PROJECT REPORT

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FV 256

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

Final report for the 2006 trial

September 2006

Commercial - in Confidence

FV 256 FINAL REPORT 2006

Project title:	Vegetables: Solutions to the loss of active ingredients for weed control in vegetable crops
Project number:	FV 256
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Date project started: **Date project completed**:	1 April 2006, 31 August 2006
Keywords:	Drilled: bulb Onion, Leek, Carrot, Parsnip, Coriander, Swede, Vining peas, Baby-leaf spinach, Dwarf French beans, Transplanted: Celery, Cauliflower, Lettuce; 'Volunteer' potatoes Crop safety, herbicides, oxadiargyl, s-metolachlor, mesotrione, dimethachlor, Callisto, Dual, Gold Raft

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

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Headline

Potential alternative herbicides for the future, which appear to be safe (non-phytotoxic) to some crops have been identified on a range of vegetables and are worth further evaluation.

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, made available to relevant crop sectors for further development, was extremely useful. Crop Protection 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 expire 31 December 2007. Alternatives are therefore sought and HDC project FV 256 screened "new" herbicides for crop tolerance in 2004, 2005 and 2006. 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 HRI, Wellesbourne, discussions with vegetable sectors in other European Member States and the USA IR 4 Project. Only herbicides with a future, i.e. on Annex 1 or supported in the EC Review, are 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).

Summary of Results

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

Vegetable crops in trial were: drilled bulb onion, leek, carrot, parsnip. coriander, vining pea, dwarf French bean, swede, baby leaf spinach; transplanted celery, cauliflower and lettuce. Parsnips were not tolerant of the herbicides tested. *Active substances in italics are not yet registered in the UK and it will take time before they are available to the grower.*

- Residual herbicides *oxadiargyl* at 0.5 L/ha (200 g a.i./ha), *BUK 9900* at 1.25 L/ha, *s-metolachlor* 0.7 L/ha (672 g a.i./ha) and *dimethachlor* (tested FV 256 in 2005) at 1.5 L/ha (250g a.i./ha), applied pre-weed-emergence, have potential for use in lettuce.
- *BUK 9900* was the most effective pre-emergence herbicide - it controlled a wide weed spectrum. It was also safe to cauliflower transplants at 2.5 L/ha, drilled onion at 1.25

L/ha, leek 0.625 L/ha. Efficacy was poor on emerged weeds except on small nettle and speedwells but it was safe to cauliflower, onion and leek.

- *s-metolachlor* pre-emergence at 0.7 L/ha also appeared safe to baby-leaf spinach, dwarf French beans and at 1.4 L/ha (1344 g a.i./ha) to swedes. However a tank-mix partner or a programme will be needed to control knotgrass. It has mainly residual soil activity.
- *212 H* has residual and foliar activity. It was more effective pre-weed-emergence but safer in some crops post-emergence. There appears to be a marked dose response to this herbicide in terms of crop safety and efficacy. *212 H* was safe to cauliflower and peas at 60 g/ha (30 g a.i./ha) post-emergence and at 30 g/ha possibly to swede. *212 H* applied at 120g/ha post-weed-emergence, killed potatoes and is therefore worth further investigation for crop safety in onions and carrots applied at different dose rates at later growth stages than 2 true-leaves. It has a weakness on polygonums.
- Callisto (mesotrione) at all dose rates (1.5, 0.75 and 0.37 L/ha) was a very effective foliar-acting herbicide but was not safe to any broad-leaved crops tested.

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, (in parentheses marginally safe); # applied pre-transplanting

Herbicide 'Normal' dose/ha	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Vining Pea**	**Swede**	**Spinach**
BUK 9900 N 2.5 L	3 ½N	3 ¼ N	x	x	x	x	3	3 ½N	x	x	x	x
#s-metolachlor N 1.4 L	x	x	x	x	3 ½ N	3	3	3 ½N	3 ½ N	x	3	3 ½N
212 H N 60g	3 ¼ N	3 ¼ N	x	x	x	x	3 ½N	x	3 (½N)	3 (½N)	x	x
#oxadiargyl N 1.0 L								3 ½N				

Oxadiargyl was tested in other crops in FV 256 2004, when lettuce was not requested by growers

Table 2. Post-weed-emergence herbicides 3 safe; x not safe; *s-metolachlor (shaded) had very little activity on emerged weeds

Herbicide 'Normal' dose	**Onion**	**Leek**	**Carrot**	**Parsnip**	**Coriander**	**Celery transplants**	**Cauliflower transplants**	**Lettuce transplants**	**Dwarf Bean**	**Vining Pea**	**Swede**	**Spinach**
BUK 9900 N 2.5 L	3	3	x	x	x	x	3	x	x	3 ½N	3 ½N	x
*s-metolachlor N 0.6 L	3	3	3 ½N	3 ½N	3	3	3	3	3	3	3	3 ½N
212 H N 60g	3 ¼N	3 ¼N	3 ½N	x	x	3 ½N	3	x	x	3	3 ½N	x

Callisto 0.75 L	x	x	x	x	x	x	x	x	x	x	x	x

Weed species controlled

There were very high populations of shepherd's purse, mayweeds and field speedwell at this site, other predominant weed species were redshank, knotgrass and small nettle and there were low numbers of black-bindweed, chickweed, groundsel and smooth sow-thistle.

Table 3. Pre-weed-emergence herbicides: 3 weed species controlled; **x** poor control or not controlled at various dose rates; - weeds not present on untreated plots; (low populations limited data); ? variable control

Pre-weed-emergence Herbicide	Shepherd's purse	Mayweeds	Small nettle	Knotgrass	Pale persicaria	Redshank	Chickweed	Smooth sow-thistle	Groundsel	Field speedwell	Ivy leaved speedwell	Fat-hen
BUK 9900 5.0 L	3	3	3	3	-	3	-	3	3	3	3	3
BUK 9900 2.5 L	3	3	3	3	-	3	-	3	3	3	3	3
BUK 9900 1.25 L	3	3	3	3	-	3	-	3	x	3	3	3
BUK 9900 0.625 L	x	x	3	x	-	x	-	-	x	3	3	3
s-metolachlor 2N	3	3	3	x	3	3	3	3	3	3	-	3
s-metolachlor N 1.4 L	3	3	3	x	x	(3)	3	3	3	3	3	(3)
s-metolachlor ½ N	x	x	3	x	x	x	x	3	3	3	3	x
s-metolachlor ¼ N	x	x	x	x	x	x	x	-	-	x	x	x
212 H 2N	3	3	3	3	3	3	3	3	3	3	-	-
212 H N 60g	3	3	3	x	3	(3)	3	3	3	3?	3	(3)
212 H ½ N	(3)	3	3	x	x	x	3	3	(3)	x	x	x
212 H ¼ N	x	x	(3)	x	x	x	x	-	x	x	x	x

Table 4 . Post-weed-emergence herbicides: 3 weed species controlled; x poor control or not controlled at various dose rates; - weeds not present on untreated plots; (low populations limited data)

Post-weed-emergence Herbicide	Shepherd's purse	Mayweed	Small nettle	Chickweed	Smooth sow-thistle	Groundsel	Redshank	Field speedwell	Ivy-leaved speedwell	Knotgrass	Black bindweed
BUK 9900 5.0 L	x	x	3	-	-	x	3	3	3	3	3
BUK 9900 2.5 L	x	x	3	-	-	x	3	3	3	x	3
BUK 9900 1.25 L	x	x	3	-	-	x	x	x	3	x	x
BUK 9900 0.625 L	x	x	x	-	-	x	x	x	3	x	x
s-metolachlor 2N	x	x	x	x	-	x	x	3	3	x	x
s-metolachlorN 0.6L	x	x	x	x	-	x	x	3	3	x	x
s-metolachlor ½ N	x	x	x	x	-	x	x	x	x	x	x
s-metolachlor ¼ N	x	x	x	x	-	x	x	x	x	x	x
212 H 2N	3	3	3	-	-	(3)	3	3	-	x	-
212 H N 60g	x	x	3	-	-	(3)	3	3	3	x	-
212 H ½ N	x	x	3	-	-	x	x	x	3	x	-
212 H ¼ N	x	x	3	-	-	x	x	-	3	x	-
Callisto 2N	3	3	3	-	3	-	3	3	-	3	-
Callisto 0.75 L	3	3	3	-	3	-	3	x	3	x	x
Callisto ½ N	3	3	3	-	3	-	3	x	x	x	x

Callisto ¼ N	3	3	3	-	-	-	3	x	x	x	x

212 H post-emergence gave very good suppression of volunteer potatoes.

Recommendations

Further work is needed to evaluate:

- residual herbicides oxadiargyl, BUK 9900, s-metolachlor and dimethachlor (FV 256 2005) in lettuce.
- s-metolachlor pre-emergence in baby-leaf spinach, swedes, dwarf French beans but a tank-mix partner or a programme will be needed to control knotgrass.
- efficacy of 212 H against potatoes and assess crop safety in onions and carrots for applications at later growth stages and different dose rates or split doses. 212 H has a weakness on polygonums.
- dimethachlor (tested in 2005, FV 256) in cauliflower, swede.
- BUK 9900 pre-emergence in onion and leek. It was included in Brassica trial FV 270, 2006.

Herbicides: Current Approval Status

Herbicide Product	**Company**	**active substance (formulation)**	**'Normal' N rate product/ ha (g a.i./ha)**	**Registered now *or in future?***
Pre-weed-emergence				
BUK 9900H # post transplants	Confidential	Confidential EC	2.5 L	*No UK registration*
(Dual Gold)# (Mercantor Gold) pre-transplant	Syngenta	s-metolachlor 960 g/L EC	1.4 L (1344g)	*No UK registration*, sugar beet The Netherlands etc.; carrots USA. Dwarf French beans France
212H# post transplants	Confidential	Confidential 50WP 500 g/kg	60 g (30g)	*No UK registration yet* vines France
(Raft) pre-transplant lettuce only	Bayer	oxadiargyl 400 g/L	1.0 L	*No UK registration*
Post-weed-emergence				
BUK9900H#	Confidential	Confidential EC	2.5 L	*No UK registration*
(Dual Gold)# (Mercantor Gold)	Syngenta	s-metolachlor 960 g/L EC	0.6 L (1344g)	*No UK registration*
212H#	Confidential	Confidential 50WP 500 g/L	60 g (30g)	*No UK registration yet*, Onion USA, vines France
Callisto	Syngenta	mesotrione SC 100 g/L	0.75 L (75g)	UK maize, *US potential onion*

green text active ingredient achieved Annex 1 status; # no UK product yet, Callisto is the only product registered in UK; the other names are for products registered in other EU member states

Action Points for Growers

- Need to be aware that there may be further losses if actives fail to achieve Annex 1 listing. At product re-registration stage there may be restrictions on timings and dose rates.

- Establish an early stage screening system to evaluate new herbicides when available.

- Need to review their current weed control strategy for several vegetable crops because "Essential Uses" for important herbicides metoxuron, prometryn, terbutryn, fomesafen, cyanazine, pentanochlor expire 31 December 2007.

- New active substances identified in previous FV 256 screening tests (e.g. aclonifen, diflufenican) have been evaluated further in commercial crops of carrots and parsnips HDC Project FV 236b and in vining peas; (bifenox, oxadiargyl, oxyfluorfen, prosulfocarb, diflufenican) in brassicas HDC Project FV 270; pendimethalin/imazamox in peas. Some of them will eventually be available for vegetables.

- Some potential alternative herbicides which appear to be safe (non-phytotoxic) to some crops have been identified in 2006 and further work is needed to assess crop safety of residual herbicides on very light soils/sands and to evaluate efficacy and programmes.

- Where no data are available, two years residues trials may be required for a SOLA (Specific Off-Label Approval) application.

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 study also identified herbicides that are too damaging, and the type of symptoms that would render salad onions or leaf crops coriander and 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. The last 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 (source CSL Pesticide Usage Survey 2003), crop value and gross margins (J Nix, Farm Management Pocketbook, 2005) for a range of some important vegetable crops

Crop	***Crop area ha last survey***	***% Herbicide treated area last survey***	***Crop value £/ha 2006***	***Gross Margin £/ha 2006***
Brassicas	32,424	195	3,500 cauliflower	1,175
Peas & Beans	46,211	263	1,000 vining peas	750
Onions & leeks	12,397	1101(split doses)	3,850 bulb onions	1,500
Carrots, parsnips, celery	13,062	594 (split doses)	6600 maincrop carrots	1,800

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As a result of the EC 91/414 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 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.

Alternatives are urgently needed.

The areas sprayed (CSL Pesticide Usage Survey 2003) are shown below.

List of active substances permitted for **vegetables** in the UK, for the following herbicide 'Essential Uses' only, until 31 December 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,

EXPERIMENTAL SECTION

Introduction

Herbicide screening trials on a range of vegetable crops were funded by the Agrochemical Industry and carried out at NVRS/HRI until 1990. Information on crop tolerance, made available to relevant crop sectors for further development, was extremely useful. Crop Protection 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" expire 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 December 2007

Experiment Details

Site: Warwick HRI Kirton

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

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. Transplants were planted with a Michigan planter 3 rows/plot, except lettuce 4 rows/plot.

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

Sowing dates and herbicide application dates

Rainfall after all pre-emergence applications (Appendix 2).

Pre-weed-emergence			
Crop (Variety)	***Sowing/transplant date***	***Crop Growth stage***	***Date applied***
Onion (Wellington)	18 April	Pre-emergence	18 April
Leek ((Roxton)	18 April	Pre-emergence	18 April
Dwarf French Bean (Laguna)	10 May	Pre-emergence	12 May
Pea (Cabree)	10 May	Pre-emergence	12 May
Celery transplant (Victoria)	11 May	B pre transplanting A, C after transplanting	11 May 12 May
Cauliflower transplant (Fremont)	11 May	B pre transplanting A, C after transplanting	11 May 12 May
Lettuce transplant (Saladin iceberg)	11 May	B pre transplanting A, C after transplanting	11 May 12 May
Coriander (Santos)	10 May	Pre-emergence	12 May
Swede (Magres)	10 May	Pre-emergence	12 May
Spinach baby leaf (Whale)	10 May	Pre-emergence	12 May
Carrot (Nairobi)	2 May	Pre-emergence	4 May
Parsnip (Javelin)	2 May	Pre-emergence	4 May

Extra plots lettuce, oxadiargyl N 1.0 L/ha, 2N & 1/2N applied pre-transplanting:

Pre-weed-emergence			
Crop (Variety)	***transplant date***	***Crop Growth stage***	***Date applied***
Lettuce transplant (Saladin iceberg)	11 May	oxadiargyl pre transplanting	11 May

Post-emergence plots: a standard pre-emergence herbicide at ½ Normal dose was applied Ramrod + Stomp (4.5 + 0.75) L/ha to onion, leek on 18 April; Stomp + Linuron (500 g/L formulation) (1.6 + 1.0) L/ha to carrot, parsnip on 4 May.

Post-weed-emergence			
Crop (Variety)	***Sowing/transplant date***	***Crop Growth stage***	***Date applied***
Onion (Wellington)	18 April	2 Leaves	25 May
Leek ((Roxton)	18 April	2 Leaves	25 May
Dwarf French Bean (Laguna)	10 May	1 trifoliate Leaf	13 June
Pea (Cabree)	10 May	3 node	6 June
Celery transplant (Victoria)	11 May	established	6 June
Cauliflower transplant (Fremont)	11 May	established	6 June
Lettuce transplant (Titan flathead; Versaille red oakleaf)	11 May	established	6 June
Coriander (Santos)	10 May	2 True Leaves	6 June
Swede (Magres)	10 May	2-3 True Leaves	6 June
Spinach baby leaf (Whale)	10 May	4 True Leaves	6 June
Carrot (Nairobi)	2 May	2 True Leaves	6 June
Parsnip (Javelin)	2 May	1 True Leaves	6 June

Potatoes	18 April	Large shoots	25 May

Herbicides

Herbicides were screened 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.

Code	Herbicide Product	Company	active substance (formulation)	'Normal' N rate product/ha (g a.i./ha)	Registered now *or in future?*
Pre-weed-emergence					
A	BUK 9900H # post transplants	Confidential	Confidential EC	2.5 L	*No UK registration*
B	(Dual Gold)# (Mercantor Gold) pre-transplanting	Syngenta	s-metolachlor 960 g/L EC	1.4 L (1344g)	*No UK registration*, sugar beet The Netherlands etc.; carrots USA. Dwarf French beans France
C	212H# post transplants	Confidential	Confidential 50WP 500 g/kg	60 g (30g)	*No UK registration yet* vines France
Post-weed-emergence					
D	BUK9900H#	Confidential	Confidential EC	2.5 L	*No UK registration*
E	(Dual Gold)# (Mercantor Gold)	Syngenta	s-metolachlor 960 g/L EC	0.6 L (1344g)	*No UK registration*
F	212H#	Confidential	Confidential 50WP 500 g/L	60 g (30g)	*No UK registration yet*, Onion USA, vines France
G	Callisto	Syngenta	mesotrione SC 100 g/L	0.75 L (75g)	UK maize, *US potential onion*

* green text active ingredient achieved Annex 1 status; # no UK product yet, Callisto is the only product registered in UK; the other names are for products registered in other EU member states; code used in field

Oxadiargyl (Raft) 400 g/L formulation was evaluated FV 256, 2004 in 11 crops but lettuce was not included. In 2006 it was applied pre-transplanting lettuce. It is on Annex 1 and submitted for registration in Spain for use in lettuce at 0.3 to 0.4 L/ha.

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 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.
- Weed species present on untreated control plots.
- Weed species 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	GS Crop; Soil	GS weeds
Pre-emergence Onion & Leek (sown 18 April)			
18 April 1/4N, ½ N, N tr A to C	9ºC; 75% RH; cloud cover 7; wind 3mph; rain after application 19 April 11.8mm	Pre-em crop Sowing depth 1 cm; seedbed fine surface dry	-
Pre-emergence Carrot & Parsnip (sown 2 May)			
4 May tr A to C	17.8ºC; 69% RH; sunny, cloud cover 2; wind 3mph; rain after application 6 May 30.5mm; irrigation 12.5mm	Pre-em crop Sowing depth 1 cm; seedbed fine surface dry	-
Pre-transplant pre-weed-emergence Celery, Lettuce & Cauliflower (planted 11 May)			
11 May tr B & oxadiargyl	14.7ºC; 64% RH; sunny, cloud cover 1; wind 1mph; rain after application 12 May 3.6mm some rainfall every day until 31 May	Pre-transplanting seedbed fine surface moist	-
Post-transplant pre-weed-emergence Celery, Lettuce & Cauliflower (planted 11 May)			
11 May trs A & C	14.7ºC; 64% RH; sunny, cloud cover 1; wind 1mph; rain after application 12 May 3.6mm some rainfall every day until 31 May	Pre-transplanting seedbed fine surface moist	-
Pre-emergence (Peas, Dwarf Beans, Swede, Spinach, Carrot, Parsnip, Coriander sown 10 May)			
11 May trs A, B & C	14.7ºC; 64% RH; sunny,cloud cover 1; wind 1mph; rain after application 12 May 3.6mm some rainfall every day until 31 May	Pre-transplanting seedbed fine surface moist	-

Post-weed-emergence Herbicide Trial

Date applied	Weather	GS crop (TL); Soil	GS weeds (TL)
*Pre-emergence Standard *Onion & Leek (sown 18 April),*			
18 April Standard only	9ºC; 75% RH; cloud cover 7; wind 3mph; rain after application 19 April11.8mm	Pre-em crop; Sowing depth 1 cm; seedbed fine surface dry	-
*Pre-emergence Standard **Carrot & Parsnip (sown 2 May)*			
4 May Standard only	17.8ºC; 69% RH; sunny, cloud cover 2; wind 3mph; rain after application 6 May 30.5mm; irrigation 12.5mm	Pre-em crop; Sowing depth 1 cm; seedbed fine surface dry	-
Post-weed-emergence Onion & Leek, Potatoes (planted 18 April)			
25 May tr D to G	11.8ºC (17ºC later); 70% RH; sunny, cloud cover 3; wind 2mph; no rain after application, 5.3mm later	Onion, Leek, 2 leaves, Potatoes 5-8 shoots/ plant, 50cm tall; Soil surface moist	black-bindweed 1; ivy-leaved speedwell 2; small nettle, redshank 2-4; shepherd's purse 4-6
Post-weed-emergence Carrot, Parsnip (sown 2 May) Coriander, Peas, Swede, Spinach, (sown 10 May); Celery, Lettuce & Cauliflower (planted 11 May)			
6 June tr D to G	13.8ºC (20ºC later); 62% RH; sunny cloud cover 1; wind 1mph; no rain after application; irrigation on 7 June 12.5mm	Coriander, Carrot 2; Parsnip 1; Swede 2-3; Spinach 4; Peas 3 node; transplants established. Soil surface dry	mayweeds, speedwell, nettle 2-4; knotgrass 3; redshank, pale persicaria 1 TL, shepherd's purse 4-6 TL
Post-weed-emergence dwarf beans (sown 10 May)			
13 June tr D to G	16.6ºC (20ºC later); 75% RH; cloud cover 7; wind 3mph; no rain after application	Dwarf Beans 1st Trifoliate Leaf	Small plants

TL true leaves;
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

April was warmer than average and onions and leeks emerged more quickly than in previous years, so did the carrots and parsnips sown at the beginning of May. May was a very wet month and 30.5mm rain fell at Kirton on the 6th May. Hence the irrigation applied on 4 June and above average rainfall provided a stringent test of safety of residual soil-acting herbicides. BUK 9900 was the most effective residual soil-acting herbicides at the dose rates tested.

BUK 9900

BUK 9900 applied post-transplanting but pre-weed-emergence appeared very safe to cauliflower at all dose rates. It was safe to lettuce at 1.25 L/ha, and possibly 2.5 L/ha - although there was some initial stunting, harvest date was not delayed. BUK 9900 appeared safe to onion at 1.25 L/ha, leek at 0.63 L/ha but the 2.5 L/ha dose caused stunting and plant loss, which was more severe in leek.

All dose rates caused delayed emergence and plant loss in carrots and parsnips. Coriander was less sensitive possibly because it emerged through the soil-treated layer faster than carrots. but emergence was delayed. BUK 9900 may have also caused fanging on carrot roots. Damage to celery transplants from 2.5 L/ha appeared acceptable until 16 June when the crop had become stunted. Later, leaves of celery and remaining carrot, parsnip became distorted, crinkled and stuck together.

BUK 9900 at all dose rates reduced emergence and caused distortion of the growing points in peas; 2.5 L/ha and 5.0 L/ha caused necrosis of leaf margins and unacceptable stunting of dwarf French beans. Swede and spinach emerged but soon died.

S-metolachlor

S-metolachlor, at all dose rates applied pre-transplanting, was very safe to cauliflower.

The highest dose rate 2.8 L/ha (2688 g a.i./ha) caused some chlorosis and stunting in celery and lettuce, but 1.4 L/ha (1344 g a.i./ha) was safe to celery, 0.7 L/ha (672 g a.i./ha) to lettuce.

It caused no damage to swede and at 0.7 L/ha was safe to baby-leaf spinach.

S-metolachlor caused distortion of the growing points in peas, leaves were stuck together and plants were stunted.

At 1.4 L/ha dwarf bean leaves suffered chlorosis and necrosis but the 0.7 L/ha appeared safe.

In onion and leek, s-metolachlor caused delayed and reduced emergence and further plant loss and effects were more severe in carrot and parsnip. Coriander was less sensitive, 0.7 L/ha may be safe.

212 H

212 H at 120 g/ha (60 g a.i./ha), applied just after transplanting caused some plant death in cauliflower, stunting at 60 g/ha (30 g a.i./ha) but 30 g/ha (15 g a.i/ha) appeared safe.

212 H at 30 and 60 g/ha damaged the base of onion and leek plants at the 1 to 2-leaf growth stage and there was some plant loss. Although there was some recovery only 15 g/ha (7.5 g a.i./ha) appeared safe but at this dose rate weed control was very poor.

212 H at all dose rates completely killed carrot, parsnip, coriander, swede and spinach. Coriander failed to emerge, the other crops emerged but were chlorotic and died in a few days.

212 H applied just after transplanting caused severe scorch and wilting of lettuce at 120 g/ha and all dose rates delayed maturity by *c.* one week – unacceptable in a programmed crop.

The leaves of celery transplants were scorched and later stunted by 212 H at 60 g/ha and above. There was some recovery but even the 30g/ha dose was too damaging.
Peas and dwarf beans were stunted by the high rates of 212 H, and peas also suffered some necrosis. At 60 g/ha crop safety was marginal.

Oxadiargyl
Oxadiargyl was evaluated in FV 256, 2004 in 11 crops but lettuce was not included. In lettuce, oxadiargyl at 2.0 L/ha (800 g a.i./ha) caused initial chlorosis followed by necrosis and stunting, effects were much less severe at 1.0 L/ha (400 g a.i./ha). There were necrotic spots caused by rain-splash on the outer leaves, but these would be discarded when harvested. The 0.5 L/ha (200 g a.i./ha) dose was safe to lettuce.

Phytotoxicity symptoms post-weed-emergence herbicides

All except dwarf beans were sprayed on 25 May or 6 June and irrigation on 7 June may have increased any residual activity of BUK 9900, s-metolachlor and 212 H.

BUK 9900
BUK 9900 was safe to waxy-leaved crops: onion, leek and transplanted cauliflower at all dose rates tested (5.0, 2.5 and 1.25 L/ha). BUK 9900 at 1.25 L/ha appeared safe in peas, higher doses caused chlorosis and some vigour loss.
In baby-leaf spinach it caused unacceptable scorch, leaf crinkling and stunting from all dose rates and the crop did not recover. There was slight scorch on swede but the damage was outgrown. BUK 9900 at 5.0 L/ha scorched, stunted and caused wilting of dwarf beans, at 2.5 L/ha damage was wilting and scorch.
Carrots, parsnip and coriander were severely damaged: chlorosis and scorch followed by leaf loss in carrots, leaf spotting in parsnips and coriander. Later all developed crinkled, distorted leaves. Any leaf blemish is unacceptable in coriander. There was less effect on celery but the leaf crinkling also reduced quality.
BUK 9900 scorched and bleached outer leaves of lettuce, particularly flat leaved cv. Titan, and the hearts/inner leaves of both cvs. were stunted. Damage was severe from all dose rates on established transplants – none was safe.

S-metolachlor
S-metolachlor had negligible foliar activity thus weed control was very poor and it was safe at all dose rates tested 0.3, 0.6 and 1.2 L/ha (288, 576 and 1152 g a.i./ha) to a wide range of crops onion, leek, cauliflower, celery, lettuce, pea, dwarf bean. At 1.2 L/ha it reduced wax on spinach leaves and stunted coriander; in carrots 0.6 L/ha caused leaf-crinkling and this effect was more severe in parsnips.

212 H
212 H at 60 g/ha (30 g a.i./ha) and 30 g/ha (15 g a.i./ha) caused damage to the base of onions and leeks causing collapse of some plants and leaf loss, and at 60 g/ha some plant death. Effects were negligible at 15 g/ha (0.75 g a.i./ha).
212 H was safe to peas at all dose rates (120, 60 and 30 g/ha).
212 H at 60 g/ha appeared safe to cauliflower transplants. It caused some scorch and spotting on the leaves initially, but new growth was not affected and the plants recovered. 212 H at 120g/ha also caused unacceptable stunting. Effects were similar in swede and celery, but recovery was slower – 212 H at 30 g/ha was safe, at 60 g/ha crop tolerance was marginal.

Carrots and parsnips were scorched by 212 H at 60 and 120 g/ha, and damage to parsnips (where more spray collects on the leaf) was severe and they were also stunted. 212 H appeared safe to carrots at 30 g/ha.
212 H at all dose rates caused severe stunting and scorch to dwarf beans and spinach and severe scorch to outer leaves of lettuce and maturity was delayed. The damage to coriander reduced marketable quality. There was a marked dose response to this herbicide in terms of crop safety and efficacy.

Callisto (mesotrione)
Callisto at all dose rates (1.5, 0.75 and 0.37 L/ha) was a very effective foliar-acting herbicide, bleaching leaves and/or growing points and killing weeds and most crops within a week. Some carrots, parsnips, coriander, onions and leeks survived the lowest dose. Callisto, a maize herbicide, was not safe to any of these broad-leaved crops tested.

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-weed-emergence herbicides 3 safe; x not safe, (in parentheses marginally safe); # applied pre-transplanting

Herbicide 'Normal' dose/ha	Onion	Leek	Carrot	Parsnip	Coriander	Celery transplants	Cauliflower transplants	Lettuce transplants	Dwarf Bean	Vining Pea	Swede	Spinach
BUK 9900 N 2.5 L	3 ½N	3 ¼ N	x	x	x	x	3	3 ½N	x	x	x	x
#s-metolachlor N 1.4 L	x	x	x	x	3 ½ N	3	3	3 ½N	3 ½ N	x	3	3 ½N
212 H N 60g	3 ¼ N	3 ¼ N	x	x	x	x	3 ½N	x	3 (½N)	3 (½N)	x	x
#oxadiargyl N 1.0 L								3				

Oxadiargyl was tested in other crops in FV 256 2004, when lettuce was not requested by growers

Table 2. Post-weed-emergence herbicides 3 safe; x not safe; *s-metolachlor (shaded) had very little activity on emerged weeds

Herbicide 'Normal' dose	Onion	Leek	Carrot	Parsnip	Coriander	Celery transplants	Cauliflower transplants	Lettuce transplants	Dwarf Bean	Vining Pea	Swede	Spinach
BUK 9900 N 2.5 L	3	3	x	x	x	x	3	x	x	3 ½N	3 ½N	x
*s-metolachlor N 0.6 L	3	3	3 ½N	3 ½N	3	3	3	3	3	3	3	3 ½N
212 H N 60g	3 ¼N	3 ¼N	3 ½N	x	x	3 ½N	3	x	x	3	3 ½N	x

Callisto 0.75 L	x	x	x	x	x	x	x	x	x	x	x	x

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

Table 5. Onion and leek sown 18 April, pre-emergence herbicides applied 18 April, onion emerged 6 May, leek 8 May. Assessment date, growth stage L leaf, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment Date:*** ***Untreated GS:***	**Rate**	**Onion** **8/5** **crook**	**16/5** **1 L**	**2/6** **2 L**	**16/6** **3L**	**29/6** **4 ½ L**	**Leek** **8/5** **crook**	**16/5** **1 L**	**2/6** **2 L**	**16/6** **3L**	**29/6** **4 L**
BUK 9900 N 2.5 L	N	10	10	6 loss	6 st loss	6	7 cl red em	7 st	6	5 st loss	5
BUK 9900	1/2N	10	10	9	9	9	10	9	8	7 loss	7
BUK 9900	1/4N	10	10	10	10	10	10	10	9	9	9
s-metolachlor N 1.4 L	N	7 red em	6	3	0	0	5 red em del	4	2 loss	0	0
s-metolachlor	1/2N	10	9	5	2 loss	2	8	7	4	1	1
s-metolachlor	1/4N	10	10	7	5	6	10	9	6	4	4
212 H N 60g	N	10	6*	6	5 st	6	9	5*	5	5 st	6
212 H	1/2N	10	9	7 loss	6 st	7	10	7	6	5 st	7
212 H	1/4N	10	10	9	9	9	10	9	8	8	9

red em reduced emergence, del delayed emergence or maturity; st stunting; loss plant loss; *damage stem base and breakage

Table 6. Carrot and parsnip sown 2 May, pre-emergence herbicides applied 4 May, carrot emerged 16 May, parsnip 23 May. Coriander sown 10 May, pre-emergence herbicides applied on 12 May, coriander emerged on 23 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 16/5 cot**	**23/5 cot**	**2/6 2 TL**	**16/6 4-5TL**	**29/6 5 ½ TL**	**Parsnip 23/5 cot**	**2/6 1 TL**	**16/6 2 TL**	**29/6 4 TL**	**Coriander 23/5 cot**	**2/6 1/2 TL**	**16/6 4TL**	**29/6 bolting**
BUK 9900	2N	1 del red em	1	0	0	0	0	1	0	0	0	6	4 st loss	4
BUK 9900 N 2.5 L	N	2	2	1	0	0	1.5 del red em	3	1 loss	1	1 cl del	8	6	6
BUK 9900	1/2N	3	3	3	2	2 #	2.5	5	3 st loss	3 #	3 cl	9	10	10
s-metolachlor	2N	3 del red em	2	1	0	0	1del red em cl	1	0	0	2 del	8 del	6 cr st	6
s-metolachlor N 1.4 L	N	4	3	4	1 st sc loss	1	2	4del	1	0	5	9	8 st	7
s-metolachlor	1/2N	5	5	5	4	4	4	5	4	3	7	9	9	9
212 H	2N	1 del red em	0	0	0	0	0	0	0	0	0	0	0	0
212 H N 60g	N	2	0	0	0	0	0	0	0	0	0	0	0	0
212 H	1/2N	3	0	0	1	1	0	0	0	0	0	0	0	0

red em reduced emergence, del delayed emergence or maturity; st stunting; loss plant loss; cl chlorosis; cr crinkling; sc scorch; # severe distortion and crinkling new leaves

Table 7. Vining peas, dwarf French beans sown 10 May, pre-emergence herbicides applied 12 May. Assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Pea** **23/5** **1 node**	**2/6** **2 node**	**16/6** **bud enclosed**	**29/6** **pod set**	**DF Beans** **23/5** **simple leaf**	**2/6** **simple leaf**	**16/6** **1 ½ trifoliate**	**29/6** **green bud**
BUK 9900	2N	6 del	1 red em loss #	1 dist cr	1	8 st	3 severe st	3 dist st	2.5 dist st
BUK 9900 N 2.5 L	N	8	3 #	3 del	2	10	6 nec leaf margins	5 st	5
BUK 9900	½ N	10	5 #	5	4	10	8 nec leaf margins	6 del	6
s-metolachlor	2N	8 st del	3 #	2	2	10	4 st cl nec	4	5
s-metolachlor N 1.4 L	N	10	6 #	4	5	10	6 dist nec	6	8
s-metolachlor	½ N	10	7 #	6	6	10	8 dist	10	10
212 H	2N	9 del	4 st sc	4	5	9 st small leaves	4 red em st	4st	4.5
212 H N 60g	N	10	6	6	6	10	7	6	6
212 H	½ N	10	8	8	8	10	8	8	8

red em reduced emergence; del delayed emergence or maturity; st stunting; sc scorch loss plant loss; cl chlorosis; dist distortion; nec necrosis; # severe crinkling and distortion of growing point, leaves stuck together

Table 8. Swede and spinach sown 10 May, pre-emergence herbicides applied 12 May, emerged c. 20 May. Assessment date, growth stage (cot cotyledon, TL true leaf), crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:*** ***GS:***	**Rate**	**Swede** **23/5** **cotyledon**	**2/6** **2TL**	**16/6** **4 1/2 TL**	**29/6** **7 TL**	**Spinach** **23/5** **cotyledon**	**2/6** **2TL**	**16/6** **4-5TL harvest**
BUK 9900	2N	10	1cot	0	0	4 cot turned down st	0	0
BUK 9900 N 2.5 L	N	10	2 cot	0	0	5	0	0
BUK 9900	½ N	10	3 cot	1	1	7	2	1
s-metolachlor	2N	10	9 st	10	10	6 cot dist st	5	6 recovery
s-metolachlor N 1.4 L	N	10	10	10	10	10	7	8
s-metolachlor	½ N	10	10	10	10	10	10	10
212 H	2N	0 em dead cl	0	0	0	0 em dead cl	0	0
212 H N 60g	N	1	0	0	0	1.5	0	0
212 H	½ N	4	0	0	0	5	0	1

em dead emerged but dead; Cot remained at cotyledon stage; cl chlorosis; st stunting; dist distortion

Table 9. Celery, cauliflower and lettuce transplants: pre-weed-emergence herbicide s-metolachlor, oxadiargyl applied pre-transplanting 5 May: BUK 9900 and 212H applied post-transplanting pre-weed-emergence May, assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Herbicide ***Assessment Date:***	**Rate**	**Celery 16/5**	**23/5**	**2/6**	**16/6**	**29/6**	**Cauli flower 26/5**	**23/5**	**16/6**	**29/6**	**Lettuce 16/5**	**23/5**	**2/6**	**16/6**	**29/6 harvest**
BUK 9900	2N	10	10	6 sc	5 st	3 #	10	10	10	10	10	7.5 w	4.5sc st	6st	6
BUK 9900 N 2.5L	N	10	10	8	7 st	5 #	10	10	10	10	10	8.5 st	9	10	10
BUK 9900	½ N	10	10	10	10	10	10	10	10	10	10	10	10	10	10
s-metolachlor	2N	10	8 cl	9	7 loss	7	10	10	10	10	10	9	4.5 cl st	5 st	5
s-metolachlor N 1.4L	N	10	9 cl	10	9 st	9	10	10	10	10	10	9.5	6	7	7
s-metolachlor	½ N	10	10	10	10	10	10	10	10	10	10	10	7.5	10	10
212 H	2N	8 cl sc	4 cl nec st	3 nec leaf loss	3.5 rec	5	6 sc	5 sc st	5 st loss	4	2 sc w	1 nec	1	2	2 del
212 H N 60g	N	9	6 cl	5	5.5	7	8	7	7	7	4	2	2	3	3 del
212 H	½ N	10	8	7	7	9	10	10	10	10	6	3	3	5	5 del
oxadiargyl	2N										9 st	7 st cl cr	5 nec	5	5
oxadiargyl N 1.0L	N										10	9	8	9	9
oxadiargyl	½ N										10	10	10	10	10

cl chlorosis; del delayed maturity; dist distortion; sc scorch; nec necrosis; st stunting; rec recovering; # distortion and crinkling new leaves; w leaves wilting

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

Table 10. Onion and leek sown 18 April, post-emergence herbicides applied 25 May. Assessment date, growth stage (L leaf), crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment Date:*** ***Untreated GS:***	**Rate**	**Onion** **2/6** **2-3 L**	**15/6** **3 L**	**29/6** **5 L**	**Leek** **2/6** **2 – 3 L**	**15/6** **3 L**	**29/6** **4 ½ L**
BUK 9900 N 2.5 L	N	10	9.5	9.5	7 cl del em	9.5	9.5
BUK 9900	1/2N	10	10	10	10	10	10
BUK 9900	1/4N	10	10	10	10	10	10
s-metolachlor N 0.6 L	N	9	10	10	9	10	10
s-metolachlor	1/2N	10	10	10	10	10	10
s-metolachlor	1/4N	10	10	10	10	10	10
212 H N 60g	N	3#	4 # plant loss st	4	4 #	5 # plant loss	5
212 H	1/2N	6#	6 # leaf loss	6	7	7	7
212 H	1/4N	9	9	9	10	9	10
Callisto 0.75 L	N	2 bl	0	0	4 bl	1	1
Callisto	1/2N	4 bl	0	0	6 bl	3	2
Callisto	1/4N	6	2	2	8	5	5

#collapse breakage stem base; del em delayed emergence; st stunting; bl bleaching; cl chlorosis

Table 11. Carrot and parsnip sown 2 May, carrot emerged 16 May, parsnip 23 May. Coriander sown 10 May, emerged on 23 May. Post-emergence herbicides applied 6 June. Assessment date, growth stage (TL true leaf), crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment date:*** ***Untreated GS:***	**Rate**	**Carrot** **15/6** **3 ½ TL**	**29/6** **6 ½ TL**	**Parsnip** **15/6** **2 - 2 ½ TL**	**29/6** **4 TL**	**Coriander** **15/6** **3 ½ TL**	**29/6** **bolting**
BUK 9900	2N	4 cl *	2.3 lf cr	4 cl severe cr	2 cr	7 sc cr	5 cr
BUK 9900 N 2.5 L	N	5 cl*	4 cr	5 cl cr sp	3 cr	8 cr	6 cr
BUK 9900	1/2N	7 cl sc	7.5	7 cr sp	7 cr	9	8
s-metolachlor	2N	6 cr	6 cr	5 cr	5 cr	8 st	8
s-metolachlor N 0.6 L	N	9	8	8	7	10	10
s-metolachlor	1/2N	10	10	10	10	10	10
212 H	2N	5 sc	5	2 severe sc st	2st	4 st cr sc	4
212 H N 60g	N	8 slight sc	8	4 sc st	4	6	6
212 H	1/2N	9	10	6	7	7.5	7
Callisto	2N	0 bl nec	0	0	0	0	0
Callisto 0.75 L	N	1	1	1	1	2	2
Callisto	1/2N	3	3	3	2	2.3	4

* first TL loss; sc scorch, cr leaf crinkling; st stunting; cl chlorosis; nec necrosis; sc scorch; bl bleaching; sp spots on leaves

Table 12. Celery, cauliflower, lettuce flathead (g) and red oakleaf (r) transplanted 11 May, post-emergence herbicides applied 6 June. Assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment date:***	**Rate**	**celery 15/6**	**29/6**	**cauliflower 15/6**	**29/6**	**lettuce 15/6 g**	**15/6 r harvest**
BUK 9900	2N	8 sc	7 cr	10	10	4 ##	5
BUK 9900 N 2.5 L	N	9	8 cr	10	10	5 ##	6
BUK 9900	1/2N	10	9	10	10	6 #	7
s-metolachlor	2N	10	10	10	10	10	10
s-metolachlor N 0.6L	N	10	10	10	10	10	10
s-metolachlor	1/2N	10	10	10	10	10	10
212 H	2N	6 sc st	6	4 sc st	6	1	1
212 H N 60g	N	8	8	6 sc st	8	2	2
212 H	1/2N	9	9	9	10	4	4
Callisto	2N	1new lves dead	0	1 bl	0	1 bl heart, old leaves sc	1 pink heart, old lves sc
Callisto 0.75 L	N	2.5bl cl	0	1 bl	0	1 bl	1 bl
Callisto	1/2N	3.5bl cl	0	1 bl	0	1 bl	1bl

sc scorch; st stunting; cr leaves crinkled and distorted; # severe bleaching 1st leaves; ## severe scorch and heart stunted

Table 13. Dwarf French beans: post-emergence herbicides applied 13 June: assessment date, growth stage, crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment date:*** ***Untreated GS:***	**Rate**	**Dwarf F beans 22/6 2 trifoliate**	**29/6 green bud**
BUK 9900	2N	4 # st	3
BUK 9900 N 2.5 L	N	6	5
BUK 9900	1/2N	10	8
s-metolachlor	2N	10	10
s-metolachlor N 0.6 L	N	10	10
s-metolachlor	1/2N	10	10
212 H	2N	2 st sc	2 st sc
212 H N 60g	N	3 sc	3 sc
212 H	1/2N	4 sc	4 sc
Callisto	2N	2bl	0
Callisto 0.75 L	N	2bl	0
Callisto	1/2N	2	0

leaves turned down; st stunting; sc scorch; 212H severe scorch on 15 June only 3DAT

Table 14. Peas, swede and spinach sown 10 May: post -weed-emergence applied 6 June. Assessment date, growth stage (TL true leaf), crop damage score (0 total kill; 7 acceptable; 10 no damage)

Product ***Assessment date:*** ***Untreated GS:***	**Rate**	**peas** **15/6** **bud enclosed**	**29/6** **pod set**	**swede** **15/6** **4 ½ TL**	**29/6**	**spinach** **15/6** **5 exp TL**
BUK 9900	2N	7 cl st	7	7sc	9	2 severe st cr
BUK 9900 N 2.5 L	N	9	9	8sc	10	3
BUK 9900	1/2N	10	10	9sc	10	5 bl outer leaves
s-metolachlor	2N	10	10	9 slight spotting	10	6 reduced wax
s-metolachlor N 0.6L	N	10	10	10	10	10
s-metolachlor	1/2N	10	10	10	10	10
212 H	2N	9 sc	9	5 sc st	6	2.5 severe sc
212 H N 60g	N	10	10	7	8	4
212 H	1/2N	10	10	9	10	5
Callisto	2N	1*	0	1 bl	0	1 bl
Callisto 0.75 L	N	1*	0	1 bl	0	1 bl
Callisto	1/2N	1*	1	2 bl	1	2 bl

cl chlorosis; sc scorch; st stunting; cr leaves crinkled; bl bleaching; * upper plant 100% bleached

Results Weed Control (more detail in the following Tables)

Pre-weed-emergence herbicides

There were very high populations of shepherd's purse and field speedwell on this area of the trial. Other predominant weed species were mayweeds, knotgrass and small nettle. Numbers of redshank and pale persicaria were variable, low to high, and numbers of fat-hen, chickweed, groundsel and smooth sow-thistle were low.

BUK 9900
In the trial BUK 9900 at dose rates of 5.0 L/ha, 2.5 L/ha and 1.25 L/ha was very effective on a wide weed spectrum: knotgrass, small nettle, field and ivy-leaved speedwell, redshank, smooth sow-thistle. It was particularly effective on the very high population of shepherds purse over 200/m^2 and mayweeds over 50/m^2. Groundsel was controlled by the higher doses but 1.25 L/ha was inadequate. In onion and leek the lowest dose rate 0.625 L/ha was effective on small nettle, speedwells and fat-hen.

S-metolachlor
S-metolachlor at 1.4 L/ha (1344 g a.i./ha) and 2.8 L/ha (2688 g a.i./ha) was very effective on the high population of shepherd's purse, mayweeds, field speedwell, small nettle and the low numbers of groundsel. It did not control knotgrass, even at 2.8 L/ha, and activity on pale persicaria and possibly redshank was poor. S-metolachlor at 0.7 L/ha (672 g a.i./ha) controlled field speedwell, small nettle, groundsel and smooth sow-thistle but was ineffective on the other species. The lowest dose in onion and leek had no activity on any of the species present.

212 H
At the 2N dose 212H controlled all species in the trial, but at 60 g/ha (30 g a.i./ha) did not control knotgrass and was not effective on other polygonums. It appeared less reliable on the high population of field speedwell at 60 g/ha and results were variable.
212 H at 30 g/ha (15 g a.i./ha) controlled mayweeds, small nettle, and low numbers of groundsel, chickweed, smooth sow-thistle. The lowest dose 15 g/ha in onion and leek had no activity on any of the species present.

Oxadiargyl (in lettuce only)
Oxadiargyl at 1.0 L/ha has a weakness on chickweed but controlled all species (shepherd's purse, field speedwell, mayweeds, groundsel, knotgrass). At the dose rate safe to lettuce 0.5 L/ha one or two knotgrass remained.

Post-weed-emergence herbicides

Onions and leeks were treated pre-emergence with a half dose of standard Stomp + Ramrod (0.75 + 4.5) L/ha but control was poor and a high population of shepherd's purse, and other species remained. In contrast, carrots and parsnips treated pre-emergence with half dose of standard Stomp + Linuron (500 g/L formulation) (1.6 + 1.0) L/ha on 4 May were weed free thus there were no weed assessments for the experimental treatment.

There were very high populations of shepherd's purse, mayweeds and field speedwell in the other crops; other predominant weed species were redshank and small nettle. The numbers of

knotgrass varied from 3 to 60 plants/m^2. There were low numbers of black-bindweed, chickweed, groundsel and smooth sow-thistle.

BUK 9900
BUK 9900 was less active on emerged weeds - only small nettle, speedwells, redshank and black-bindweed were controlled by 2.5 L/ha (and 5.0 L/ha).

S-metolachlor
This herbicide had negligible foliar activity – only speedwells (field and ivy-leaved) were scorched and eventually died.

212 H
The highest dose rate of 120 g/ha (60 g a.i./ha) controlled all weed species except knotgrass. 212 H at 60 g/ha (30 g a.i./ha) was ineffective on shepherd's purse, mayweeds and knotgrass, but controlled small nettle, speedwells redshank and possibly groundsel.

Callisto
Callisto was a highly effective contact-acting post-weed-emergence treatment, giving complete control of all species at the 2N dose 1.5 L/ha. Weeds were killed within a few days. At 0.75 L/ha shepherd's purse, mayweeds, small nettle, redshank and smooth sow-thistle were controlled – only a few field speedwell, knotgrass and possibly black-bindweed remained.

Volunteer potato control post-emergence (Table 25)
Potatoes are a frequent problem in several vegetable crops and the means of control in carrots, with metoxuron, will be lost after 2007.

Volunteer potatoes were chitted and planted at the same time as onions and leeks (18 April). Growth was very advanced: there were 5 to 8 shoots per plant, *c.* 0.5m tall, at the time of post-emergence applications on 25 May. Scores for control are shown 8, 21 and 42 days after treatment (DAT) in Table 25. The potatoes were affected by potato blight later in July.

BUK 9900 caused scorch and chlorosis at 5.0 L/ha and reduced % potato ground cover by 50 %, but the lower doses had little effect.

S-metolachlor appeared to stimulate growth and shoots became elongated. There was no control.

Callisto caused bleaching of the growing point and potatoes were severely affected. The effect of the 2N dose (1.5 L/ha) persisted to reduce ground cover by 70% 42 DAT, but potatoes recovered from the N dose rate of 0.75 L/ha.

212 H applied at 120g/ha post-weed-emergence, killed potatoes (Table 25) and there was very little re-growth, 90% reduction in ground cover compared with untreated potatoes 42 DAT. 212 H at 60g/ha N dose rate had reduced potato cover by 90% at 21 DAT, but 42 DAT there was some regrowth and ground cover was reduced by 65% compared to untreated potatoes. Unusually, regrowth was from the damaged stems not from the tubers. Samples dug from plots indicated that some tubers may have been destroyed by 212 H at 120 or 60 g/ha.

Weed species controlled (summary)

Table 3. Pre-weed-emergence herbicides: 3 weed species controlled; **x** poor control or not controlled at various dose rates; - weeds not present on untreated plots; (low populations limited data); ? variable control

Pre-weed-emergence Herbicide	Shepherd's purse	Mayweeds	Small nettle	Knotgrass	Pale persicaria	Redshank	Chickweed	Smooth sow-thistle	Groundsel	Field speedwell	Ivy leaved speedwell	Fat-hen
BUK 9900 5.0 L	3	3	3	3	-	3	-	3	3	3	3	3
BUK 9900 2.5 L	3	3	3	3	-	3	-	3	3	3	3	3
BUK 9900 1.25 L	3	3	3	3	-	3	-	3	x	3	3	3
BUK 9900 0.625 L	x	x	3	x	-	x	-	-	x	3	3	3
s-metolachlor 2N	3	3	3	x	3	3	3	3	3	3	-	3
s-metolachlor N 1.4 L	3	3	3	x	x	(3)	3	3	3	3	3	(3)
s-metolachlor ½ N	x	x	3	x	x	x	x	3	3	3	3	x
s-metolachlor ¼ N	x	x	x	x	x	x	x	-	-	x	x	x
212 H 2N	3	3	3	3	3	3	3	3	3	3	-	-
212 H N 60g	3	3	3	x	3	(3)	3	3	3	3?	3	(3)
212 H ½ N	(3)	3	3	x	x	x	3	3	(3)	x	x	x
212 H ¼ N	x	x	(3)	x	x	x	x	-	x	x	x	x

Table 4 . Post-weed-emergence herbicides: √ weed species controlled; x poor control or not controlled at various dose rates; - weeds not present on untreated plots, (low populations limited data)

Post-weed-emergence Herbicide	Shepherd's purse	Mayweed	Small nettle	Chickweed	Smooth sow-thistle	Groundsel	Redshank	Field speedwell	Ivy-leaved speedwell	Knotgrass	Black bindweed
BUK 9900 5.0 L	x	x	3	-	-	x	3	3	3	3	3
BUK 9900 2.5 L	x	x	3	-	-	x	3	3	3	x	3
BUK 9900 1.25 L	x	x	3	-	-	x	x	x	3	x	x
BUK 9900 0.625 L	x	x	x	-	-	x	x	x	3	x	x
s-metolachlor 2N	x	x	x	x	-	x	x	3	3	x	x
s-metolachlorN 0.6L	x	x	x	x	-	x	x	3	3	x	x
s-metolachlor ½ N	x	x	x	x	-	x	x	x	x	x	x
s-metolachlor ¼ N	x	x	x	x	-	x	x	x	x	x	x
212 H 2N	3	3	3	-	-	(3)	3	3	-	x	-
212 H N 60g	x	x	3	-	-	(3)	3	3	3	x	-
212 H ½ N	x	x	3	-	-	x	x	x	3	x	-
212 H ¼ N	x	x	3	-	-	x	x	-	3	x	-
Callisto 2N	3	3	3	-	3	-	3	3	-	3	-
Callisto 0.75 L	3	3	3	-	3	-	3	x	3	x	x
Callisto ½ N	3	3	3	-	3	-	3	x	x	x	x
Callisto ¼ N	√	√	√	-	-	-	√	x	x	x	x

212 H post-emergence gave very good suppression of volunteer potatoes.

Results: Weed Control

Pre-weed-emergence treatments (predominant species in bold type)

Table 15. Pre-weed-emergence herbicides applied 18 April: weed species remaining after treatment, weed species controlled, weed species on untreated plots of **onion** and **leek** drilled early on April. Assessed 7 June. Related weed counts see below.

Herbicide	Weed species not controlled	Weed species controlled
BUK 9900 N 2.5 L	-	shepherd's purse mayweeds knotgrass field speedwell ivy-leaved speedwell small nettle groundsel redshank fat-hen
BUK 9900 ½ N	**shepherd's purse** mayweeds groundsel redshank	knotgrass field speedwell, ivy-leaved speedwell small nettle fat-hen
BUK 9900 ¼ N	**shepherd's purse redshank** mayweeds groundsel knotgrass	field speedwell ivy-leaved speedwell small nettle fat-hen
Untreated**: shepherd's purse mayweeds knotgrass field speedwell** ivy-leaved speedwell small nettle groundsel redshank fat-hen		
s-metolachlor N 1.4 L	**knotgrass**	shepherd's purse mayweeds field speedwell redshank ivy-leaved speedwell chickweed small nettle pale persicaria fat-hen
s-metolachlor ½ N	**knotgrass redshank, mayweeds** shepherds' purse pale persicaria fat-hen	field speedwell ivy-leaved speedwell small nettle
s-metolachlor ¼ N	**knotgrass redshank shepherd's purse mayweeds** field speedwell ivy-leaved speedwell pale persicaria chickweed small nettle fat-hen	
Untreated: **shepherd's purse mayweeds field speedwell redshank** ivy-leaved speedwell knotgrass chickweed small nettle pale persicaria fat-hen		
212 H N 60g	**knotgrass redshank pale persicaria** field speedwell	shepherd's purse mayweeds ivy-leaved speedwell chickweed fat-hen
212 H ½ N	**knotgrass redshank pale persicaria field speedwell** shepherd's purse fat-hen	mayweeds chickweed groundsel
212 H ¼ N	**knotgrass redshank pale persicaria shepherd's purse field speedwell** ivy-leaved speedwell chickweed mayweeds groundsel fat-hen	
Untreated: **shepherd's purse field speedwell knotgrass mayweeds redshank** ivy-leaved speedwell chickweed small nettle pale persicaria groundsel fat-hen		

Mayweed: scentless mayweed

Number of weed species/m^2 on 16 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 2 replicates **onion** and **leek**

	Shepherd's purse	Mayweeds	Field speedwell	Ivy-leaved speedwell	Knotgrass	Small nettle	Groundsel	Sow-thistle, smooth	Chickweed	Redshank	Pale persicaria	Fat-hen	TOTAL
Untreated (BUK 9900)	86	54	36	9	23	8	4	1	1	9	0	7	238
Untreated (s-metolachlor)	156	42	33	11	11	3	3	2	10	32	4	3	310
Untreated (212 H)	168	29	35	9	23	2	4	3	5	24	3	3	322
Untreated	*137*	*37.5*	*34.7*	*9.7*	*19*	*4.3*	*3.7*	*2*	*5.3*	*21.7*	*2.3*	*3*	*288.5*

Table 16. Pre-weed-emergence herbicides applied 4 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of **carrot** and **parsnip**. Assessed 7 June and 7 July. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
BUK 9900 2N	-	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank smooth sow-thistle groundsel
BUK 9900 N 2.5 L	-	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank smooth sow-thistle groundsel
BUK 9900 ½ N	groundsel	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank smooth sow-thistle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass small nettle redshank** smooth sow-thistle groundsel		
s-metolachlor 2 N	-	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank pale persicaria smooth sow-thistle
s-metolachlor N1.4 L	**knotgrass** redshank pale persicaria	shepherd's purse field speedwell mayweeds small nettle smooth sow-thistle
s-metolachlor ½ N	**knotgrass** redshank pale persicaria	shepherd's purse field speedwell mayweeds small nettle smooth sow-thistle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass small nettle redshank pale persicaria** smooth sow-thistle		
212 H 2N		shepherd's purse field speedwell mayweeds knotgrass redshank small nettle groundsel smooth sow-thistle
212 H N60g	**knotgrass** redshank	shepherd's purse field speedwell mayweeds small nettle groundsel smooth sow-thistle
212 H ½ N	**knotgrass** redshank field speedwell	shepherd's purse mayweeds small nettle groundsel smooth sow-thistle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass redshank** small nettle groundsel smooth sow-thistle		

Mayweed: scentless mayweed

Number of weed species/m^2 on 2 June on untreated (pre-weed-emergence) for each herbicide area (mean 4 counts in 0.33 m^2 quadrat) and overall (mean 12 counts) in 2 replicates of **carrot** and **parsnip**

	Shepherd's purse	Mayweeds	Field speedwell	Ivy-leaved speedwell	Knotgrass	Small nettle	Groundsel	Sow-thistle, smooth	Chickweed	Redshank	Pale persicaria	Fat-hen	TOTAL
Untreated (BUK 9900)	151	25	37	1	21	13	5	6	2	12	0	3	276
Untreated (s-metolachlor)	230	27	58	1	22	10	2	8	4	27	45	0	434
Untreated (212 H)	260	31	54	0	36	9	9	5	0	26	2	0	432
Untreated	*214*	*28*	*50*	*1*	*26*	*11*	*5*	*6*	*2*	*22*	*16*	*1*	*382*

Table 17. Pre-weed-emergence herbicides applied 12 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of **pea** and **dwarf French bean**. Assessed 7 June and 7 July. Related weed counts see below.

Herbicide	**Weed species not controlled**	**Weed secies controlled**
BUK 9900 2N		shepherd's purse field speedwell mayweeds small nettle knotgrass groundsel fat-hen smooth sow-thistle
BUK 9900 N 2.5 L		shepherd's purse field speedwell mayweeds small nettle knotgrass groundsel fat-hen smooth sow-thistle
BUK 9900 ½ N	shepherd's purse groundsel	field speedwell mayweeds small nettle knotgrass fat-hen smooth sow-thistle
Untreated**: shepherd's purse field speedwell mayweeds small nettle knotgrass** groundsel fat-hen smooth sow-thistle		
s-metolachlor 2 N	knotgrass	shepherd's purse field speedwell pale persicaria mayweeds small nettle redshank smooth sow-thistle groundsel fat-hen
s-metolachlor N1.4 L	**knotgrass** redshank pale persicaria shepherd's purse	field speedwell mayweeds small nettle smooth sow-thistle groundsel fat-hen
s-metolachlor ½ N	**knotgrass pale persicaria redshank** mayweeds shepherd's purse fat-hen	shepherd's purse field speedwell pale persicaria mayweeds knotgrass small nettle redshank smooth sow-thistle groundsel
Untreated**: shepherd's purse field speedwell pale persicaria mayweeds knotgrass small nettle** redshank smooth sow-thistle groundsel fat-hen		
212 H 2N		shepherd's purse field speedwell mayweeds knotgrass redshank pale persicaria small nettle groundsel chickweed
212 H N60g	**knotgrass**	shepherd's purse field speedwell mayweeds redshank pale persicaria small nettle groundsel chickweed
212 H ½ N	**knotgrass shepherd's purse redshank** field speedwell pale persicaria mayweeds groundsel	small nettle chickweed
Untreated**: shepherd's purse field speedwell mayweeds knotgrass** redshank pale persicaria small nettle groundsel chickweed		

Mayweeds: pineappleweed and scentless mayweed

Number of weed species / m^2 on 2 June on untreated (pre-weed-emergence) for each herbicide area (mean 4 counts in 0.33 m^2 quadrat) and overall (mean 12 counts) in 2 replicates of **pea** and **dwarf French bean**

	Shepherd's purse	Mayweeds	Field speedwell	Ivy-leaved speedwell	Knotgrass	Small nettle	Groundsel	Sow-thistle, smooth	Chickweed	Redshank	Pale persicaria	Fat-hen	TOTAL
Untreated (BUK 9900)	174	63	131	0	14	20	3	7	2	1	1	3	419
Untreated (s-metolachlor)	192	47	98	1	16	25	5	5	3	9	80	5	486
Untreated (212 H)	234	66	134	1	24	3	3	0	3	3	5	0	478
Untreated	*200*	*60*	*121*	*1*	*18*	*16*	*4*	*4*	*3*	*4*	*28*	*3*	*462*

Table 18. Pre-weed-emergence herbicides s-metolachlor applied pre-transplanting 11 May, BUK 9900 and 212H post-transplanting 12 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of **lettuce, cauliflower** and **celery.** Assessed 7 June and 7 July. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
BUK 9900 2N		shepherd's purse field speedwell mayweeds small nettle knotgrass groundsel fat-hen
BUK 9900 N 2.5 L		shepherd's purse field speedwell mayweeds small nettle knotgrass groundsel fat-hen
BUK 9900 ½ N	groundsel	shepherd's purse field speedwell mayweeds small nettle knotgrass fat-hen
Untreated**: shepherd's purse field speedwell mayweeds small nettle knotgrass** groundsel fat-hen		
s-metolachlor 2 N	knotgrass	shepherd's purse field speedwell mayweeds small nettle redshank pale persicaria
s-metolachlor N1.4 L	**knotgrass**	shepherd's purse field speedwell mayweeds small nettle redshank pale persicaria
s-metolachlor ½ N	**knotgrass shepherd's purse** pale persicaria redshank mayweeds	field speedwell small nettle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank pale persicaria		
212 H 2N		shepherd's purse field speedwell mayweeds knotgrass groundsel redshank
212 H N60g	**knotgrass** field speedwell	shepherd's purse mayweeds groundsel redshank
212 H ½ N	**knotgrass** field speedwell groundsel redshank	shepherd's purse mayweeds
Untreated**: shepherd's purse field speedwell mayweeds knotgrass** groundsel redshank		

Mayweeds: pineappleweed and scentless mayweed

Number of weed species / m^2 on 5 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 weed species on untreated plots of **lettuce, cauliflower** and **celery**.

	Shepherd's purse	Mayweeds	Field speedwell	Small nettle	Ivy-leaved speedwell	Knotgrass	Groundsel	Fat-hen	Sow-thistle, smooth	Redshank	Pale persicaria	TOTAL
Untreated (BUK 9900)	218	31	58	10	2	12	5	4	3	2	1.5	346.5
Untreated (s-metolachlor)	255	36	90	6	1	25	1.5	3	3	5	6	431
Untreated (212 H)	344	50	54	2	0	29	7	2	3	4	3	498
Untreated	*272.3*	*39*	*67.3*	*6*	*1*	*22*	*4.5*	*3*	*3*	*3.7*	*3*	*425*

Table 19. Pre-weed-emergence herbicides s-metolachlor applied 11 May pre-transplanting, BUK 9900 and 212H post-transplanting 12 May: weed species remaining after treatment, weed species controlled, weed species on untreated plots of **spinach, swede** and **coriander.** Assessed date 7 June and 7 July. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
BUK 9900 2N	-	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank groundsel
BUK 9900 N 2.5 L	-	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank groundsel
BUK 9900 ½ N	groundsel	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank
Untreated**: shepherd's purse field speedwell mayweeds knotgrass small nettle** redshank		
s-metolachlor 2 N	-	shepherd's purse field speedwell mayweeds knotgrass pale persicaria small nettle redshank
s-metolachlor N1.4 L	**knotgrass**	shepherd's purse field speedwell mayweeds pale persicaria small nettle redshank
s-metolachlor ½ N	**knotgrass** redshank	shepherd's purse field speedwell mayweeds pale persicaria small nettle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass pale persicaria small nettle** redshank		
212 H 2N		shepherd's purse field speedwell mayweeds knotgrass redshank pale persicaria small nettle
212 H N60g	**knotgrass**	shepherd's purse mayweeds redshank pale persicaria small nettle field speedwell
212 H ½ N	**knotgrass field speedwell redshank** pale persicaria mayweeds	shepherd's purse small nettle
Untreated**: shepherd's purse field speedwell mayweeds knotgrass redshank** pale persicaria small nettle		

Mayweeds: pineappleweed and scentless mayweed

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 **spinach, swede** and **coriander**

	Shepherd's purse	Mayweeds	Field speedwell	Knotgrass	Small nettle	Chickweed	Redshank	Black-bindweed	Groundsel	Pale persicaria	TOTAL
Untreated (BUK 9900)	196	34	80	28	14	0	5	0	2	1	360
Untreated (s-metolachlor)	187	36	131	28	9	1	5	1	1	12	411
Untreated (212 H)	228	37	103	42	3	1	8	0	1	5	428
Untreated	*204*	*36*	*105*	*33*	*9*	*1*	*6*	*0*	*1*	*6*	*401*

Table 20. Pre-weed-emergence pre-transplanting herbicide oxadiargyl applied 11 May, weed species remaining after treatment, weed species controlled, weed species on untreated plots of **lettuce.** Assessed 7 and 29 June. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
oxadiargyl 2N	**chickweed**	shepherd's purse field speedwell knotgrass mayweeds groundsel
oxadiargyl N 1.0L	**chickweed**	shepherd's purse field speedwell knotgrass mayweeds groundsel
oxadiargyl ½ N	**chickweed** knotgrass	shepherd's purse field speedwell mayweeds groundsel
Untreated**: shepherd's purse field speedwell knotgrass** mayweeds groundsel chickweed		

Number of weed species / m^2 on 5 June on untreated (pre-weed-emergence) for the herbicide area (mean 2 counts in 0.33 m^2 quadrat) in 1 replicate

	Shepherd's purse	Mayweeds	Field speedwell	Knotgrass	Groundsel	Chickweed	TOTAL
Untreated (oxadiargyl)	88	6	159	66	6	3	328

Weed Control Scores (mean of two replicates) pre-weed-emergence herbicides

Table 21. Pre-weed-emergence herbicides applied 18 April **onion, leek** sown 18 April. Assessment date 16 May, 7 June and 7 July; DAT; growth stage (L leaf), weed control score (0 no control; 7 acceptable; 10 complete control)

Herbicide	**Onion**			**Leek**		
	Post crook - 1Leaf	**2L**	**4-5 L**	**Post crook - 1Leaf**	**2L**	**3-4 L**
DAT:	***30***	***52***	***82***	***30***	***52***	***82***
BUK 9900 N 2.5 L	10	10	6	10	10	6
BUK 9900 ½ N	10	7	4	10	7	4
BUK 9900 ¼ N	9	4.5	2	9	4.5	2
s-metolachlor N 1.4 L	10	9	3	10	9	3
s-metolachlor ½ N	9	5	2	9	5	2
s-metolachlor ¼ N	5	2	0	5	2	0
212 H N 60g	9	8	3	9	7	3
212 H ½ N	7	4	2	7	3	2
212 H ¼ N	5	2	1	5	1.5	1

Table 22. Pre-weed-emergence herbicides applied 4 May **carrot, parsnip** sown 2 May: weed control score (0 no control; 7 acceptable; 10 complete control) Assessment date 7 June and 7 July; DAT; growth stage (TL true leaf)

Herbicide	**Carrot**		**Parsnip**	
	2TL	**6TL**	**1TL**	**4TL**
DAT:	***34***	***64***	***34***	***64***
BUK 9900 2N	10	10	10	10
BUK 9900 N 2.5 L	10	10	10	10
BUK 9900 ½ N	10	10	10	9
s-metolachlor 2N	10	10	10	10
s-metolachlor N 1.4 L	10	9	10	9
s-metolachlor ½ N	9.5	5	9.5	5
212 H 2N	10	10	10	10
212 H N 60g	10	9	10	9
212 H ½ N	10	6	10	6

Table 23. Pre-weed-emergence herbicides applied on 12 May drilled crops; s-metolachlor applied pre- transplants 11 May; BUK 9900 and 212 H applied post transplants 12 May **peas, dwarf beans, swede, spinach, coriander** drilled 10 May**; lettuce, cauliflower, celery** transplanted 11 May: weed control score (0 no control; 7 acceptable; 10 complete control) assessment date 7 June and 7 July except for coriander, baby leaf spinach and lettuce which were past harvest date; DAT

Herbicide	**Peas**		**D Beans**		**Celery**		**Cauliflower**		**Lettuce**	**Swede**		**Spinach**	**Coriander**
Untreated GS	**2node**	**Flat pod**	**Simple leaf**	**Green bud**						**5TL**	**7 TL**	**4-5 TL**	**2TL**
DAT:	***28***	***58***	***28***	***58***	***28***	***58***	***28***	***58***	***28***	***28***	***58***	***28***	***28***
BUK 9900 2N	10	10	10	10	10	10	10	10	10	10	10	10	10
BUK 9900 N 2.5 L	10	10	10	10	10	10	10	10	10	10	10	10	10
BUK 9900 ½ N	10	9.5	10	9.5	10	9	10	10	10	10	9.5	10	10
BUK 9900 ¼ N	-		-		-		-		-	-	-	-	-
s-metolachlor 2N	10	6	10	5	10	9	10	9	10	10	10	10	10
s-metolachlor N 1.4 L	9	3	9	3	9.5	7	9.5	6	9.5	9	7	9	9.5
s-metolachlor ½ N	4.5	2	5.5	2	9	5	8	5	8	7	5	7	9.5
s-metolachlor ¼ N	-		-		-		-		-	-		-	-
212 H 2N	10	10	10	10	10	10	10	10	10	10	10	10	10
212 H N 60g	10	9	10	9	10	9	10	9.5	10	10	9	10	10
212 H ½ N	8	5	8	5	10	8	9.5	8	9.5	10	7	10	10
212 H ¼ N	-		-		-		-		-	-		-	-

Table 24. Pre-weed-emergence herbicide oxadiargyl applied pre-transplanting **lettuce**: weed control score (0 no control; 7 acceptable; 10 complete control except for chickweed) assessments date DAT lettuce. Harvest date 29 June.

Herbicide	**Lettuce**		**Harvest**
DAT:	**22**	**27**	**49**
oxadiargyl 2N	10	10	10
oxadiargyl N 1.0L	10	10	9
oxadiargyl ½ N	9	9	8 knotgrass

Post-weed-emergence treatments (predominant species in bold type)

Table 25. 'Volunteer' potato control; potatoes planted 18 April**;** herbicides applied on 25 May when there were 5 - 8 shoots/ potato plant and shoots were 0.5 m tall. Potato control scores (0=no control, 10=complete kill of foliage); % ground cover compared with untreated 100%

Product *Assessment date:* *DAT:*	**Rate**	**Potato control 2/6** *8*	**Potato control 15/6** *21*	**Potato control 6/7** *42*	**% ground cover 6/7** *42*
BUK 9900	2N	0	4	5	50 sc cl
BUK 9900 N 2.5 L	N	0	3	3	70
BUK 9900	1/2N	0	2	0	90
s-metolachlor	2N	1	3	0	100 taller than unt
s-metolachlor N 0.6 L	N	0	2	0	100
s-metolachlor	1/2N	0	2	0	100
212 H	2N	10 (90% necr)	10 (100% necr)	8	10#
212 H N 60g	N	7 (70% necr)	9 (90% necr)	6.5	35#
212 H	1/2N	4 (40% necr)	5 (50% necr)	5	50#
Callisto	2N	5 (50% st bl cl)	10 bl dist 100%	6	30
Callisto 0.75 L	N	3 (30% bl g pt)	9	3	70
Callisto	1/2N	2 (20% bl)	8	0	100

Necr necrosis; st stunting; bl bleching; cl chlorosis; dist distortion; # sprouting from damaged stems not tuber; on 10 August samples dug from plots indicated that tubers had been destroyed by 212 H at 120 and 60 g/ha.

Table 26. 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 several weeds escaped control. Assessed 19 June and 6 July. Related weed counts see below

Herbicide	**Weed species not controlled**	**Weed species controlled**
BUK 9900H N2.5L		shepherd's purse small nettle redshank black-bindweed mayweeds ivy-leaved speedwell knotgrass groundsel
BUK 9900H ½ N	mayweeds redshank shepherd's purse groundsel	small nettle ivy-leaved speedwell knotgrass black-bindweed
BUK 9900H ¼ N	mayweeds redshank shepherd's purse black-bindweed groundsel	small nettle ivy-leaved speedwell knotgrass
Untreated: **shepherd's purse small nettle redshank** mayweeds black-bindweed ivy-leaved speedwell		
s-metolachlor N 0.6L	**shepherd's purse redshank** mayweeds small nettle black-bindweed knotgrass	Ivy-leaved speedwell
s-metolachlor ½ N	**shepherd's purse redshank** small nettle mayweeds speedwell black-bindweed knotgrass	
s-metolachlor ¼ N	**shepherd's purse redshank** small nettle mayweeds speedwell black-bindweed knotgrass	
Untreated: **shepherd's purse small nettle redshank** mayweeds black-bindweed ivy-leaved speedwell knotgrass		
212H N 60g	knotgrass	shepherd's purse small nettle redshank mayweeds ivy-leaved speedwell
212H ½ N	knotgrass mayweeds	shepherd's purse small nettle redshank ivy-leaved speedwell
212H¼ N	knotgrass mayweeds redshank	shepherd's purse small nettle ivy-leaved speedwell
Untreated: **shepherd's purse small nettle redshank** mayweeds ivy-leaved speedwell knotgrass		
Callisto N 0.75L	black-bindweed	shepherd's purse small nettle redshank mayweeds ivy-leaved speedwell knotgrass
Callisto ½ N	knotgrass black-bindweed ivy-leaved speedwell	shepherd's purse small nettle redshank mayweeds
Callisto ¼ N	knotgrass black-bindweed ivy-leaved speedwell	shepherd's purse small nettle redshank mayweeds
Untreated: **shepherd's purse small nettle redshank** knotgrass mayweeds black-bindweed ivy-leaved speedwell		

Mayweeds: scentless mayweed, pineappleweed.

Number of weed species / m^2 remaining on 30 May after pre-emergence ½ N dose Stomp + Ramrod (mean of 16 counts in 0.33 m^2 quadrat) on 2replicates in **onion** and **leek**

	Shepherd's purse	Mayweeds	Small nettle	Chickweed	Redshank	Black-bindweed	Ivy-leaved speedwell	Fumitory	Black-nightshade	Knotgrass	TOTAL
Untreated (Standard)	*105*	*10*	*34*	*1*	*19*	*6*	*5*	*1*	*1.5*	*2*	*184*

Table 27. **Post-weed-emergence herbicides** applied 6 June to **peas**, 13 June **dwarf French beans**: weed species controlled, weed species on untreated. These crops were covered initially to prevent attack by birds and weeds were at a more advanced growth stage than in other crops. Assessed 13 June and 4 July.

Herbicide	Weed species not controlled	Weed species controlled
BUK 9900H 2 N	shepherd's purse mayweeds	field speedwell small nettle black-bindweed knotgrass
BUK 9900H N 2.5L	**shepherd's purse mayweeds** knotgrass	field speedwell small nettle black-bindweed
BUK 9900H ½ N	**shepherd's purse field speedwell mayweeds** small nettle black-bindweed knotgrass fat-hen	
Untreated: **shepherd's purse field speedwell mayweeds** small nettle black-bindweed knotgrass		
s-metolachlor 2N	**shepherd's purse mayweeds** small nettle black-bindweed chickweed knotgrass	field speedwell
s-metolachlor N 0.6L	**shepherd's purse mayweeds** knotgrass small nettle black-bindweed chickweed	field speedwell
s-metolachlor ½ N	**shepherd's purse mayweeds** field speedwell small nettle black-bindweed chickweed knotgrass	
Untreated: **shepherd's purse field speedwell mayweeds** small nettle black-bindweed chickweed knotgrass		
212H 2N	**knotgrass** shepherd's purse mayweeds	field speedwell
212H N 60g	**shepherd's purse mayweeds knotgrass** field speedwell	
212H ½ N	**shepherd's purse mayweeds knotgrass** field speedwell	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass**		
Callisto 2N	field speedwell	shepherd's purse mayweeds knotgrass small nettle smooth sow-thistle
Callisto N 0.75L	field speedwell knotgrass	shepherd's purse mayweeds small nettle smooth sow-thistle
Callisto ½ N	field speedwell knotgrass mayweeds	shepherd's purse small nettle smooth sow-thistle
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle smooth sow-thistle		

Mayweeds: mainly pineappleweed, some scentless mayweed

Number of weed species/m^2 on 2 June on untreated (post-weed-emergence) for each herbicide area (mean 4 counts in 0.33 m^2 quadrat) and overall (mean 16 counts) in 2 replicates of **dwarf French beans** and **peas**

	Shepherd's purse	Mayweeds	Small nettle	Field speedwell	Sow-thistle, smooth	Chickweed	Knotgrass	Black-bindweed	Groundsel	Fat-hen	TOTAL
Untreated (BUK9800H)	144	130	9	162	0	0	3	6	0	2	456
Untreated (s-metolachlor)	182	128	8	112	0	2	3	2	0	0	437
Untreated (212H)	147	65	2	117	2	2	14	0	0	0	349
Untreated (Callisto)	158	96	5	161	6	0	21	0	2	0	449
Untreated overall	*158*	*105*	*6*	*138*	*2*	*1*	*10*	*2*	*1*	*1*	*424*

Table 28. **Post-weed-emergence herbicides** applied 6 June to **swede, baby-leaf spinach**: weed species controlled, weed species on untreated. Assessed 13 June and 4 July. These crops suppressed weeds

Herbicide	**Weed species not controlled**	**Weed species controlled/crop suppression**
BUK 9900H 2 N	mayweeds	shepherd's purse field speedwell knotgrass small nettle redshank
BUK 9900H N 2.5L	mayweeds shepherd's purse	field speedwell knotgrass small nettle redshank
BUK 9900H ½ N	mayweeds shepherd's purse field speedwell knotgrass small nettle redshank fat-hen	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		
s-metolachlor 2N	shepherd's purse mayweeds knotgrass small nettle redshank black-bindweed	field speedwell
s-metolachlor N 0.6L	shepherd's purse mayweeds knotgrass small nettle redshank black-bindweed	field speedwell
s-metolachlor ½ N	shepherd's purse field speedwell mayweeds knotgrass small nettle redshank black-bindweed	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank black-bindweed		
212H 2N	**knotgrass**	shepherd's purse field speedwell mayweeds small nettle redshank groundsel
212H N 60g	**knotgrass** shepherd's purse mayweeds	field speedwell small nettle redshank groundsel
212H ½ N	**knotgrass** shepherd's purse mayweeds	field speedwell small nettle redshank
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		
Callisto 2N		shepherd's purse mayweed knotgrass small nettle redshank field speedwell
Callisto N 0.75L	field speedwell knotgrass	shepherd's purse mayweed small nettle redshank
Callisto ½ N	**field speedwell knotgrass** mayweed#	shepherd's purse small nettle redshank
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		

#Mayweeds: scentless mayweed and pineappleweed

Number of weed species/m^2 on 9 June on untreated (post-weed-emergence) for each herbicide area (mean 4 counts in 0.33 m^2 quadrat) and overall (mean 16 counts) in 2 replicates of areas on **swede, baby-leaf spinach**

	Shepherd's purse	Mayweeds	Field speedwell	Knotgrass	Groundsel	Small nettle	Redshank	Black-bindweed	Sow-thistle, smooth	TOTAL
Untreated (BUK9800H)	115	84	90	7	2	11	4	1	1	315
Untreated (s-metolachlor)	133	47	109	9	1	5	11	5	3	323
Untreated (212H)	125	31	98	9	3	9	4	1	0	260
Untreated (Callisto)	140	36	75	9	3	9	4	0	0	276
Untreated overall	*128*	*50*	*93*	*9*	*3*	*8*	*8*	*2*	*1*	*301*

Table 29. **Post-weed-emergence herbicides** applied 6 June to **coriander**, weed species controlled, weed species on untreated. Assessed 13 June and 4 July.

Herbicide	**Weed species not controlled**	**Weed species controlled**
BUK 9900H 2 N	shepherd's purse mayweeds knotgrass groundsel	field speedwell redshank
BUK 9900H N 2.5L	shepherd's purse mayweeds knotgrass groundsel	field speedwell redshank
BUK 9900H ½ N	**shepherd's purse mayweeds knotgrass** redshank groundsel	field speedwell
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** redshank groundsel		
s-metolachlor 2N	shepherd's purse mayweeds knotgrass	field speedwell
s-metolachlor N 0.6L	shepherd's purse mayweeds knotgrass field speedwell	
s-metolachlor ½ N	shepherd's purse mayweeds knotgrass field speedwell	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass**		
212H 2N	**knotgrass**	field speedwell mayweeds small nettle shepherd's purse redshank
212H N 60g	**knotgrass shepherd's purse mayweeds** redshank	field speedwell small nettle
212H ½ N	**knotgrass** shepherd's purse mayweeds small nettle redshank field speedwell	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		
Callisto 2N		shepherd's purse field speedwell mayweeds knotgrass small nettle redshank
Callisto N 0.75L	knotgrass field speedwell	shepherd's purse mayweeds small nettle redshank
Callisto ½ N	**knotgrass field speedwell**	shepherd's purse mayweeds small nettle redshank
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		

Callisto did not control annual meadow-grass

Number of weed species/m^2 on 2 June on untreated (post-weed-emergence) for each herbicide area (mean 2 counts in 0.33 m^2 quadrat) and overall (mean 8 counts) in 2 replicates of areas on **coriander**

	Shepherd's purse	Mayweeds	Field speedwell	Knotgrass	Small nettle	Redshank	Groundsel	Black-bindweed	TOTAL
Untreated (BUK9800H)	144	81	153	24	0	6	2	3	417
Untreated (s-metolachlor)	159	120	120	24	0	0	0	1	427
Untreated (212H)	180	75	128	27	8	4	0	0	314
Untreated (Callisto)	150	57	165	60	6	5	0	3	446
Untreated overall	*158*	*83*	*140*	*34*	*4*	*4*	*0.5*	*2*	*402*

Table 30. Post-weed-emergence herbicides applied 17 May to small (cotyledon stage) weeds **celery, lettuce** and **cauliflower** transplants: weed species not controlled, weed species controlled, weed species on untreated. Assessed 13 June and 6 July

Herbicide	Weed species not controlled	Weed species controlled
BUK 9900H 2 N	**shepherd's purse mayweeds** groundsel	field speedwell knotgrass small nettle black-bindweed redshank
BUK 9900H N 2.5L	**shepherd's purse mayweeds** groundsel black-bindweed knotgrass	field speedwell small nettle redshank
BUK 9900H ½ N	shepherd's purse mayweeds knotgrass small nettle field speedwell redshank black-bindweed groundsel	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass black-bindweed** small nettle redshank groundsel		
s-metolachlor 2N	**knotgrass mayweeds** shepherd's purse small nettle	field speedwell
s-metolachlor N 0.6L	**knotgrass mayweeds shepherd's purse** small nettle field speedwell	
s-metolachlor ½ N	**shepherd's purse knotgrass field speedwell mayweeds** small nettle	
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle		
212H 2N	**knotgrass** mayweeds shepherd's purse	field speedwell small nettle
212H N 60g	**knotgrass shepherd's purse mayweeds**	field speedwell small nettle
212H ½ N	**knotgrass shepherd's purse mayweeds**	field speedwell small nettle
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle		
Callisto 2N		shepherd's purse field speedwell mayweeds knotgrass small nettle redshank
Callisto N 0.75L	knotgrass field speedwell	shepherd's purse mayweeds small nettle redshank
Callisto ½ N	knotgrass field speedwell	shepherd's purse mayweeds small nettle redshank
Untreated: **shepherd's purse field speedwell mayweeds knotgrass** small nettle redshank		

Mayweeds: pineappleweed and scentless mayweed

Number of weed species/m^2 on 5 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	Field speedwell	Ivy-leaved speedwell	Small nettle	Sow-thistle,	Chickweed	Redshank	Knotgrass	Black-bindweed	Groundsel	TOTAL
Untreated (BUK 9900H)	192	78	168	0.5	4	1	1	15	20	16	2	497.5
Untreated (metolachlor)	147	98	76	1	4	1	1	2	17	2	1	350
Untreated (212H)	219	39	138	1	7	2	1	0.5	30	1	1	439.5
Untreated (Callisto)	185	64.5	125	0	7	0	1.5	4	45	1.5	2	435.5
Untreated overall	*186*	*70*	*127*	*1*	*5.5*	*1*	*1*	*2*	*28*	*5*	*1.5*	*431*

Weed Control Scores Pre-weed-emergence herbicides

Table 31. **Post-weed-emergence herbicides** applied 25 May to onion and leek. A ½ dose of standard pre-emergence Stomp + Ramrod (0.75 + 4.5) L/ha was 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 and 6 July

Herbicide	**Onion**		**Leek**	
DAT:	***24***	***41***	***24***	***41***
BUK 9900H N2.5L	10	9.5	10	9.5
BUK 9900H ½ N	7	6	7	6
BUK 9900H ¼ N	4	2.5	4	2.5
s-metolachlor N 0.6L	2	1	2	1
s-metolachlor ½ N	0	0	1	0
s-metolachlor ¼ N	0	0	0	0
212H N60 g	10	9.5	10	9.5
212H ½ N	9.5	9	9.5	9
212H ¼ N	9	6	9	6
Callisto N 0.75L	10	9.5	10	9.5
Callisto ½ N	9.5	9	9.5	9
Callisto ¼ N	7	5	7	5

Table 32. Post-weed-emergence herbicides applied 6 June to celery, cauliflower, lettuce transplants, peas, swede, baby-leaf spinach, coriander; applied 13 June to dwarf French beans, Assessed 19 June (3 July dwarf French beans) and 4 July unless past harvest stage Weed control score (0 no control; 7 acceptable; 10 complete control)

Herbicide	**DFBeans**	**Peas**		**Swede**		**Spinach**	**Coriander**
DAT:	***18***	***13***	***28***	***13***	***28***	***13***	***13***
BUK 9900H 2 N	5	5	4	8	8	7	4.5
BUK 9900H N 2.5L	3	3	2	6	6	6	2
BUK 9900H ½ N	1	1	0	4	4	4	1
s-metolachlor 2N	1	2	1	5	5	4	0
s-metolachlor N 0.6L	0	1	0	3	3	2	0
s-metolachlor ½ N	0	0	0	2	2	1	0
212H 2N	3	4	2	9	7	7	5
212H N 60 g	2	2	1	5	4.5	4	2
212H ½ N	1	1	0	3	3	2	0
Callisto 2N	9	10	9.5	10	9.5	10	10
Callisto N 0.75L	7	9.5	8.5	10	9	10	9.5
Callisto ½ N	5.5	5	4.5	6	4	6	8

Swede and spinach suppressed weeds thus scores were higher; lower scores peas and beans weeds more advanced at application because these crops were covered to prevent bird attack.

Table 33. Post-weed-emergence herbicides applied 6 June to celery, cauliflower, lettuce transplants. Assessed 19 June and 4 July (except lettuce past harvest date). Weed control score (0 no control; 7 acceptable; 10 complete control)

Herbicide	**Celery**		**Cauliflower**		**Lettuce**
DAT:	**13**	**28**	**13**	**28**	**13**
BUK 9900H 2 N	4.5	4	4.5	3.5	6
BUK 9900H N 2.5L	2	2	3.5	2.5	5.5
BUK 9900H ½ N	1	0.5	2	2	3.5
s-metolachlor 2N	0	0	2	1.5	2
s-metolachlor N 0.6L	0	0	0.5	0	1
s-metolachlor ½ N	0	0	0	0	0
212H 2N	5	4	5	4	6
212H N 60 g	2	1	3	3	4
212H ½ N	0	0	0.5	0	1
Callisto 2N	10	9.5	10	10	10
Callisto N 0.75L	9.5	9	10	9	10
Callisto ½ N	8	6	6	5	6

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.*

April was warmer than average and onions and leeks emerged more quickly than in previous years, so did the carrots and parsnips sown at the beginning of May. May was a very wet month and 30.5mm rain fell at Kirton on 6 May. Hence the irrigation applied on 4 May and above average rainfall provided a stringent test of safety of residual soil acting herbicides. In contrast June was extremely dry, with long hours of sunshine and temperatures about 2ºC above average and 30ºC was recorded at Kirton on 12 June.
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.

Crop safety (Tables 1, 2, 5 – 14)
This study has identified potential alternative active substances (Tables 1 and 2) which, on limited data on a light soil, would appear to be non-phytotoxic to some vegetable crops, at the timing and dose rates suggested. The most promising safe and effective herbicides, rate product/ha (a.i./ha) were for:

- Bulb onion – pre-emergence *BUK 9900* appeared safe at 1.25 L/ha, but the 2.5 L/ha dose caused stunting and plant loss. Post-weed-emergence *BUK 9900* was less effective on weeds, but safe to onion at all dose rates tested (5.0, 2.5 and 1.25 L/ha).

- Leek – was less safe to *BUK 9900* pre-emergence than onion but 0.63 L/ha appeared safe. Applied post-weed-emergence, *BUK 9900* was safe to leek at all dose rates tested (5.0, 2.5 and 1.25 L/ha).

- Carrot - *212 H* post-weed-emergence possibly at 30 g/ha (15 g a.i./ha) at 2 true-leaf stage but weed control is poor at this ½ N dose rate. Carrots at 3 or 4 true leaves might tolerate 60 g/ha (30 g a.i./ha) and this dose caused damage to 'volunteer' potatoes.

- Parsnip – no herbicide was safe and effective.

- Vining peas – *212 H* at 30 g/ha was marginally safe applied pre-emergence, and safe at 60 g/ha post-weed-emergence. *BUK 9900* at 1.25 L/ha also appeared safe.

- Dwarf French beans – pre-emergence *s-metolachlor* 0.7 L/ha (672 g a.i./ha). It is registered in France for dwarf French beans and used at 1.0 to 1.4 L/ha.

- Celery transplants – *s-metolachlor* 1.4 L/ha (1344 g a.i./ha) applied pre-transplanting pre-weed-emergence was safe and effective.

- Cauliflower transplants – *BUK 9900* applied post-transplanting pre- or post-weed-emergence appeared very safe to cauliflower at all dose rates. *S-metolachlor*, at all dose rates applied pre-transplanting, was also very safe and because it has no foliar activity, would be safe post-transplanting and pre-weed-emergence. Post-weed-emergence *212 H* at 60 g/ha (30 g a.i./ha) appeared safe to cauliflower transplants. It caused some

scorch and spotting on the leaves initially, but new growth was not affected and the plants recovered. It was more damaging when applied earlier post- transplanting pre-weed-emergence. (*BUK 9900, 212 H* and *oxadiargyl* were evaluated in the 2006 brassicatrials, FV 270).

- Lettuce transplants – pre-transplanting pre-weed-emergence *oxadiargyl* 0.5 L/ha (200 g a.i./ha) (submitted for registration in Spain for use in lettuce at 0.4 L/ha). *Oxadiargyl* would not be suitable for baby-leaf salad crops because of the risk of damage from rain-splash to leaves touching the soil. *S-metolachlor* 0.7 L/ha ((672 g a.i./ha) was safe *BUK 9900* was safe at 1.25 L/ha. It was applied post-transplanting in this trial but it is likely to be more suitable pre-transplanting.

- Swede – was tolerant of *s-metolachlor* applied pre-weed-emergence at 1.4 L/ha.

- Coriander – pre-weed-emergence *s-metolachlor* was marginally safe at 0.7 L/ha..

- Spinach - pre-weed-emergence only *s-metolachlor* at 0.7 L/ha was safe. It is registered for use in sugar beet in other EU member states.

212 H has residual and foliar activity. It was more effective pre-weed-emergence but safer to crops post-emergence. *212 H* post-weed-emergence was safe to celery, carrot, and possibly to swede at 30 g/ha but weed control was poor. Post-weed-emergence *212 H* at 30 and 60 g/ha caused damage to the base of onion and leek causing collapse of some plants and leaf loss, and at 60 g/ha some plant death. Damage was negligible at 15 g/ha but there was no activity on any of the weed species present. There appears to be a marked dose response to this herbicide in terms of crop safety and efficacy.
Interestingly, *212 H* applied at 120g/ha post-weed-emergence, killed potatoes (Table 25) and there was very little re-growth, 42 days after treatment the 60g/ha N dose rate had reduced potato cover by 65% compared to untreated potatoes. *212 H* is therefore worth further evaluation of crop safety at different dose rates in onions and carrots at growth stages later than the 2-leaf stage, or as a split dose.

Callisto (mesotrione) is a very effective foliar-acting maize herbicide. At all dose rates (1.5, 0.75 and 0.37 L/ha), it bleached leaves and/or the growing points and killed most crops within a week Only a few carrot, parsnip and coriander plants survived the lowest dose. It was not safe to any of the broad-leaved crops tested.

Weed control (Tables 3, 4, 15 – 33)
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.

On untreated areas there were very high populations of shepherd's purse and field speedwell, other predominant weed species were mayweeds, redshank, knotgrass and small nettle. There were low numbers of fat-hen, black-bindweed, chickweed, groundsel and smooth sow-thistle.

- *BUK 9900* was the most effective residual pre-emergence herbicide - it controlled a wide weed spectrum: knotgrass, small nettle, field and ivy-leaved speedwell, redshank, smooth sow-thistle. It was particularly effective on the very high population of shepherd's purse (over 200/m^2) and mayweeds (over 50/m^2). Groundsel was controlled

at the higher doses but 1.25 L/ha was inadequate. *BUK 9900* was less active on emerged weeds - only small nettle, speedwells, redshank and black-bindweed were controlled by 2.5 L/ha (or 5.0 L/ha).

- *S-metolachlor* applied pre-weed-emergence at 1.4 L/ha (and 2.8 L/ha) controlled the high population of shepherd's purse, mayweeds, field speedwell, small nettle and the low numbers of groundsel. It did not control knotgrass even at 2.8 L/ha, and activity on pale persicaria and possibly redshank was poor. *S-metolachlor* at 0.7 L/ha controlled field speedwell, small nettle, groundsel and smooth sow-thistle but was ineffective on the other species. *S-metolachlor* was safe to several crops, and control of groundsel is of particular interest but a tank-mix partner or a programme will be needed to control knotgrass and other polygonums. Pendimethalin would be complementary. *S-metolachlor* had mainly residual soil and little foliar activity except on speedwells.

- Pre-weed-emergence *212 H* at the 2N dose controlled all species in the trial, but at 60 g/ha did not control knotgrass or some other polygonums. It appeared less reliable on the high population of field speedwell at 60 g/ha and results were variable. *212 H* at 30 g/ha controlled mayweeds, small nettle, and low numbers of groundsel, chickweed, smooth sow-thistle. Post-weed-emergence *212 H* at the highest dose rate of 120 g/ha controlled all weed species except knotgrass. *212 H* at 60 g/ha was ineffective on shepherd's purse, mayweeds and knotgrass, but controlled small nettle, speedwells redshank and possibly groundsel.

- Callisto was a highly effective contact-acting post-weed-emergence treatment, giving rapid kill of all species at the 2N dose 1.5 L/ha. At 0.75 L/ha shepherd's purse, mayweeds, small nettle, redshank and smooth sow-thistle were controlled – only a few field speedwell, knotgrass and possibly black-bindweed remained. Unfortunately it lacked safety on broad-leaved crops.

Herbicides: Current Approval Status

Herbicide Product	**Company**	**Active substance (formulation)**	**'Normal' N rate product/ha (g a.i./ha)**	**Registered now *or in future?***
Pre-weed-emergence				
BUK 9900H # post transplants	Confidential	Confidential EC	2.5 L	*No UK registration*
(Dual Gold)# (Mercantor Gold) pre-transplant	Syngenta	s-metolachlor 960 g/L EC	1.4 L (1344g)	*No UK registration*, sugar beet The Netherlands etc.; carrots USA. Dwarf French beans France
212H# post transplants	Confidential	Confidential 50WP 500 g/kg	60 g (30g)	*No UK registration yet* vines France
(Raft) pre-transplant lettuce only	Bayer	oxadiargyl 400 g/L	1.0 L	*No UK registration*
Post-weed-emergence				
BUK9900H#	Confidential	Confidential EC	2.5 L	*No UK registration*
(Dual Gold)# (Mercantor Gold)	Syngenta	s-metolachlor 960 g/L EC	0.6 L (1344g)	*No UK registration*
212H#	Confidential	Confidential 50WP 500 g/L	60 g (30g)	*No UK registration yet,* Onion USA, vines France
Callisto	Syngenta	mesotrione SC 100 g/L	0.75 L (75g)	UK maize, *US potential onion*

green text active ingredient achieved Annex 1 status; # no UK product yet, Callisto is the only product registered in UK; the other names are for products registered in other EU member states

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 in other Member States in the same climatic (e.g. The Netherlands, Germany)zone. UK registration is being sought through Mutual Recognition for 212 H; s-metolachlor for maize.

Further work is needed to evaluate:

- new herbicides and to continue this early stage screening system on the irrigated site at Kirton.
- *Oxadiargyl* (submitted for registration in Spain for use in lettuce), *BUK 9900, s-metolachlor* and *dimethachlor* (FV 256, 2005) in lettuce.
- *S-metolachlor* pre-emergence in baby-leaf spinach, swede, dwarf French beans. In other EU member states it is registered for sweet corn and strawberries. However a tank-mix partner or a programme will be needed to control knotgrass.
- Efficacy of *212 H* against potatoes and assess crop safety in onions and carrots at later growth stages or at split doses. *212 H* has a weakness on polygonums.
- *Dimethachlor* (FV 256 2005) in cauliflower, swede.
- To obtain residues data, if available from other countries, to support SOLA applications by HDC 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
Matricaria spp.	Mayweeds
Matricaria disoidea	Pineappleweed
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

Rainfall and Irrigation 2006