PROJECT REPORT

To:
Horticultural Development Council
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FV 270

To investigate safe and effective new herbicides for weed control in brassicas (cauliflower, cabbage and spring greens) to replace those lost through the EC Review

Annual report 2005

November 2005

Commercial - in Confidence

To investigate safe and effective new herbicides for weed control in brassicas (cauliflower, cabbage and spring greens) to replace those lost through the EC Review
Project FV 270

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Annual report: first year of 2-year project completed December 2005

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Project coordinator: Andy Richardson, Allium and Brassica Centre, Kirton

Project started: March 2005, first year completed December 2005

Keywords:
Cauliflower, cabbage, transplants, crop safety, annual broad-leaved weed control, herbicides, pre-transplanting, pre-weed-emergence, post-emergence, SOLA (Specific Off-label Approval)

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FV 270

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Annual report 2005

Project title: **To investigate safe and effective new herbicides for weed control in brassicas (cauliflower, cabbage and spring greens) to replace those lost through the EC Review**

Project number: **FV 270**

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Report: Annual report completed November 2005
Previous report: some potential alternatives were identified in project FV 256

Key workers:

Geoff Clarke, Warwick HRI, Kirton
Cathy Knott, above address
Bill Herring, Duchy of Cornwall demonstration

Locations:

The Kirton Research Centre, Kirton, (cauliflower & cabbage)
Commercial crop cauliflower, Sleaford
Cornwall

Project coordinator: Andy Richardson, Allium and Brassica Centre, Kirton

Date project started: 1 March 2005,
Date project completed: 31 December 2006

Keywords: Cauliflower, cabbage, transplants, crop safety, annual broad-leaved weed control, herbicides, pre-transplanting, pre-weed-emergence, post-weed-emergence, SOLA (Specific Off-label Approval)

FV 270 Brassicas: Evaluation of safe and effective new herbicides to fill identified gaps, resulting from EC review of pesticides.

Headline

Herbicides were evaluated in summer and late autumn maturing cauliflower, and (post-weed-emergence herbicides only) in Savoy cabbage.

Residual herbicides that are safe to cauliflower transplants (one years trial only):

- *Oxadiargyl* 1.0 L/ha applied pre-planting controlled volunteer oilseed rape, charlock, shepherds purse and other weed species that are not susceptible to Treflan (trifluralin). It did not control chickweed and control of fat-hen was incomplete.

- The best treatment at both cauliflower sites was *oxadiargyl* 1.0 L/ha applied pre-planting, followed by Butisan (metazachlor) after planting but pre-weed-emergence at both sites. This provided season-long control and no other weeding was needed.

- Defy (prosulfocarb) tank-mixed with Stomp (pendimethalin) pre-planting improved control of charlock and possibly oilseed rape, but not of other weeds in these trials.

Post-weed-emergence herbicides in cauliflower and cabbage (one years trial only):

- Fox (bifenox) 1.0 L/ha controlled charlock and could be a useful alternative to Fortrol (cyanazine).

- *Oxyfluorfen* has residual soil, as well as foliar action. Applied post-weed-emergence at 1.0 L/ha, it controlled oilseed rape, charlock, and all other weeds except chickweed. It also killed emerged potato foliage. However, *oxyfluorfen* caused crop damage, uneven maturity and unacceptable delay to harvest. The delay depended on growing conditions and increased for slow growing crops i.e. harvest delay was greatest for late autumn cauliflower, and Savoy cabbage was delayed more than early cauliflower. It may be safer when applied pre-transplanting.

Please note Approval status (Table 1). *Oxadiargyl,* and *oxyfluorfen* are not yet registered in the UK and it will take time before they are available to the grower. Fox has a SOLA for use in oilseed rape, Defy now has provisional UK registration for cereals.

Background and commercial objectives

Research is needed to find effective replacements following the EC review of pesticides and the loss of herbicide options. Brassica growers will lose Fortrol (cyanazine) and Croptex Steel (sodium monochloroacetate), which only have 'Essential Uses' until the end of 2007. These herbicides control a wide range of broad-leaved weeds, including charlock, and some grasses. In addition, the future of trifluralin is uncertain.

The early stage screening HDC trial FV 256 in the first year 2004, identified the safety of a range of vegetable crops to some alternative herbicides, including oxadiargyl, Defy (prosulfocarb) and Fox (bifenox) for brassicas. Oxadiargyl and oxyfluorfen are not yet registered in the UK and it will take time before they are available to the grower. These herbicides are available in other European Member States, but development by the manufacturers for UK minor crop use cannot be justified. Possible alternatives need to be developed further in commercial crops and on different soil types.

- The overall aim is to further investigate in 2005 and 2006 new alternative herbicides identified in FV 256, especially post-emergence options for brassicas to replace Fortrol and Croptex Steel. To evaluate dose-rates and tank-mixes of herbicides on two soil types.
- To find new solutions for weed control in brassicas as quickly as possible and through HDC, to obtain Specific Off-Label Approvals (SOLAs).
- To demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so they can continue until the end of 2007.

Summary of the project and main conclusions in the first year

Herbicides were evaluated in summer maturing cauliflower (variety Fremont), and (post-weed-emergence herbicides only) in Savoy cabbage (variety Famosa) on a light silt soil, and late autumn maturing cauliflower (variety Belot) on a loamy sand soil.

- The best weed control was with *oxadiargyl* 1.0 L/ha applied pre-planting followed by Butisan (metazachlor) post-planting pre-weed-emergence. The crops were weed-free until harvest stage and no other herbicide spray would have been necessary. This combination controlled a wide range of weeds at both sites, including charlock and oilseed rape.

- *Oxadiargyl* is on the EC Annex 1 (positive list) but not yet registered in the UK on any crop. It may be some time before it becomes available.

- *Oxadiargyl* controlled charlock, oilseed rape and a very high population of pale persicaria, but weaknesses were on chickweed and fat-hen which were controlled by Butisan at 1.5 L/ha. Programmes with Ramrod (propachlor) or Centium (clomazone) were less effective on fat-hen at one site.

- *Oxadiargyl* was very safe to the cauliflower crop. It has short soil persistence compared to some residual herbicides and is suitable where following crops are likely to be sown.

- Stomp 400SC (pendimethalin) at 3.3 L/ha had poor efficacy on charlock, oilseed rape emerged but remained at cotyledon stage and died later; Defy 4.0 L/ha in tank-mix with Stomp improved control of both but not of other species on these sites.

- Defy (prosulfocarb) is newly approved for use in UK cereals, but it will be used with a partner herbicide.

- Post-weed-emergence, Fox was effective on charlock and could be a useful alternative to Fortrol in a programme. Fortrol, Fox 1.0 L/ha alone or at lower doses in tank-mixes caused only slight crop damage to cauliflower or cabbage.

- Fox needs a partner for other species – it did not control pale persicaria, chickweed, smooth sowthistle, scentless mayweed, fool's parsley or oilseed rape (it has a SOLA for use in rape). Control of fat-hen was incomplete. Both Shield (clopyralid) or Alpha

DFF (diflufenican) were useful partners but both may be needed to cover all these species together with a higher dose of Fox than in these trials.

- *Oxyfluorfen* applied post-weed-emergence caused severe damage to cauliflower and cabbage: a large area of leaf was scorched and the growing point was distorted. The initial damage levels were similar at all sites. It took about 20 days for growing points of all crops treated with 0.5 L/ha or 1.0 L/ha dose to recover. The highest dose of *oxyfluorfen* 2.0 L/ha resulted in leaf loss and 2% plant loss at two sites. Overall *oxyfluorfen* caused more damage to Savoy cabbage than to early cauliflower. Recovery of the autumn cauliflower from *oxyfluorfen* damage at Sleaford was much slower than in the faster-maturing crop grown in warmer weather at Kirton. *Oxyfluorfen* caused unacceptable harvest delays: for the 1.0 l/ha dose about 4 days in early cauliflower, 14 days in Savoy cabbage, and considerably longer for autumn cauliflower. Harvest stage for the autumn cauliflower was on 4 November, 128 days after planting (and 110 days after application of *oxyfluorfen*) but cauliflower treated with the lowest 0.5 L/ha dose had not matured and at 2.0 L/ha, curds were only just initiated.

- *Oxyfluorfen* at 1.0 and 2.0 L/ha gave excellent control of all weed species including charlock, oilseed rape and black nightshade and completely scorched potato shoots but more emerged later. *Oxyfluorfen* at 0.5 L/ha was less effective on oilseed rape, charlock and chickweed, and on pale persicaria at one site.

- *Oxyfluorfen* is a very effective herbicide and it controlled the target species but applied post-transplanting, it does not have a sufficient margin of crop safety to justify further evaluation. Application pre-transplanting could be assessed in 2006.

- *Oxyfluorfen* is registered for use pre- (but not post-) transplanting brassicas in Spain. It is not registered for any UK crop and it may be some time before it becomes available for N European vegetables.

Samples from some successful treatments were sent for residue analysis through HDC (oxyfluorfen, DFF, Fox for cauliflower and cabbage; oxadiargyl, cauliflower only). No residues were detected.

Table 1. Herbicide Current Approval Status (November 2005)

Herbicide active ingredient	*Product*	*Company*	*Formulation*	*Approval Status*
trifluralin	Alpha Treflan 48EC	Makhteshim	480 g/L EC	UK approval for brassicas
pendimethalin	Stomp 400	BASF	400 g/L SC	UK approval for brassicas
prosulfocarb	Defy	Syngenta	800 g/L SC	new UK approval for wheat
oxadiargyl	-	Bayer	400 g/L SC	no UK approval for any crop
propachlor	Ramrod Flowable	Monsanto	480 g/L SC	UK approval for brassicas
clomazone	Centium 360CS	Belchim	360 g/L CS	SOLA1031/04 for brassicas
metazachlor	Butisan S	BASF	500 g/L SC	UK approval for brassicas
bifenox	Fox	Makhteshim	500 g/L SC	UK approval for brassicas
clopyralid	Dow Shield	Dow	200 g/L SC	UK approval for brassicas
oxyfluorfen	-	Makhteshim	240 g/L EC	no UK approval for any crop
diflufenican	Alpha DFF 500 SC	Makhteshim	500 g/L SC	UK approval for cereals
cyanazine standard	Fortrol	Makhteshim	500 g/L SC	SOLA1074/03 for cauliflower, etc. Essential Use until end 2007

Green text on Annex 1 positive list EU Review; SOLA Specific Off-label Approval

A brief, separate report from the Duchy of Cornwall (demonstration for growers in the South-West to view crop safety) will be available to HDC later.

Action Points for Growers

The new herbicides tested are either not yet available in the UK for any crop, or there are no residues data available yet to support SOLAs (Table 1).

Growers will need to review current weed control strategy for brassicas because the "Essential Use" for cyanazine and sodium monochloroacetate will cease 31 December 2007. It also seems likely that trifluralin will fail to achieve Annex 1 listing and will be revoked and alternatives for control of polygonums and annual meadow-grass will be needed.

The project, FV 270 have allowed the industry to demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so that this use can continue. Importantly, work is in progress to look at alternatives to trifluralin if it is revoked and this has been highlighted in a request (if required) for an 'Essential Use' for trifluralin.

Practical and Financial Benefits from this Study

All conventionally grown outdoor field vegetables are dependent on herbicides to control weeds that cause loss of quality, yield and harvesting difficulties. Herbicides are used to avoid contamination of produce with weedy parts that could result in crop rejection thus incurring considerable financial loss. A Pesticide Usage Survey (CSL/Defra Pesticide Usage Survey 2003) showed that the herbicide-treated area in brassica crops was 195%. Inter-row cultivation is widely practiced but weeds within the row are not controlled and is not possible, or ineffective, when soil conditions are too wet. Without a range of herbicides to control a wide weed spectrum, growing UK vegetables could become uneconomic.

- New actives could provide growers with alternatives for weed control after the loss of cyanazine and sodium monochloroacetate at the end of 2007.
- Maintain efficiency in weed control in brassicas, with the consequent benefit to crop quality and yield.
- Inform HDC of safe target products for SOLAs. SOLAs are at growers risk and it may prevent financial loss from crop damage if SOLAs are not sought where crop safety is doubtful.
- Continue to demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses'

Appendix 1. Weed Susceptibility to herbicides; Key: S = susceptible; MS = Moderately Susceptible; R Resistant; MR = Moderately Resistant red text 2005 trials

	Treflan	oxadiargyl	Stomp	Ramrod	Defy	Centium	Butisan	Shield	Fox	Alpha dff	Alpha dff	oxyfluorfen	Fortrol
	Pre-plant	Pre-plant	Pre-plant	Pre-weed em	Pre-weed em	Pre-weed em	Pre-weed em	Post weed-em	Post weed-em	Post weed-em	Post weed-em	Post weed-em	Post weed-em
Common name	2.3 L/ha	1.0 L/ha	3.3 L/ha	9.0 L/ha	4.0 L/ha	0.25 L/ha	2.5 L/ha	0.5 L/ha	1.0 L/ha	0.2 L/ha	0.4 L/ha	1.0 L/ha	2 L/ha
Bindweed black	S	S		R		MR	MS	MS	S	R	MR		S
Bugloss									S				S
Charlock	R	S		R	S	R	MR		S	MS	MS	S	S
Chickweed, common	S	R	S	S	S	S	S		R	MS	S	S?	S
Cleavers	R			S	S	S	MS		S 2whorl	MS	MS		R
Corn marigold	R		S	S			S	S					
Corn spurrey	MS	S		S			MS		S	MR/MS	MS	S	
Crane's-bill, cut-leaved							S		S	R	MR		MR
Deadnettle, henbit	S		S	MS									S
Dead-nettle, red	MS	S	S	S	S	S	S		S	MR/MS	MS		S
Dock, broad-leaved													
Fat-hen	S	S	S	MR	S	MS	MS		S	MR	MR/MS	S	S
Fool's parsley	R					S							S
Forget-me-not, field			S				S		MS	MS/S	S		S
Fumitory, common	MS		MS	R	S?	R	R		S?	MR	MR	S	S
Gallant -soldier				S								S	
Groundsel	R	S	R	S		S	S	S		MR	MR/MS	S	S
Hemp-nettle, common	S	R	S	S			MR		S				S
Knotgrass	S	S	S	R		MR	R		MS	MR	MR/MS	S	S
Mayweed, scented	R	S	MS	S	MS	R	S	S	R	MR	MR/MS		S
Mayweed, scentless	R	S	MS	S	MS	R	S	S	R	MR	MR/MS	S	S
Nettle, small	MS	S	S	S		MR	MS					S	S
Nightshade black	R			MS									S
Orache, common	MS		S	MR		R			S				S
Pansy, field	S		S	S	R		MR		S	S	S		S
Parsley piert			S		S		S		R				MR
Pennycress, field	R			R			R		S				
Persicaria, pale	S					MS		MR		MR	MR/MS	S	S
Pimpernel, scarlet	S	R	S						R	S	S	S	S
Pineappleweed	R	S	MS	S		R		S	R	MR	MR		S
Poppy, common	MS		S		R	R	S		MS	MR	MR	S	S
Redshank	S	S		R		S	MS	MR				S	S
Shepherd's-purse	R	S	MS	S		S	S		MR	MS/S	S	S S	S
Sow-thistle, smooth	R	S	S	MS		MS		S	S			S S	
Speedwell, common, field	S	S	S	S	S	S	S		S	MS/S	S		S
Speedwell, ivy-leaved	S	S	S		S	S	S		S	MS/S	S		S
Sun spurge	MS	S		R									
Thistle, creeping	R					R		S					
Wild radish	R	S		R		S				MS/S	MS/S	S	S
Annual meadow grass	S		S	S	S	MS	S			R		S	S
Blackgrass	S	R	S	S	S		S						MS
Brome, barren							MS						MS
Wild-oat	MS			R	R		MR					S	R
Vol OSR	R	S	MS		S	R	R	R		MS/S	S	S	R
Vol Potatoes								MS				suppression	

FV 270 Brassicas: Evaluation of safe and effective new herbicides to fill identified gaps, resulting from EC review of pesticides.

INTRODUCTION

The problem

All conventionally grown outdoor field vegetables are dependent on herbicides to control weeds that cause loss of quality, yield and harvesting difficulties. Without a range of herbicides to control a wide weed spectrum, growing UK vegetables could become uneconomic.

In most brassica crops, weed control is achieved with a pre- or post-planting application of a residual herbicide. Treflan (trifluralin) soil incorporated pre-sowing/planting is used on 60 % of the area grown (2003 CSL/Defra Pesticide Usage Survey). It is low cost, has been used for many years, but controls a limited weed spectrum. However, the future of trifluralin is problematic because of aquatic life issues. Other popular herbicides are Butisan (metazachlor) (15,506 ha) and Ramrod (propachlor) (11,974 ha); Stomp (pendimethalin) use (1,431 ha) is increasing, usually with tank-mix partner Ramrod.

Brassica growers rely on post-emergence herbicides Fortrol (which has a SOLA for cabbage, cauliflower and calabrese) and Croptex Steel (sodium monochloroacetate) for control of weeds not controlled pre-emergence (HDC GAP Analysis) and Shield (clopyralid) (1,337 ha) is used to control thistles. Particular difficulties in control arise when the prevalent weeds are botanically related to the crop, e.g. Cruciferae in brassica crops and there are often few, or no, herbicides selective in such circumstances. Fortrol is not widely used (1,055 ha in 2003) but is effective in controlling relatively large weeds (up to 100mm high for some species), whilst having a high degree of crop safety. It gives good control of species that are often a problem in brassicas: charlock, shepherd's purse, polygonums and small nettle. Sodium monochloroacetate is used on about 14% of brassica crops (drilled and transplanted) it has a short harvest interval 21d. It has a wide weed spectrum and is effective in controlling some relatively large weeds. The derogations for 'Essential Uses' expire December 2007 and control of some weed species (e.g. charlock controlled by Fortrol, field pennycress by sodium monochloroacetate) will then be difficult unless alternatives are found.

Project aim

Research is required to find effective replacements following the EC review of pesticides and the loss of herbicide options. The early stage screening HDC trial FV 256 in the first year 2004, identified the safety of a range of vegetable crops, including brassicas, to some alternative herbicides. However, some are not yet registered in the UK and it will take time before they are available to the grower. These herbicides are available in other European Member States but development by the manufacturers cannot be justified for UK use in minor crops. Possible alternatives need to be developed further in commercial crops and on different soil types. None of them controls all weeds, so programmes and tank-mixes will be needed. Post-emergence materials are usually less safe on cauliflower, which has less well-developed leaf wax. The test crops therefore included cauliflower as well as cabbage (sensitive variety Famosa).

- The overall aim in 2005 and 2006 is to further investigate new alternative herbicides identified in 2004 in FV 256 (oxadiargyl, prosulfocarb, diflufenican), and in 2005, oxyfluorfen, especially post-emergence options for brassicas to replace cyanazine and sodium monochloroacetate and to evaluate dose-rates and tank-mixes of herbicides on two soil types.

- To find new solutions for weed control in brassicas as quickly as possible and through HDC, to obtain Specific Off-Label Approvals (SOLAs).
- To demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so they can continue until the end of 2007.

Objectives

- To assess crop safety or 'phytotoxicity' to herbicides tested
- To assess efficacy against weeds
- To review the treatments after the first year and amend if necessary
- To identify suitable candidates for SOLAs
- To demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' for cyanazine and sodium monochloroacetate so that these uses can continue until 31 December 2007.

Site Location; Soil type

Crop	Site	Soil Type (ADAS scale)
Cauliflower & cabbage	Warwick HRI Kirton Research Centre, Kirton, Lincolnshire	Silt Loam (light soil type)
Cauliflower	Sleaford, Lincolnshire	Loamy sand (very light soil type)
Cauliflower & cabbage demonstration	Duchy of Cornwall	

Table 2. Herbicide Treatments

Herbicide a.i	Site 1Kirton cauliflower Light Soil (silt loam)		Site 2 Sleaford cauliflower Very Light Soil (loamy sand)		Site 1Kirton cabbage Light Soil (silt loam)	
	g a.i/ha	L product/ha	g a.i/ha	L product /ha	g a.i/ha	L product/ha
0. untreated	-	-	-	-	-	-
Pre-transplant						
1. Treflan	1104	2.3	816	1.7		
2. Stomp	1320	3.3	1320	3.3		
3. Stomp + Defy	1320 +	3.3 + 4.0	1320 +	3.3 + 4.0		
4. oxadiargyl	400	1.0	400	1.0		
Pre-transplant followed by Pre-weed- emergenee (crop established)						
5. oxadiargyl & Ramrod	400 & 4500	1.0 & 9.0	400 & 4500	1.0 & 9.0		
6. oxadiargyl & Centium	400 & 90	1.0 & 0.25	400 & 90	1.0 & 0.25		
7. oxadiargyl & Butisan	400 & 750	1.0 & 1.5	400 & 750	1.0 & 1.5		
Pre-weed- emergenee post-transplant						
8. Butisan	750	1.5	750	1.5		
Post-emergence early						
9. untreated	-	-	-	-	-	-
10. Fox	500	1.0	500	1.0	500	1.0
11. Fox + Shield	250 + 100	0.5 + 0.5	250 + 100	0.5 + 0.5	250 + 100	0.5 + 0.5
12. oxyfluorfen	120	0.5	120	0.5	120	0.5
13. oxyfluorfen	240	1.0	240	1.0	240	1.0
14. oxyfluorfen	480	2.0	480	2.0	480	2.0
15. DFF + oxyfluorfen	75 + 120	0.15 + 0.5	75 + 120	0.15 + 0.5	75 + 120	0.15 + 0.5
16. DFF + Fox	75 + 125	0.15 + 0.25	75 + 125	0.15 + 0.25	75 + 125	0.15 + 0.25
17. Fortrol standard	500	0.5	500	0.5	500	0.5

+ denotes a tank-mix

Crop details

Sites

1. Kirton Research Centre, Lincolnshire (cauliflower, cabbage)
2. Commercial crop: Sleaford, Lincolnshire (cauliflower)
3. Duchy of Cornwall (demonstration for growers in the South-West to view crop safety)

Sowing date and crop variety

1. Transplanted 18 May 2005 with summer/early autumn maturing cauliflower (variety Fremont). Oilseed rape and charlock, sown on 17 May.
2. Transplanted 28 June commercial crop late autumn maturing cauliflower (variety Belot).
3. Transplanted 14 June with early autumn maturing Savoy cabbage (variety Famosa). Oilseed rape and charlock, sown on 13 June.
4. Duchy of Cornwall early July-planted Roscoff cauliflower (variety Alpen) and August-planted spring greens.

Trial Design Sites 1 and 2

Each plot was 8 m long x 1.83 m wide with 3 replicates of each treatment.

Records/Assessments

The following records and assessments were undertaken following application of the various experimental treatments.

- Weather during and after application.
- Observations on any phytotoxicity symptoms, crop scores for damage (0=complete kill; 7= acceptable damage; 10=untreated no damage)

Crop tolerance score	*% Phytotoxicity*
0	Complete kill
1	80 – 95% damage
2	70 – 80% damage
3	60 – 70% damage
4	50 – 60% damage
5	40 – 50% damage
6	25 – 40% damage
7	20 – 25% damage (considered unlikely to cause reduction in yield or quality at cropping)
8	10 – 20% damage
9	5 – 10% damage
10	No damage (as untreated controls)

- Assessments of % crop cover
- Observations on weed control, scores (0=untreated, no control, 7= acceptable control, 10= complete control); number of weed species /m^2 in three 0.33 m^2 quadrats per plot; % weed cover per plot.

Application Details

Sprays were applied using a gas pressurised Azo precision sprayer with a 1.8 m boom and four 110° flat fan nozzles (BCPC code F110/0.80/3) delivering 200 L/ha water volume at 2 bar pressure to give fine spray quality.

Date applied	Weather	GS weed TL (true leaves)
Kirton cauliflower planted 18 May		
18 May Treatments 1 – 7 pre-transplant. Treatment 1 soil incorporated.	11.4°C; RH% 48; cloud cover 4; soil surface dry fine seedbed; rain after application 0.1 mm, total rainfall 18 to 23 May 14.1mm	none
27 May Treatments 5 - 8	Temperatures 19.6°C; RH% 75; sunny cloud cover 4; soil surface dry; leaf surface dry; rain after application 0.1 mm, total rainfall 27 May to 1 June 7.2mm	none, charlock emerged 31 May
17 June Treatments 10 - 17	21.3°C; RH% 75; cloud cover 4; soil surface dry; leaf surface dry; no rain after application until 23 June	OSR cotyledon - 2TL; charlock 2 - 4 TL; pale persicaria 2 - 3 TL; mayweed 2 TL; chickweed 6 TL; shepherd' s purse 4 - 6 TL
Sleaford cauliflower planted 28 June		
28 June Treatments 1 – 7 pre-transplant. Treatment 1 soil incorporated.	19°C; RH% 58; sunny, cloud cover 2; soil surface dry fine seedbed; rain day of application 8.8 mm, total rainfall 28 to 30 June 11.6mm	none
30 June Treatments 5 - 8	15°C; RH% 92; overcast cloud cover 8; soil surface moist; rain day of application 1.4mm	none
13 July Treatments 10 - 17	21°C; RH% 79; sunny, cloud cover 3; soil surface dry; no rain until 18 July 3mm	Fat-hen 2-4 TL; black nightshade 2 TL; green nightshade 2 TL; groundsel 2-4 TL; fool's parsley cot-2TL
Kirton cabbage planted 14 June		
1 July Treatments 10 - 17	17°C; RH% 76; cloud cover 5; soil surface moist; no rain until 3 July 2mm	OSR cotyledon , charlock 2-3 TL; pale persicaria 3 TL; mayweed 2-4 TL; chickweed 6 TL; shepherd' s purse 2-4 TL; redshank & knotgrass small plant

RESULTS

Crop Safety

Site 1 Kirton cauliflower:crop safety (Table 3)

Table 3. Kirton cauliflower (planted 18 May). Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent leaf area scorched on 26 June when untreated crop cover was 70%; percent crop cover on 10 July and at harvest stage 29 July

Herbicide	L or kg product/ha	8 June	16 June	26 June (% scorch)	10 July (% crop cover)	29 July (% crop cover)
0. untreated	-	10	10	10	10(100)	10(100)
Pre-transplant 18 May						
1. Treflan	2.3	10	10	10	10(100)	10(100)
2. Stomp	3.3	10	10	10	10(100)	10(100)
3. Stomp + Defy	3.3 + 4.0	10	10	10	10(100)	10(100)
4. oxadiargyl	1.0	10	10	10	10(100)	10(100)
Pre-transplant 18 May & post-transplant pre-weed- emergence 27 May						
5. oxadiargyl & Ramrod	1.0 & 9.0	10	10	10	10(100)	10(100)
6. oxadiargyl & Centium	1.0 & 0.25	5 bl	6 bl	9.9	10(100)	10(100)
7. oxadiargyl & Butisan	1.0 & 1.5	10	10	10	10(100)	10(100)
Post-transplant pre-weed- emergence 27 May						
8. Butisan	1.5	10	10	10	10(100)	10(100)
Post-weed-emergence 17 June				***9 DAT***	***23 DAT***	***42 DAT***
9. untreated	-			10	10(100)	10(100)
10. Fox	1.0			9.5 sc sp	10(100)	10(100)
11. Fox + Shield	0.5 + 0.5			9.5 sc sp	10(100)	10(100)
12. oxyfluorfen	0.5			6 (25)	9 (80)	10(100)
13. oxyfluorfen	1.0			4 (50) dist	5.7 (70) L	9.5 (100) d
14. oxyfluorfen	2.0			2 (80) dist	4 (50) dist L	8 (90) d
15. DFF + oxyfluorfen	0.15 + 0.5			6 (25)	9 (80)	10 (100)
16. DFF + Fox	0.15 + 0.25			9 bl sp	10(100)	10 (100)
17. Fortrol standard	0.5			9 cl	10(100)	10 (100)

DAT days after treatment post-emergence; bl bleaching; cl chlorosis; sc scorch, sp spotting; dist distortion; d delayed maturity; L leaf loss

There was no crop damage at any stage from herbicides applied pre-transplanting cauliflower: Treflan, Stomp, Defy or oxadiargyl, or from pre-weed-emergence applications of Ramrod or Butisan (Table 3). However, on 8 June severe bleaching of leaves (50% leaf area on 40% of plants) was observed from Centium. Bleaching was mainly on new leaves rather than the four older leaves, suggesting the cause was from root uptake. After two to three weeks, the bleaching from Centium was negligible (Table 3).

Post-weed-emergence herbicides, assessed 26 June 9 days after treatment (DAT): Fox caused slight damage in the form of scorched spots on leaves; Alpha DFF caused bleached spots, and Fortrol chlorotic patches. The new growth was unaffected and no damage was apparent two weeks later.

Damage from oxyfluorfen was severe and seen as soon as 3 DAT. Large leaf areas were scorched (assessed 26 June) and at the higher dose rates of 1.0 L/ha and 2.0 L/ha, the growing points of the cauliflower were scorched and distorted. Affected leaves were lost and thus there was a reduction in ground cover by the crop compared with untreated plots (10 July), but at this stage, 23 DAT, the growing points on cauliflower treated with oxyfluorfen at 0.5 and 1.0 L/ha had recovered. There was no plant loss at this site. The tank-mix of oxyfluorfen + diflufenican (treatment 15) caused more damage than oxyfluorfen alone (12).

Cauliflower sprayed with oxyfluorfen made a very good recovery in warm wet weather, and at harvest stage the cauliflower treated with 0.5 L/ha appeared to be of similar size, maturity and number to the best treatments. At 1.0 L/ha there was a slight delay, estimated four days. However, those treated with the highest dose of oxyfluorfen 2.0 L/ha were much smaller compared with standard treatments and maturity was delayed by an estimated seven days.

Tall weeds (mainly pale persicaria) smothered the untreated crop and weed competition resulted in very small cauliflower heads. There was contamination from weed seeds (charlock and shepherd's purse) and also some *Botrytis.*

Site 2 Sleaford cauliflower: crop safety (Table 4)

There was no crop damage from herbicides applied pre-transplanting cauliflower: Treflan, Stomp, Defy or oxadiargyl, or from pre-weed-emergence applications of Ramrod or Butisan at any growth stage (Table 4). There were no visible effects on the cauliflower from Centium at Site 2.

Post-weed-emergence herbicides were applied earlier at Sleaford (18 days after planting compared with 31 days after planting cauliflower at Kirton). As at Kirton, post-weed-emergence, Fox caused slight damage in the form of scorched spots on leaves with some distortion and leaf crinkling; DFF caused bleached spots, and Fortrol caused chlorotic patches. The new growth was not damaged and no effects were apparent two weeks later.

Damage from oxyfluorfen was severe at Sleaford – large areas of leaf were scorched and all dose rates caused scorch and distortion of growing points (23 July). The growing points on cauliflower treated with oxyfluorfen at 0.5 and 1.0 L/ha had recovered 19 DAT on 5 August, but there was 2% plant loss on plots treated with 2.0 L/ha. By 15 August the severely scorched leaves were lost and there was a reduction in cauliflower ground cover compared with untreated plots. Cauliflowers treated with oxyfluorfen at 2.0 L/ha were still severely stunted on 1 September but the growing points had recovered.

The tank-mix of oxyfluorfen 0.5 L/ha + DFF caused more damage than oxyfluorfen 0.5 L/ha alone – as at Site1, Kirton.

On 21 September (67 DAT) cauliflower treated with oxyfluorfen had recovered vigour except for the 2.0 L/ha dose rate where plants remained stunted in height although ground cover was 100%.

The field was harvested on 3 November, 128 days after planting, and all except oxyfluorfen-treated cauliflower were at harvest stage. Recovery of the cauliflower from oxyfluorfen damage at Sleaford was much slower than in the faster-maturing crop grown in warmer weather at Kirton and harvest delay was considerable. The cauliflower treated with the lowest 0.5 L/ha dose and 1.0 L/ha had not matured 110 days after application of oxyfluorfen and cauliflower were much smaller than other treatments, and at 2.0 L/ha, curds were only just initiated.

Table 4. Sleaford cauliflower (planted 28 June). Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent leaf area scorched on 23 July; percent crop cover on 5 and 15 August and at harvest stage 4 November

Herbicide	L product/ha	9 July	23 July (% scorch)	5 Aug (% cover)	15 Aug (% cover)	1 Sept (% cover)	21 Sept (% cover)	4 Nov harvest
0. untreated		10	10	10 (70)	10 (90)	10 (100)	10	10
Pre-transplant 28 June								
1. Treflan	1.7	10	10	10 (70)	10 (90)	10 (100)	10	10
2. Stomp	3.3	10	10	10 (70)	10 (90)	10 (100)	10	10
3. Stomp + Defy	3.3 + 4.0	10	10	10 (70)	10 (90)	10 (100)	10	10
4. oxadiargyl	1.0	10	10	10 (70)	10 (90)	10 (100)	10	10
Pre-transplant 28 June & post-transplant pre-weed- emergence 30 June								
5. oxadiargyl & Ramrod	1.0 & 9.0	10	10	10 (70)	10 (90)	10 (100)	10	10
6. oxadiargyl & Centium	1.0 & 0.25	10	10	10 (70)	10 (90)	10 (100)	10	10
7. oxadiargyl & Butisan	1.0 & 1.5	10	10	10 (70)	10 (90)	10 (100)	10	10
Post-transplant pre-weed- emergence 30 June								
8. Butisan	1.5	10	10	10 (70)	10 (90)	10 (100)	10	10
Post-weed-emergence 17 July			***6 DAT***	***19 DAT***	***29 DAT***	***46 DAT***	***67 DAT***	***110 DAT***
9. untreated	-	-	10	10 (70)	10 (90)	10 (100)	10 (100)	10
10 Fox	1.0	-	8 dist sc sp	9.5 sc sp	10 (90)	10 (100)	10 (100)	10
11.Fox + Shield	0.5 + 0.5	-	9 dist sc sp	10 (70)	10 (90)	10 (100)	10 (100)	10
12. oxyfluorfen	0.5	-	6 (sc 30)dist	7 (50)	7 (70) L	8 (100)	9 (100)	9.7d
13. oxyfluorfen	1.0	-	4 (sc 50) dist	5 (30)	5 (50)st L	7 (80)	8 st (100)	8.7d
14. oxyfluorfen	2.0	-	2 (sc 80) dist	2 (10) L	2 (30)st L	4 (70)	5 st (100)	6d
15. DFF + oxyfluorfen	0.15 + 0.5	-	5 (sc 40) dist	6 (40)	6.3 (70)	8 (80)	8.3 (100)	9d
16. DFF + Fox	0.15 + 0.25	-	9 bl sp	10(70) bl sp	10 (90)	10 (100)	10 (100)	10
17. Fortrol standard	0.5		9 cl	10 (70)	10 (90)	10 (100)	10 (100)	10

DAT days after treatment post-emergence; bl bleaching; cl chlorosis; sc scorch, sp spotting; dist distortion; st stunted; d delayed maturity; L leaf loss

Site 3 Kirton cabbage: crop safety (Table 5)

Table 5. Kirton cabbage (planted 14 June): Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent leaf area scorched on 10 July; percent crop cover on 26 July and 9 August and at harvest stage on 26 August

Herbicide	L product/ha	10 July (% scorch)	26 July (% cover)	9 August (% cover)	26 August (% cover)
Post-weed-emergence 1 July		***9 DAT***	***25 DAT***	***39 DAT***	***56 DAT***
9. untreated	-	10	10 (80)	10 (100)	10 (100)
10. Fox	1.0	8 sc sp	10	10 (100)	10 (100)
11. Fox + Shield	0.5 + 0.5	9 slight sc sp	10	10 (100)	10 (100)
12. oxyfluorfen	0.5	6 (20) dist	8 (60) 1L	9 (100)	9 (100) d
13. oxyfluorfen	1.0	4 (50) dist	5 (50) 2L cl	8 (90)	8.3 (90) d
14. oxyfluorfen	2.0	2 (90) dist	3 (30) 3L cl	5 (57) dist	5.7 (60) d
15. DFF + oxyfluorfen	0.15 + 0.5	5 (30) w sc	5.3 (50) 2L cl	7 (70)	7 (70) d
16. DFF + Fox	0.15 + 0.25	9 slight bl sp	10	10 (100)	10 (100)
17. Fortrol standard	0.5	10	10	10 (100)	10 (100)

DAT days after treatment post-emergence; bl bleaching; cl chlorosis; sc scorch, sp spotting; dist distortion; st stunted; w wilted; d delayed maturity; L leaf loss

Post-weed-emergence, Fox caused slight damage in the form of scorched spots on leaves; Alpha DFF caused bleached spots, and Fortrol, chlorotic patches (Table 5). The new growth was unaffected and no damage was apparent two weeks later (26 July) except for very slight spotting on leaves from Fox. At this stage ground cover of the crop on untreated plots was 80% and the cabbage were at 11- leaf stage.

Oxyfluorfen caused similar phytotoxic effects on cabbage as on cauliflower – all dose rates (treatments 12, 13 and 14) scorched large areas of leaf and growing points were scorched and distorted (10 July). There was loss of the affected outer leaves (assessment 26 July) estimated at 1 to 3 leaves depending on dose rate and a reduction in ground cover by the crop compared with untreated plots. There was some plant loss (<2%) on plots treated with oxyfluorfen 2.0 L/ha. On 26 July the cabbage growing points began to recover from oxyfluorfen 0.5 L/ha and 1.0 L/ha. Plants treated with the higher doses or the tank-mix (13,14,15), were chlorotic. The tank-mix of oxyfluorfen 0.5 L/ha + DFF (15) caused far more damage than oxyfluorfen 0.5 L/ha alone (12) and recovery was slower. In addition the outer leaves wilted. On 9 August there was little recovery from oxyfluorfen 2.0 L/ha or the tank-mix (15) and the cabbage hearts had not developed. The Savoy cabbage variety Famosa has dark crinkled leaves. Some older leaves were smooth and no longer typically crinkled (treatments 13, 14, 15).

The cabbage on the standard (Fortrol) and untreated plots was at harvest stage on 26 August but those on oxyfluorfen treated plots were delayed, by one week at the lowest dose 0.5 L/ha (12). At the higher doses for oxyfluorfen (13, 14) and the tank mix (15) maturity was uneven - oxyfluorfen 1.0 L/ha dose (13), and the tank-mix (15) there was a two-week delay for most of the cabbage but some were less mature. The delay was unacceptable - three weeks or more for the highest dose (14) and the size was uneven so several were not harvestable. Overall oxyfluorfen caused more damage to Savoy cabbage than to cauliflower.

Weed control

Site 1 Kirton cauliflower: weed species (Table 6)

Latin names for weed species on the trial site are given in Appendix 2.
The trial treatments were laid out in two blocks – herbicides applied pre-transplanting and pre-weed-emergence and post-weed-emergence, with untreated plots 0 or 9 respectively for each area. There was a very high population of pale persicaria on the trial area, some shepherd's purse, and lower numbers of chickweed, fat-hen, groundsel, knotgrass and a few other species.

Treflan (treatment 1) failed to control shepherds' purse, or the low population of mayweed or groundsel but gave complete control of pale persicaria and the low numbers of knotgrass and fat-hen (Table 6).

Stomp (2) gave 93% control of pale persicaria, and complete control of shepherd's purse. The addition of Defy (3) offered no improvement in control of these species. The remaining pale persicaria later grew above crop height.

Oxadiargyl at 1.0 L/ha (4) gave excellent weed control of all species with the exception of chickweed and this was controlled by post-planting herbicides Butisan, Ramrod or Centium. Butisan post-planting alone was ineffective on pale persicaria but controlled shepherd's purse.

Post-weed-emergence treatment Fox at 1.0 L/ha (10) was effective on shepherd's purse but poor on the main weed, pale persicaria, and neither partner, DFF nor Shield, improved control although Shield caused narrowing of the leaves. Fox also has weaknesses on mayweed and groundsel and Shield controlled these species. Fox did not control chickweed.

Fortrol scorched pale persicaria but many recovered and knotgrass was not controlled – it was more effective on chickweed.

The most effective post-emergence herbicide was oxyfluorfen, weeds were completely scorched within three days, although there was some re-growth of pale persicaria on plots treated with the lowest 0.5L/ha dose rate. It appeared to have a weakness on chickweed at 0.5 and 1.0 L/ha. However, oxyfluorfen caused severe crop damage.

Table 6. Kirton cauliflower (planted 18 May): Numbers of weed species/m^2 (mean of 3 replicates, 3 counts of 0.33 m^2 per plot) on 26 June. Crop cover 70%; weed cover on untreated 100%.

Herbicide	L product/ha	Pale persicaria	Shepherd's purse	Mayweeds #	Black-bindweed	Common poppy	Fat-hen	Chickweed	Groundsel	Knotgrass	TOTAL
0. untreated	-	87	9	2.3	0.3	1.3	3.3	4.3	4	3.7	**115.3**
Pre-transplant 18 May											
1. Treflan	2.3	0	9	1	0	0.3	0	0	3	0	**13.3**
2. Stomp	3.3	5	0	0	0	0	0	0	0.7	0	**6**
3. Stomp + Defy	3.3 + 4.0	6	0	0.3	0	0	0	0	0.3	0	**6.6**
4. oxadiargyl	1.0	0	0	0	0	0	0	4.3	0.3	0	**4.6**
Pre-transplant 18 May & post-transplant pre-weed- emergence 27 May											
5. oxadiargyl & Ramrod	1.0 & 9.0	0	0	0	0	0	0	0	0	0.3	**0.3**
6. oxadiargyl & Centium	1.0 & 0.25	0	0	0	0	0	0	0	0	0	**0**
7. oxadiargyl & Butisan	1.0 & 1.5	0	0	0	0	0	0	0	0	0.3	**0.3**
Post-transplant pre-weed- emergence 27 May											
8. Butisan	1.5	26.7	0	0	0	0	0	0	0	0.7	**27.4**
Post-weed-emergence 17 June											
9. untreated	-	53	15	3.7	2	0.7	0	3.7	2.3	2.3	**82.3**
10. Fox	1.0	36.3	1.7	2.3	1	0	0.7	3.3	0.7	0.7	**46.7**
11.Fox + Shield	0.5 + 0.5	33.3	3.7	0	0	0	0.3	3.7	0	2.3	**43.3**
12. oxyfluorfen	0.5	11.7	0	0	0	0	0	3.3	0	0	**15**
13. oxyfluorfen	1.0	2.7	0	0	0	0	0	2	0	0	**4.7**
14. oxyfluorfen	2.0	0	0	0	0	0	0	0.7	0	0	**0.7**
15. DFF+ oxyfluorfen	0.15 + 0.5	16.7	0.3	0.3	0	0	0	3	0	1.7	**22**
16. DFF + Fox	0.15 + 0.25	45.3	4.7	2.3	1	0	0	4.3	1.3	3.3	**62.3**
17. Fortrol standard	0.5	28.3	3.7	1.7	0	0	0	0.3	0	3.7	**37.7**

Mayweed, scentless and scented

Site 1 Kirton cauliflower: charlock and oilseed rape scores and % control (Table 7)

Charlock and oilseed rape were unlikely to be present on the trial site therefore seeds were sown on a small area on each plot before planting cauliflower. A high population of charlock and some oilseed rape had emerged on untreated plots by 31 May; other weeds emerged a week later. The charlock was at 2-4 true leaf stage when post-emergence sprays were applied on 17 June, rape was at cotyledon-2 true leaves.

The following are approved for use in rape crops and did not control oilseed rape "volunteers": Treflan, Butisan, Fox (and tank-mixes) and Fortrol (Table 7). Counts were not made for the post-weed-emergence treatments but a few rape at cotyledon stage that were less well waxed, were killed by Fox and Fortrol. Although counts on 9 June showed several seedlings emerged on plots treated with Stomp at 3.3 L/ha they remained at cotyledon stage and eventually died. However the rapeseed was not sown at depth, where poor control might be expected. Oxadiargyl alone, Defy in tank mix with Stomp applied pre-planting, post-weed-emergence oxyfluorfen at 1.0 and 2.0 L/ha gave complete control of oilseed rape, some remained after oxyfluorfen at the 0.5 L/ha dose rate.

Treflan, Stomp and Butisan did not control charlock. Oxadiargyl or Defy pre-planting performed best. Post-weed-emergence Fortrol, the standard for charlock control, was effective and Fox at 1.0 L/ha gave a similar level of control. Oxyfluorfen at 1.0 and 2.0 L/ha gave excellent control, but at the lowest dose rate 0.5 L/ha control was less effective (80%).

Table 7. Kirton cauliflower (planted 18 May): Number of sown charlock and oilseed rape (OSR) on 9 June (count in 0.33 m^2 quadrat per plot, mean of 3 replicates); weed control score (0=untreated no control, 7= acceptable control, 10= complete control) on 10 July; percent control of oilseed rape and charlock on 26 June, 10 and 27 July

Herbicide	L product/ha	Charlock	OSR	Charlock	OSR	Charlock	OSR	Charlock	OSR
		number 9 June		% control 26 June		score 10 July		% control 27 July	
0. untreated	-	64	28	0	0	0	0	0	0
Pre-transplant 18 May									
1. Treflan	2.3	39	20	40	0	4	0	30	0
2. Stomp	3.3	21 st	11 st	67	97	5.3	10	57	97
3. Stomp + Defy	3.3 + 4.0	12 st nec	1 st	97	100	9.5	10	97	100
4. oxadiargyl	1.0	0	0	100	100	9.9	10	99	100
Pre-transplant 18 May & post-transplant pre-weed-emergenee 27 May									
5. oxadiargyl & Ramrod	1.0 & 9.0	0	0	100	100	10	10	100	100
6. oxadiargyl & Centium	1.0 & 0.25	0	0	90	99	9	10	95	100
7. oxadiargyl & Butisan	1.0 & 1.5	0	0	100	100	10	10	100	100
Post-transplant pre-weed- emergenee 27 May									
8. Butisan	1.5	25	10	67	0	6	0	63	0
Post-weed-emergence 17 June									
9. untreated	-			0	0	0	0	0	0
10 Fox	1.0			83	0	8.7	0	86	0
11.Fox + Shield	0.5 + 0.5			63	0	5	0	67	0
12. oxyfluorfen	0.5			73	85	7.7	9	80	90
13. oxyfluorfen	1.0			100	99	9.9	9.7	100	99
14.oxyfluorfen	2.0			100	100	10	10	100	100
15.DFF + oxyfluorfen	0.15 + 0.5			70	83	6.7	9	70	85
16. DFF+ Fox	0.15 + 0.25			50	0	4	0	50	0
17.Fortrol standard	0.5			82	0	9	0	87	0

st stunted; nec necrotic

Site 1 Kirton cauliflower: weed control scores (Table 8)

The predominant species, pale persicaria, became very competitive and grew above crop height and so did the few fat-hen. On untreated plots and where control was poor, shepherd's purse and charlock senesced and shed seed that contaminated cauliflower at harvest.

Pale persicaria became a problem resulting in unacceptable weed control on all plots except those treated with oxadiargyl, oxyfluorfen 1.0 or 2.0 L/ha and Treflan.

By the 10 July weed cover from pale persicaria above the crop was 100% on untreated plots (treatments 0 and 9) and on plots treated with low doses of Fox + Shield (11) or diflufenican (16). On 27 July plots treated with Fortrol (17), Fox at 1.0 L/ha (10) and Butisan (8) weed cover by pale persicaria was 60 to 70%. There was some re-growth of pale persicaria on plots treated with oxyfluorfen at 0.5 L/ha. The few pale persicaria (5 and 6 plants/m^2 respectively) that escaped control with Stomp (2) or Stomp + Defy (3) resulted in unacceptable weed control by harvest.

The crop suppressed low growing species, including chickweed. Chickweed was the only species to escape control with oxadiargyl. By harvest the cauliflower treated with oxadiargyl + Butisan (7) or oxadiargyl + Ramrod (5) were still weed free and no post-weed-emergence herbicides would have been needed. Of the post-weed-emergence treatments, oxyfluorfen at 1.0 and 2.0 L/ha gave excellent weed control.

Table 8. Kirton cauliflower (planted 18 May): Weed control score excluding sown charlock and oilseed rape (0=untreated no control, 7 acceptable control, 10 complete control); percent weed cover, mainly pale persicaria, on 29 July

Herbicide	L product/ha	20 June	26 June	10 July	29 July (% weed cover)
0. untreated	-	0		0	0 (100)
Pre-transplant 18 May					
1. Treflan	2.3	9.8		8	8 (0)
2. Stomp	3.3	8.7		7	6 (7)
3. Stomp + Defy	3.3 + 4.0	8.8		7	6 (7)
4. oxadiargyl	1.0	9.5		9	9.5 (0)
Pre-transplant 18 May & post-transplant pre-weed- emergenee 27 May					
5. oxadiargyl & Ramrod	1.0 & 9.0	10		10	10 (0)
6. oxadiargyl & Centium	1.0 & 0.25	10		10	10 (0)
7. oxadiargyl & Butisan	1.0 & 1.5	10		10	10 (0)
Post-transplant pre-weed- emergenee 27 May					
8. Butisan	1.5	6		3.7	3.3 (40)
Post-weed-emergence 17 June					
9. untreated	-		0	0	0 (100)
10. Fox	1.0		4	4	3.3 (70)
11.Fox + Shield	0.5 + 0.5		4	2	2 (70)
12. oxyfluorfen	0.5		6	6	6.7 (20)
13. oxyfluorfen	1.0		9.5	9.5	10 (0)
14.oxyfluorfen	2.0		10	10	10 (0)
15.DFF + oxyfluorfen	0.15 + 0.5		7	7	5 (30)
16. DFF+ Fox	0.15 + 0.25		2	2.3	1.7 (100)
17. Fortrol standard	0.5		6	5	3.7 (70)

Site 2 Sleaford cauliflower: weed species (Table 9)

Latin names for weed species on the trial site are given in Appendix 2.

The trial layout was in two blocks – herbicides applied pre-transplanting/ pre-weed-emergence and post-weed-emergence, with untreated plots in each replicate 0 or 9 respectively on each area. At the Sleaford site there was a wide weed spectrum, with a high population of fat-hen and black nightshade, and populations were higher in untreated plots 9 (Table 9) than in untreated 0.

Pre-transplanting Treflan gave good control of the fat-hen but not of black- or green-nightshade.

Stomp was not quite as effective on fat-hen and the tank-mix of Stomp + Defy offered no improvement.

Oxadiargyl alone gave poor control of fat-hen, but was effective on all other species including nightshades and there was no chickweed at this site. Oxadiargyl followed by Butisan pre-weed-emergence gave complete control of all weeds and so did Butisan applied alone. Fat-hen is not susceptible to Ramrod or Centium and oxadiargyl followed by Ramrod or Centium only improved fat-hen control slightly.

Post-weed-emergence herbicides were applied earlier at this site (18 days after planting compared with 31 days after planting cauliflower at Kirton) and there was a further emergence of a few fool's parsley later (cotyledon to 4 leaf stage on 5 August). Herbicides applied post-weed-emergence, with the exception of the low dose of Fox + DFF (16), controlled nightshade and most other species, but several fat-hen remained except where oxyfluorfen was applied. Fox at 1.0 L/ha scorched fat-hen but some recovered, and at lower doses in tank-mixes (treatments 11 and 16) control was poor. Fortrol (17) was ineffective on fat-hen. Shield (11) in tank-mix killed the low numbers of mayweed. A few mayweed and black-nightshade escaped control with the tank-mix DFF + Fox (16).

Oxyfluorfen at all dose rates alone (12, 13, 14) or in tank-mix with DFF (15) gave excellent control of all weed species (except the fool's parsley emerging after the sprays were applied) but caused severe crop damage.

There was an unevenly distributed population of volunteer potatoes at the Sleaford site. Assessments on 23 July and 5 August showed that Shield (11) in tank-mix distorted volunteer potato shoots. Oxyfluorfen at all dose rates caused very severe damage in the form of scorch. Although more shoots emerged later, growth remained below crop height until harvest stage.

Table 9. Sleaford cauliflower (planted 28 June): number of weed species /m^2 (mean of 3 replicates, three 0.33 m^2 quadrats per plot) on 5 August, 19 days after treatment (DAT) with post-emergence herbicides

Herbicide	L product/ha	Fat-hen	Black nightshade	Green nightshade	Fool's parsley	Sun spurge	Smooth sowthistle	Groundsel	Field pansy	Mayweeds	Redshank	Small nettle	TOTAL
0. untreated		29	6	1	3	7	2.3	2.7	4	2.3	0.7	1	**59**
Pre-transplant 28 June													
1. Treflan	2.3	3.3	3	0.7	2	9	1.7	0.7	8	1	0	1.7	**31.1**
2. Stomp	3.3	9.3	1.7	0.3	0.3	5	0	1.7	0	0	0	0	**18.3**
3. Stomp + Defy	3.3 + 4.0	8.7	1.7	0	0	3	0.3	2.3	0	0.7	0.7	0.7	**18.1**
4. oxadiargyl	1.0	13.7	0	0	0	0.3	0.3	0	0	0	0	0	**14.3**
Pre-transplant 28 June & post-transplant pre-weed- emergence 30 June													
5. oxadiargyl & Ramrod	1.0 & 9.0	5.3	0	0	0	0.3	0	0	0	0	0	0	**5.7**
6. oxadiargyl & Centium	1.0 & 0.25	7.7	0	0	0	0.7	0	0	0	0	0.3	0	**8.7**
7. oxadiargyl & Butisan	1.0 & 1.5	0	0	0	0	0	0	0	0	0	0	0	**0**
Post-transplant pre-weed- emergence 30 June													
8. Butisan	1.5	0	0	0	0	0	0	0	0	0	0	0	**0**
Post-weed-emergence 17 July													
9. untreated	-	48.3	22.3	4	9	6.3	5	1.3	4.3	2	3	1.7	**107.6**
10. Fox	1.0	18.7	0	0	8.7	0.3	6	0.3	0	2	0	0	**36**
11. Fox + Shield	0.5 + 0.5	26.7	0	0	5.7st	1.3	0	0	0	0	0	0	**33.7**
12. oxyfluorfen	0.5	1	0	0	8	0	0	0	0	0	0	0	**9**
13. oxyfluorfen	1.0	0	0	0	5	0	0	0	0	0	0	0	**5**
14. oxyfluorfen	2.0	0	0	0	0	0	0	0	0	0	0	0	**0**
15. DFF+ oxyfluorfen	0.15 + 0.5	1	0	0	9.7	0	0	0	0	0	0	0	**10.7**
16. DFF+ Fox	0.15 + 0.25	23.7	5.3	0	8.7	0.7	0	1	0	2.3	1.7	0	**43.4**
17. Fortrol standard	0.5	29	0.3	0	7.3	3.3	2.3	0.3	0	0.7	0.7	0.7	**44.7**

Site 2 Sleaford cauliflower: weed control scores (Table 10)

Table 10. Sleaford cauliflower (planted 28 June): Weed control score (0=untreated no control, 7 acceptable control, 10 complete control); percent weed cover on 15 August and 1 September, mainly fat-hen above crop height and some nightshade and potatoes

Herbicide	L product/ha	23 July	5 Aug	15 Aug (% weed cover)	1 Sept (% weed cover)	21 Sept (% weed cover)
0. untreated		0	0	0 (50)*	0 (50)**	0 (50)**
Pre-transplant 28 June						
1. Treflan	1.7	8.8	8	7.7 (7)	7 (5)	7 (5)
2. Stomp	3.3	6.5	6.5	6.3 (10)	6 (18)	4.7(15)
3. Stomp + Defy	3.3 + 4.0	6.5	6.5	6.3 (10)	6 (18)	4.7(15)
4. oxadiargyl	1.0	7	6	5 (25)	5 (27)	4 (27)
Pre-transplant 28 June & post-transplant pre-weed-emergence 30 June						
5. oxadiargyl & Ramrod	1.0 & 9.0	9	8	9 (1)	8.7 (2.3)	8.7 (2)
6. oxadiargyl & Centium	1.0 & 0.25	8	7	7 (5)	7 (9)	6 (10)
7. oxadiargyl & Butisan	1.0 & 1.5	10	10	10 (0)	10 (0)	10 (0)
Post-transplant pre-weed- emergence 30 June						
8. Butisan	1.5	10	10	10 (0)	10 (0)	10 (0)
Post-weed-emergence 17 July						
9. untreated	-	0	0	0 (100)	0 (100)	0 (100)
10. Fox	1.0	7.7	5.3	6 (13)	6 (20)	5 (20)
11. Fox + Shield	0.5 + 0.5	6	4	4 (35)	3.3 (45)	3.3 (40)
12. oxyfluorfen	0.5	10	9.7	9.7 (<1)	9.7 (<1)	9.7 (<1)
13. oxyfluorfen	1.0	10	10	10 (0)	10 (0)	10 (0)
14. oxyfluorfen	2.0	10	10	10 (0)	10 (0)	10 (0)
15. DFF + oxyfluorfen	0.15 + 0.5	10	9.8	9.8 (<1)	9.7 (<1)	9.6 (<1)
16. DFF + Fox	0.15 + 0.25	3.3	3.3	3 (50)	3 (60)	2 (77)
17. Fortrol standard	0.5	3.3	3.3	3 (50)	3 (50)	3 (33)

crop cover on untreated * 90%; ** 100%

Fat-hen was the most competitive species, growing above the crop, and nightshade was also vigorous and this is taken into account in the scores, with Treflan performing better than the other pre-transplant treatments at this site. Fat-hen was the only weed remaining after oxadiargyl. The very safe programme of oxadiargyl followed by Butisan, or Butisan alone gave complete control, so did the damaging oxyfluorfen.

On 15 August, weed cover (Table 10) was mainly with fat-hen. Shield (treatment 11) caused distortion of the growing point of potatoes. Oxyfluorfen at all dose rates killed potato shoots but by 15 August more shoots were beginning to emerge. However, on all other plots potato growth was vigorous and several were flowering. By 15 August there was a further flush of a small number of some weeds on all plots except those treated with the 1.0 or 2.0 L/ha oxyfluorfen. Oxyfluorfen has residual soil, as well as contact, activity.

On untreated plots on 1 September the fat-hen were well above crop height and so were a few potatoes and nightshade. On 21 September cauliflower had smothered weeds except for fat-hen on all plots.

Site 3 Kirton cabbage: weed species (Table 11)

Latin names for weed species on the trial site are given in Appendix 2.

Table 11. Kirton cabbage (planted 14 June): number of weed species /m^2 (mean of 3 replicates, three 0.33 m^2 quadrats per plot) on 27 July

Herbicide	L product/ha	Chickweed	Shepherd's purse	Mayweed #	Annual meadow-grass	Pale persiscaria	Knotgrass	Fat-hen	Common poppy	TOTAL
Post-weed-emergence 1July										
9. untreated	-	12.3	11	10	3.3	2.3	0	1	0	**40**
10. Fox	1.0	5.3	2	2.7	1.3	0.7	0	0.7	0	**13.7**
11. Fox + Shield	0.5 + 0.5	3.7	4.7	0	1.7	0	0	0.3	0	**10.7**
12. oxyfluorfen	0.5	2.3	0	0	0	0	0	0	0	**2.3**
13. oxyfluorfen	1.0	1.3	0	0	0	0	0	0	0	**1.3**
14. oxyfluorfen	2.0	1	0	0	0	0	0	0	0	**1**
15. DFF+ oxyfluorfen	0.15 + 0.5	0	0	0.7	0	0	0.7	0	0	**2.4**
16. DFF+ Fox	0.15 + 0.25	0	0	9.3	3.7	4	1	1	0.7	**19.7**
17. Fortrol standard	0.5	0	0	0	0.3	2.7	0.3	1	0	**4.3**

Mayweed, scentless, scented and pineappleweed

Weed numbers on the trial area were low and the predominant weed species were chickweed, shepherd's purse and scentless mayweed (Table 11).

Post-weed-emergence sprays were applied 17 days after transplanting. Fortrol at 0.5 L/ha (treatment 17) was effective on some weeds present at this site including large shepherd's purse, but not on the low numbers of pale persicaria and fat-hen, and these tall species competed with the crop later.

Fox at 1.0 L/ha (10) did not control chickweed and control of shepherd's purse, mayweed and possibly fat-hen was incomplete. The addition of DFF (16) to Fox improved efficacy on chickweed and shepherds purse but control of mayweed, annual meadow-grass and pale persicaria was poor – these species are resistant to DFF and the dose of Fox was too low. The addition of Shield gave complete control of mayweed but not shepherd's purse or chickweed. Fox alone and at lower doses in tank-mixes (11, 16) appeared safe to the crop and higher dose rates could be used.

Oxyfluorfen (12, 13, 14) completely controlled the low numbers of annual meadow-grass and all broad-leaved weeds with the exception of a few chickweeds. The tank-mix with DFF controlled the chickweed remaining at this site but not at Site 1.

Site 3 Kirton cabbage: charlock and oilseed rape control (Table 12)

Table 12. Kirton cabbage (planted 14 June): Oilseed rape (OSR) and charlock weed control scores (0=untreated no control, 7= acceptable control, 10= complete control) 10 July; number of charlock and oilseed rape/0.33 m^2 on 26 July (mean 3 replicates, one count 0.33 m^2 quadrat per plot); percent control 9 August

Herbicide	L product/ha	Charlock	OSR	Charlock	OSR	Charlock	OSR
		10 July score		26 July No.		9 Aug % control	
Post-weed-emergence 1July							
9. untreated	-	0	0	21	11	0	0
10. Fox	1.0	10	0	0	9	100	0
11. Fox + Shield	0.5 + 0.5	10	0	2	8	99	0
12. oxyfluorfen	0.5	10	9	0	5	100	50
13. oxyfluorfen	1.0	10	10	0	2	100	80
14. oxyfluorfen	2.0	10	10	0	0	100	100
15. DFF + oxyfluorfen	0.15 + 0.5	10	10	0	5	100	55
16. DFF + Fox	0.15 + 0.25	10	0	0	10	99	0
17. Fortrol standard	0.5	9.5	0	1	9	99	0

Oilseed rape and charlock were sown pre-transplanting cabbage in an area on each plot, and the growth stages at application were 2 true leaves and cotyledon – 2 true leaves respectively. A few oilseed rape plants may have emerged after herbicides were applied.

All the post-weed-emergence herbicides gave excellent control of charlock, even low doses of Fox (16) Table 12). Fox and Fortrol, both with approvals for use in oilseed rape, did not control the "volunteers" although a few of the smaller, less well waxed rape seedlings may have been killed. Oxyfluorfen 2.0 L/ha gave complete control of oilseed rape, 1.0 L/ha was also effective but in this trial the 0.5 L/ha was inadequate. On 26 August, at harvest stage both species had finished flowering, produced seeds and the charlock had senesced.

Site 3 Kirton cabbage: weed control scores (Table 13)

Table 13. Kirton cabbage: weed control score excluding sown charlock and oilseed rape (0=untreated no control, 7= acceptable control, 10= complete control); % weed cover (in parentheses).

Herbicide	L product/ha	10 July	26 July	1 August	9 August	26 August
Post-weed-emergence 1July						
9. untreated	-	0	0	0 (60%)	0 (60%)	0 (80%)
10. Fox	1.0	9	6.3	5.7	5.3	5 (40%)
11. Fox + Shield	0.5 + 0.5	9.2	7.3	7.3	6	6 (23%)
12. oxyfluorfen	0.5	10	9.8	9.8	9.3	9.3 (3%)
13. oxyfluorfen	1.0	10	10	10	9.9	10 (0%)
14. oxyfluorfen	2.0	10	10	10	10	10 (0%)
15. DFF + oxyfluorfen	0.15 + 0.5	10	10	10	10	10 (0%)
16. DFF + Fox	0.15 + 0.25	9.3	7.3	7.7	6.7	6 (23%)
17. Fortrol standard	0.5	9.5	7.7	7.3	8	8 (15%)

Oxyfluorfen gave a high level of control at all dose rates and in tank-mix with diflufenican, in spite of the reduced ability of the damaged cabbage to smother weeds on these plots (Table 13).

On untreated plots weed cover was 60% on 9 August, mainly from chickweed but some from shepherd's purse and the few pale persicaria grew vigorously. Chickweed was also a problem for treatments 10, 11 and the only weed on 12. Pale persicaria grew above the crop in plots where DFF + low dose Fox, Fox alone or Fortrol was applied. Weed control became unacceptable (9 August) for Fox and the Fox tank-mixes.

CONCLUSIONS

- The best weed control was with *oxadiargyl* 1.0 L/ha applied pre-planting followed by Butisan post-planting pre-weed emergence. The crops were weed-free until harvest stage and no other herbicide spray would have been necessary. This combination controlled a wide range of weeds at both sites, including charlock and oilseed rape.

- *Oxadiargyl* controlled charlock, oilseed rape and a very high population of pale persicaria, but weaknesses were on chickweed and fat-hen which were controlled by Butisan at 1.5 L/ha. Programmes with Ramrod or Centium were less effective on fat-hen at one site.

- *Oxadiargyl* was very safe to the cauliflower crop. It has short soil persistence and is suitable where following crops are likely to be sown.

- Stomp 400SC (pendimethalin) at 3.3 L/ha had poor efficacy on charlock, oilseed rape emerged but remained at cotyledon stage and died later; Defy 4.0 L/ha in tank-mix with Stomp improved control of both charlock and oilseed rape but not of other species on these sites. Defy (prosulfocarb) is newly approved for use in UK cereals.

- Post-weed-emergence, Fox was effective on charlock and could be a useful alternative to Fortrol in a programme. Fortrol, and Fox 1.0 L/ha alone and at lower doses in tank-mixes, caused only slight crop damage to cauliflower or cabbage.

- Fox needs a partner for other species – it did not control pale persicaria, chickweed, smooth sowthistle, scentless mayweed, fool's parsley or oilseed rape (it has a SOLA for use in rape). Both Shield or DFF were useful partners but both may be needed to cover a wider spectrum together with a higher dose of Fox than 0.5 L/ha.

- *Oxyfluorfen* applied post-weed-emergence caused severe damage to cauliflower and cabbage: a large area of leaf was scorched and the growing point was distorted. The initial damage levels were similar at all sites. It took about 20 days for growing points of all crops treated with 0.5 L/ha or 1.0 L/ha dose to recover. The highest dose of *oxyfluorfen* 2.0 L/ha resulted in leaf loss and 2% plant loss at two sites. Overall, *oxyfluorfen* caused more damage to Savoy cabbage than to early cauliflower. Recovery of the autumn cauliflower from *oxyfluorfen* damage at Sleaford was much slower than in the faster-maturing crop grown in warmer weather at Kirton and harvest delay was considerable. *Oxyfluorfen* caused unacceptable harvest delays: for the 1.0 l/ha about 4 days in early cauliflower, 14 days in Savoy cabbage, and considerably longer for autumn cauliflower. Harvest stage for the commercial autumn cauliflower crop was on 4 November, 128 days after planting (and 110 days after application of *oxyfluorfen*) but cauliflower treated with the lowest 0.5 L/ha dose had not matured, and at 2.0 L/ha, curds were only just initiated.

- The tank-mix of *oxyfluorfen* 0.5 L/ha with DFF was more damaging than *oxyfluorfen* at 0.5 L/ha alone.

- *Oxyfluorfen* at 1.0 and 2.0 L/ha gave excellent control of all weed species including charlock, oilseed rape and black nightshade and completely scorched potato shoots but more emerged later. *Oxyfluorfen* at 0.5 L/ha was less effective on oilseed rape, charlock and chickweed, and on pale persicaria at one site.

- *Oxyfluorfen* is a very effective herbicide and it controlled the target species but applied post-transplanting, it does not have a sufficient margin of crop safety to justify further evaluation. Application pre-transplanting could be assessed in 2006.

Oxadiargyl is on the EC Annex 1 (positive list) but not registered in the UK on any crop.

Oxyfluorfen is not registered for any UK crop and it may be some time before it becomes available for N European vegetables

Samples from some successful treatments were sent for residue analysis through HDC for *oxyfluorfen*, DFF, Fox cauliflower and cabbage; *oxadiargyl*, cauliflower only. No residues were detected.

Weed control and herbicide activity
Appendix 1 of this report shows product label claims and other information on weed species.

Current Herbicide Approval Status (as of November 2005)

Herbicide active ingredient	*Product*	*Company*	*Formulation*	*Approval Status (as at November 2005*
trifluralin	Alpha Treflan 48EC	Makhteshim	480 g/L EC	UK approval for brassicas, may not achieve Annex 1 list
pendimethalin	Stomp 400 SC	BASF	400 g/L SC	UK approval for brassicas
prosulfocarb	Defy	Syngenta	800 g/L SC	new UK approval for cereals
oxadiargyl	-	Bayer	400 g/L SC	no UK approval for any crop
propachlor	Ramrod Flowable	Monsanto	480 g/L SC	UK approval for brassicas
clomazone	Centium 360CS	Belchim	360 g/L CS	SOLA1031/04 for brassicas
metazachlor	Butisan S	BASF	500 g/L SC	UK approval for brassicas
bifenox	Fox	Makhteshim	500 g/L SC	UK approval for brassicas
clopyralid	Dow Shield	Dow	200 g/L SC	UK approval for brassicas
oxyfluorfen	-	Makhteshim	240 g/L EC	no UK approval for any crop
diflufenican	Alpha DFF 500 SC	Makhteshim	500 g/L SC	UK provisional approval for cereals
cyanazine standard	Fortrol	Makhteshim	500 g/L SC	SOLA1074/03 for cauliflower, cabbage etc. Essential Use until end 2007

SOLA Specific Off-label Approval; green text on Annex 1 the positive list of the EC Review

RECOMMENDATIONS

In the second year 2006, treatments will include oxadiargyl, Butisan, oxyfluorfen pre-transplanting (not post); tank-mixes with Fox at a higher dose rate.

Growers will need to review current weed control strategy for brassicas because the "Essential Use" for Fortrol and sodium monochloroacetate will cease 31 December 2007.

It also seems likely that trifluralin will fail to achieve Annex 1 listing and will be revoked and alternatives for control of polygonums and annual meadow-grass will be needed.

The FV 270 project, has allowed the industry to demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so that this use can continue. Importantly, work is in progress to look at alternatives to trifluralin if it is revoked and this has been included in a request for an 'Essential Use' for trifluralin.

ACKNOWLEDGEMENTS

This work was funded by the Horticultural Development Council and the support of the Brassica Industry through the HDC Vegetable Panel and the BGA (Brassica Growers Association) is gratefully acknowledged. Special thanks are due to the project co-ordinator Andy Richardson for his input and ideas, and to Mark Gedney and Dave Bunn, Gedney Farms for provision of the Sleaford commercial site and for their co-operation.

Appendix 1. Weed Susceptibility to herbicides; Key: S = susceptible; MS = Moderately Susceptible; R Resistant; MR = Moderately Resistant red text 2005 trials

	Treflan	oxadiargyl	Stomp	Ramrod	Defy	Centium	Butisan	Shield	Fox	Alpha dff	Alpha dff	oxyfluorfen	Fortrol
	Pre-plant	Pre-plant	Pre-plant	Pre-weed em	Pre-weed em	Pre-weed em	Pre-weed em	Post weed-em	Post weed-em	Post weed-em	Post weed-em	Post weed-em	Post weed-em
Common name	2.3 L/ha	1.0 L/ha	3.3 L/ha	9.0 L/ha	4.0 L/ha	0.25 L/ha	2.5 L/ha	0.5 L/ha	1.0 L/ha	0.2L/ha	0.4 L/ha	1.0 L/ha	
Bindweed black	S	S		R		MR	MS	MS	S	R	MR		S
Bugloss									S				S
Charlock	R	S		R	S	R	MR		S	MS	MS	S	S
Chickweed, common	S	R	S	S	S	S	S		R	MS	S	MR	S
Cleavers	R			S	S	S	MS		S 2whorl	MS	MS		R
Corn marigold	R		S	S			S	S					
Corn spurrey	MS	S		S			MS		S	MR/MS	MS	S	
Crane's-bill, cut-leaved							S		MS	R	MR		MR
Deadnettle, henbit	S		S	MS									S
Dead-nettle, red	MS	S	S	S	S	S	S		S	MR/MS	MS		S
Dock, broad-leaved													
Fat-hen	S	S	S	MR	S	MS	MS		S MS	MR	MR/MS	S	S
Fool's parsley	R					S							S
Forget-me-not, field			S				S		MS	MS/S	S		S
Fumitory, common	MS		MS	R	S?	R	R		S?	MR	MR	S	S
Gallant -soldier				S								S	
Groundsel	R	S	R	S		S	S	S		MR	MR/MS	S	S
Hemp-nettle, common	S	R	S	S			MR		S				S
Knotgrass	S	S	S	R		MR	R		MS	MR	MR/MS	S	S
Mayweed, scented	R	S	MS	S	MS	R	S	S	R	MR	MR/MS		S
Mayweed, scentless	R	S	MS	S	MS	R	S	S	R	MR	MR/MS	S	S
Nettle, small	MS	S	S	S		MR	MS			S		S	S
Nightshade black	R			MS									S
Orache, common	MS		S	MR		R			S				S
Pansy, field	S		S	S	R		MR		S	S	S		S
Parsley piert			S		S		S		R				MR
Pennycress, field	R			R			R		S				
Persicaria, pale	S					MS		MR		MR	MR/MS	S	S
Pimpernel, scarlet	S	R	S						R	S	S	S	S
Pineappleweed	R	S	MS	S		R		S	R	MR	MR		S
Poppy, common	MS		S		R	R	S		MS	MR	MR	S	S
Redshank	S	S		R		S	MS	MR				S	S
Shepherd's-purse	R	S	MS	S		S	S		MR	MS/S	S	S S	S
Sow-thistle, smooth	R	S	S	MS		MS		S	S			S S	
Speedwell, common, field	S	S	S	S	S	S	S		S	MS/S	S		S
Speedwell, ivy-leaved	S	S	S		S	S	S		S	MS/S	S		S
Sun spurge	MS	S		R									
Thistle, creeping	R					R		S					
Wild radish	R	S		R		S			MR/R	MS/S	MS/S	S	S
Annual meadow grass	S		S	S	S	MS	S			R		S	S
Blackgrass	S	R	S	S	S		S						MS
Brome, barren							MS						MS
Wild-oat	MS			R	R		MR					S	R
Vol OSR	R	S	MS		S	R	R	R	R	MS/S	S	S	R
Vol Potatoes								MS				MS	

Appendix 2

Weeds found on the untreated trial areas

Common name	Latin name
Annual meadow-grass	*Poa annua*
Black-bindweed	*Polygonum convolvulus*
Charlock	*Sinapis arvensis*
Chickweed, common	*Stellaria media*
Fat-hen	*Chenopodium album*
Fumitory, common	*Fumaria officinalus*
Groundsel	*Senecio vulgaris*
Knotgrass	*Polygonum aviculare*
Mayweeds	*Matricaria* spp.
Mayweed, scented	*Matricaria recutita*
Mayweed, scentless	*Matricaria inodorum*
Nettle, small	*Urtica urens*
Nightshade, green	*Solanum physalifolium*
Nightshade, black	*Solanum nigrum*
Pale persicaria	*Polygonum lapathifolium*
Pansy, field	*Viola arvensis*
Pineappleweed	*Matricaria discoidea*
Poppy, common	*Papaver rhoeas*
Redshank	*Persicaria maculosa*
Shepherd's purse	*Capsella bursa-pastoris*
Smooth sowthistle	*Sonchus oleraceus*
Speedwell, common field	*Veronica persica*
Speedwell, ivy-leaved	*Veronica hederifolia*
Sun spurge	*Euphorbia helioscopia*