scentless	*Tripleurospermum inodorum*	S S	S S	S S	S S	S	S S	S MS
Nettle, small	*Urtica urens*	S	S	S S	S S	S	S	S
Nightshade, black	*Solanum nigrum*	MS		S			S	
Orache, common	*Atriplex patula*		S					
Pansy, field	*Viola arvensis*	MS	MS					S
Parsley piert	*Aphanes arvensis*							
Pennycress, field	*Thlaspi arvense*		S					
Persicaria, pale	*Persicaria lapathifolia*	MS S	MS S	S	S	S	S S	-
Pimpernel, scarlet	*Anagalis arvensis*					S		
Pineappleweed	*Matricaria discoidea*	S	S	S	S		S	S
Poppy, common	*Papaver rhoeas*	-	MR MR	S S	S	S	S -	-
Redshank	*Persicaria maculosa*	S	-	S	-	S	S	-
Shepherd's-purse	*Capsella bursa-pastoris*	MS S	MS MS	S S	R	S S	S S	S S
Sow-thistle, smooth	*Sonchus oleraceus*	MS S	S	S S	S	S S	S -	S
Speedwell, common, field	*Veronica persica*	S	S	S	R			S
Speedwell, ivy-leaved	*Veronica hederifolia*	S	S	S	R			S
Sun spurge	*Euphorbia helioscopia*			S			S	
Thistle, creeping	*Cirsium arvense*				S S		S	
Wild radish	*Raphanus raphanistrum*	MS		S		S	S	
Annual meadow-grass	*Poa annua*	S	S	S		S		
Blackgrass	*Alopecurus myosuroides*		S					
Brome, barren	*Anisantha sterilis*							
Wild-oat	*Avena fatua*					S		
Vol OSR	*Brassica napus*			S		S	S	S
Vol Potatoes	*Solanum tuberosum*							

Appendix 3