PROJECT REPORT

To:
Horticultural Development Council
Bradbourne House
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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

Final report 2006

December 2006

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

FV 270

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Final report: Final report completed December 2006
Previous reports: First year FV 270 Annual Report December 2005; some potential alternatives were identified in project FV 256
Project started: March 2005
Project completed: December 2006

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Keywords:
Cauliflower, cabbage, transplants, crop safety, annual broad-leaved weed control, herbicides, pre-transplanting, pre-weed-emergence, post-emergence, SOLA (Specific Off-label Approval); trifluralin (Treflan), pendimethalin (Stomp), prosulfocarb (Defy), oxadiargyl, propachlor (Ramrod), clomazone (Centium), metazachlor (Butisan), bifenox (Fox), clopyralid (Shield), oxyfluorfen, diflufenican (Alpha DFF), cyanazine (Fortrol), 212 H, BUK 9900H, BUK 9800H, GF-1049.

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Project number:	**FV 270**
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Locations:	The Kirton Research Centre, Kirton, (cauliflower & cabbage) Commercial crops cauliflower at Sleaford and Holbeach Hurn Duchy of Cornwall demonstration
Project coordinator:	Andy Richardson, Allium and Brassica Centre, Kirton, Boston.
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); trifluralin (Treflan), pendimethalin (Stomp), prosulfocarb (Defy), oxadiargyl, propachlor (Ramrod), clomazone (Centium), metazachlor (Butisan), bifenox (Fox), clopyralid (Shield), oxyfluorfen, diflufenican (Alpha DFF), cyanazine (Fortrol), 212 H, BUK 9900, BUK 9800H, GF-1049.

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. All were single applications except for oxadiargyl programmes. The aim of the project was: to identify alternatives for control of charlock (Fortrol replacement) and oilseed rape volunteers which could become an problem as the rape area increases; to evaluate herbicides for control of fat-hen and polygonums as alternatives to Treflan. None of the new herbicides identified (in italics) are available for brassicas yet. The following were the most promising safe treatments:

Pre-weed emergence residual herbicides

- *Defy (prosulfocarb)* tank-mixed with Stomp (pendimethalin) pre-planting improved control of charlock and possibly oilseed rape, but there was little improvement on other weeds.
- *Oxadiargyl* 1.0 L/ha applied pre-planting in 2005 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. Under dry conditions in 2006 it was less effective. *Oxadiargyl* is likely to be used at a lower dose rate (because of cost) in a programme to control chickweed. Programmes of *oxadiargyl* followed by Ramrod (propachlor), Centium (clomazone) in 2005 only, or Butisan (metazachlor) controlled chickweed. Overall the Butisan programme performed best.
- *BUK 9900H* at 4.0 L/ha pre-transplanting was safe and gave excellent control of all species, including oilseed rape and charlock. *BUK 9900H* applied 2d post-transplanting at 2.5 L/ha appeared to be safe and weed control was good, except for oilseed rape and charlock.
- *GF-1049* 1.0 L/ha applied pre-transplanting was safer than the post-weed-emergence application and controlled all species including charlock but was ineffective on oilseed rape, and may have a weakness on chickweed, which was present in low numbers.

Post-weed-emergence herbicides

- *Fox (bifenox)* 1.0 L/ha controlled small charlock and could be a useful alternative to Fortrol (cyanazine) but there were several gaps in the weed spectrum including chickweed. *Fox* at 1.0 L/ha was the safest post-weed emergence treatment. In 2006 it caused more damage to Savoy cabbage leaves than cauliflower.
- *GF-1049* at 0.5 L/ha performed best, controlling a wide range of species including oilseed rape and charlock but this dose rate was too phytotoxic for grower acceptability. *GF-1049* even at 0.25 L/ha gave 91% control of total weed numbers. It caused scorched spotting on cauliflower leaves, and temporary distortion of the growing point in Savoy cabbage. Early application 2-3 weeks after transplanting would improve crop safety.

The following lacked crop safety or gave inadequate weed control

- *Oxyfluorfen* has residual soil, as well as foliar, activity. In 2005 the 240g/L EC formulation applied post-weed-emergence at 1.0 L/ha, 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. It is safer when applied pre-transplanting.
- *212 H* appeared safe pre- and post-transplanting but control of polygonums was poor.

There was limited data (cauliflower at one site only) for *BUK 9800H* a new herbicide for use in oilseed rape.

Weed species: susceptibility to herbicides

Appendix 1 of this report shows some product label claims and other information.

Approval status

Please note Approval Status Table 1. The new herbicides identified (below in italics) are not available for brassicas yet, because residues data are needed for SOLAs. Some herbicides are not registered for any UK crop and it may be some time before they become available for UK vegetables.

Prosulfocarb is registered in the UK for cereals and there is a SOLA for onions. It is supported in the EC Review but not yet on Annex 1. Residues studies are required.
Oxadiargyl is on the EC Annex 1 (positive list) but not registered in the UK on any crop, it is registered in Spain for use in lettuce. The company (Bayer CropScience) aims to register *oxadiargyl* in the UK.
BUK 9900H is a confidential mixture (both actives on Annex 1) and residue data will be needed.
Fox (bifenox) is registered for UK cereals and has a SOLA for use in UK oilseed rape (at 6 true-leaf stage). It is supported in the EC Review but is not on Annex 1 yet. Metabolism studies and residues data are needed.
Oxyfluorfen 240g/L EC formulation is not registered in the UK, but is registered in Spain for brassicas and onions. It is supported in the EC Review but is not on Annex 1 yet. Residues data for N Europe are needed.
GF-1049 is not registered in the UK. It is supported in the EC Review but is not on Annex 1 yet. There are metabolism studies but residues data for N Europe are needed.

Table 1. Herbicide Current Approval Status (December 2006)

Herbicide active ingredient	***EC Review status***	***Product***	***Company***	***Formulation***	***Approval Status***
trifluralin	List 2	Alpha Treflan	Makhteshim	480 g/L EC	UK Approval for brassicas
pendimethalin	Annex 1	Stomp 400	BASF	400 g/L SC	UK Approval for brassicas
prosulfocarb	List 3	Defy	Syngenta	800 g/L SC	UK Approval for wheat
oxadiargyl	Annex 1	(Raft)	Bayer	400 g/L SC	no UK Approval for any crop, Spain Approval lettuce
propachlor	List 3	Ramrod Flowable	Monsanto	480 g/L SC	UK Approval for brassicas
clomazone	List 3	Centium 360CS	Belchim	360 g/L CS	SOLA 1031/04 for brassicas
metazachlor	List 3	Butisan S	BASF	500 g/L SC	UK Approval for brassicas
bifenox	List 3	Fox	Makhteshim	500 g/L SC	SOLA for oilseed rape
clopyralid	Annex 1	Dow Shield	Dow	200 g/L SC	UK Approval for brassicas
oxyfluorfen	List 3	(Goal)	Makhteshim	240 g/L EC	no UK Approval for any crop, Spain approval brassicas, onions
diflufenican	List 3	Alpha DFF	Makhteshim	500 g/L SC	UK Approval for cereals
212 H	Annex 1	-	confidential	confidential	no UK Approval for any crop
BUK 9900H	Annex 1/Annex 1	-	confidential	confidential	no UK Approval for any crop
BUK 9800H	List 3 / Annex 1	-	confidential	confidential	-
GF-1049	List 3	-	confidential	confidential	no UK Approval for any crop
cyanazine	Not supported	Fortrol	Makhteshim	500 g/L SC	SOLA1074/03 cauliflower,

etc. Essential Use until end 2007

SOLA Specific Off-label Approval, (product names in other countries in parentheses).

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 doubtful because it may not achieve Annex 1 listing.

The early stage screening HDC trial FV 256 identified the safety of a range of vegetable crops to some alternative herbicides, including oxadiargyl, oxyfluorfen, 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 crops 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.
- 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 *(please note Approval status Table 1)*

Herbicides were evaluated in summer and late autumn maturing cauliflower, and (post-weed-emergence herbicides only) in Savoy cabbage. All were single applications, except for oxadiargyl programmes. The aim was to identify a Fortrol replacement for control of charlock, a herbicide for control of oilseed rape volunteers, which could become a problem as the rape area increases and for control of fat-hen and polygonums as alternatives to Treflan.

Charlock and oilseed rape were unlikely to be present on the trial site therefore seeds were sown on a small area on each plot and raked into the soil surface before planting cauliflower or cabbage. This did not represent a normal volunteer/weed situation because none emerged from depth therefore results should be treated with caution.
Herbicides in italics are not available for brassica crops yet.

Pre-weed emergence residual herbicides

- Stomp 400SC (pendimethalin) at 3.3 L/ha had poor efficacy on charlock and groundsel. It was effective on (shallow sown) oilseed rape, which emerged but remained at cotyledon stage and died later. Stomp gave excellent control of knotgrass, pale persicaria and redshank in spite of dry conditions in 2006 and performed better than Treflan (trifluralin).

- *Defy (prosulfocarb)* 4.0 L/ha tank-mixed with Stomp (pendimethalin) 3.3 L/ha pre-planting improved control of charlock and possibly oilseed rape, but there was no significant improvement on other weeds in these trials.

- *Oxadiargyl* 1.0 L/ha applied pre-planting in 2005 controlled volunteer oilseed rape, charlock, shepherds purse and other weed species that are not susceptible to Treflan. Under dry conditions in 2006 it was less effective. It did not control chickweed and control of fat-hen was incomplete. *Oxadiargyl* is likely to be used at a lower dose rate (because of cost) in a programme to control chickweed. Programmes of *oxadiargyl* followed by Ramrod (propachlor) 9.0 L/ha, Centium 360 CS (clomazone) 0.25 L/ha, or Butisan (metazachlor) 1.5 L/ha controlled remaining chickweed. In both years the *oxadiargyl* and Butisan programme performed best overall, with cauliflower remaining weed free until harvest in 2005.

- *BUK 9900H* evaluated in 2006 only, performed best. *BUK 9900* at 4.0 L/ha pre-transplanting was safe and gave excellent control of species at the sites. At 2.5 L/ha applied 2d post-transplanting it appeared to be safe and effective, except on oilseed rape and charlock.

- *GF-1049* 1.0 L/ha applied pre-transplanting was safer than the post-weed-emergence application. It controlled all species including charlock, but was ineffective on oilseed rape and may have a weakness on chickweed, which was present in low numbers.

- *212 H* at 0.06 kg/ha in 2006, caused some initial stunting of cauliflower and cabbage if applied 2 d post-transplanting but the plants soon recovered. *212 H* appears to be very dependent on moisture for good activity. It was the least effective treatment pre-transplanting/pre-weed-emergence - failing to control knotgrass, redshank, oilseed rape or charlock and was slightly less effective than other treatments on some other species.

There was only limited data for *BUK 9800H* 2.5 L/ha a new herbicide for use in oilseed rape applied 2 days after transplanting (one site only).

Post-weed-emergence herbicides
All post-weed-emergence treatments caused more crop damage when applied 55 days after transplanting (at Holbeach Hurn in 2006) because the large leaves caught more spray. This was also the case in the Duchy trial. The normal application timing is 14-21 days after transplanting.

- *Fox (bifenox)* at 1.0 L/ha was the safest post-weed emergence treatment but it caused more damage to Savoy cabbage leaves than cauliflower.

- *Fox* 1.0 L/ha controlled small charlock and could be a useful alternative to Fortrol (cyanazine). It has a SOLA for use in rape at 6 true leaves, but it killed small oilseed rape i.e. at an early growth stage when leaf wax was poor. At a site in 2005 it also controlled small nettle.

- *Fox* needs a partner for other species – control of chickweed, knotgrass, redshank, pale persicaria, mayweeds, smooth sow-thistle, fool's parsley was poor and it was inadequate on large fat-hen. In 2005, Shield or *DFF* were useful partners with *Fox* at 0.5 L/ha for control of some species but a higher dose rate of *Fox* was needed. However, in 2006 the tank-mix of *Fox + Alpha DFF* (1.0 + 0.5) L/ha improved control but caused unacceptable damage.

- *Oxyfluorfen* has residual soil, as well as foliar, activity. In 2005 the 240g/L EC formulation applied post-weed-emergence at 1.0 L/ha, 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. Recovery of the autumn cauliflower from oxyfluorfen damage was much slower than in the faster-maturing crop grown in warmer weather and harvest delay was considerable. *Oxyfluorfen* could be safer when applied pre-transplanting.

- *GF-1049* at 0.5 L/ha was the most effective post-emergence treatment in 2006, controlling a wide range of species including oilseed rape and charlock but this dose rate was too phytotoxic for grower acceptability. *GF-1049* even at 0.25 L/ha gave 91% control of total weed numbers. It caused scorch spotting on cauliflower leaves, and temporary distortion of the growing point in Savoy cabbage. Early application 2-3 weeks after transplanting would optimize efficacy and crop safety.

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

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 cultivations are not possible, or are ineffective, when soil conditions are too wet.

- New alternatives to cyanazine and sodium monochloroacetate, which will be lost at the end of 2007, and to trifluralin if it fails Annex 1 listing would help to maintain efficient weed control in brassicas, with the consequent benefit to crop quality and yield.
- Promising treatments have been identified but are unlikely to be available until 2008 /2009: pre-transplanting oxadiargyl, Defy in tank-mix with Stomp, BUK 9900H, GF-1049; post-weed-emergence Fox, GF-1049.
- HDC have been informed 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.
- Growers could demonstrate to the European Commission that action has been taken to find alternatives to replace the 'Essential Uses' so they could continue until the end of 2007.

Action Points for Growers

- 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 (List 2) will fail to achieve Annex 1 listing. The European Commission has stated that 'Essential Use' cannot be extended and that no further 'Essential Use' derogations will be granted for supported List 1, 2 or 3 actives that fail Annex 1 Listing.
- If trifluralin is lost then alternatives for control of polygonums and annual meadow-grass will be needed. Stomp (pendimethalin) pre-transplanting would be the only available herbicide for polygonum control and it is effective on fat-hen, but others are in the pipeline. The new herbicides tested in this project are either not yet available in the UK for any crop, or there are no residues data available yet to support SOLAs. None would be approved for incorporation, as is trifluralin, although there is some limited (company) evidence that Defy could be useful.
- The following promising treatments have been identified: pre-transplanting *oxadiargyl, Defy* in tank-mix with Stomp, *BUK 9900H, GF-1049*; post-weed-emergence *Fox, GF-1049*.

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

	Treflan	oxadiargyl	Stomp	Ramrod	Defy	Centium	Butisan	Shield	Fox	Alpha dff	Alpha dff	oxyfluorfen	Fortrol
	Pre-plant	Pre-plant	Pre-plant	Pre-weedem	Pre-weedem	Pre-weedem	Pre-weedem	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	1.5 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	S	R	MR		S
Bugloss									S				S
Charlock	R	S		R	S	R			S	MS	MS	S	S
Chickweed, common	S	R	S	S	S	S	S		R	MS	S	MR	S
Cleavers	R			S	S	S	MR		S 2 whorl	MS	MS		R
Corn marigold	R		S	S				S					
Corn spurrey	MS	S		S					S	MR/MS	MS	S	
Crane's-bill, cut-leaved							MR		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			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		R	R		S?	MR	MR	S	S
Gallant -soldier				S								S	
Groundsel	R	S	R	S	R	S	S	S		MR	MR/MS	S	S
Hemp-nettle, common	S	R	S	S					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						S	S

Nightshade black	R			MS									S
Orache, common	MS		S	MR		R			S				S
Pansy, field	S		S	S	R		R		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	MS		MS	MR	MR	S	S
Redshank	S	S		R		S		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
Wild-oat	MS			R	R							S	R
Vol OSR	R	S	MS		S	R	R	R		MS/S	S	S	R
Vol Potatoes												suppression	

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

SCIENCE SECTION

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, trifluralin may not achieve Annex 1 listing. 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 mainly to control thistles. Particular difficulties with 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). 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. 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 Savoy cabbage. The overall aim in 2005 and 2006 was:

- To further investigate new alternative herbicides to replace cyanazine and sodium monochloroacetate and possibly trifluralin. Potential alternatives for brassicas identified in 2004 in FV 256 (oxadiargyl, prosulfocarb, diflufenican) and in 2005, oxyfluorfen, were evaluated. .
- 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 and 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.

Charlock and oilseed rape were unlikely to be present at the Kirton site, therefore in both years seeds were sown on a small area on each plot and raked into the soil surface before planting cauliflower. This did not represent a normal volunteer/weed situation because none emerged from depth therefore results should be treated with caution.

SUMMARY for the first year 2005

Herbicide Treatments 2005 (+ denotes a tank-mix, & denotes followed by)

	Site 1Kirton cauliflower		**Site 2 Sleaford cauliflower**		**Site 1Kirton cabbage**	
Herbicide	**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- emergence (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- emergence 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

2005 Site Location; Soil type

Crop	Site	Soil Type (ADAS scale)
Cauliflower & cabbage 2005	Warwick HRI Kirton Research Centre, Lincs.	Silt Loam (light)
Cauliflower 2005	Sleaford, Lincolnshire	Loamy sand (very light)
Cauliflower, cabbage demonstration	Duchy of Cornwall	

RESULTS 2005

Pre-transplanting or 2d post-transplanting

- 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 1.0 L/ha 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 approved for use in UK cereals.

Post-weed-emergence

- Post-weed-emergence, Fox was effective on charlock and could be a useful alternative to Fortrol in a programme. Fortrol, Fox at 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 sow-thistle, scentless mayweed, fool's parsley or oilseed rape (it has a SOLA for use in rape). Both Shield or DFF were useful partners for control of some species but both may be needed to cover a wider spectrum together with a higher dose of Fox than 0.5 L/ha.

- Oxyfluorfen, as a 240g/L EC formulation, 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.

Samples from some successful treatments in 2005 were sent for residue analysis through HDC (oxyfluorfen, DFF, Fox for cauliflower and cabbage; oxadiargyl, cauliflower only). No residues were detected.

Summary conclusions from (single observation plots) Duchy demonstration site in Cornwall in 2005

Herbicide treatments were the same as for the main trials and only post-weed-emergence treatments were applied in cabbage.
Cauliflower (variety Alpen)
Transplanted 11 July 2005 - a long period of very dry weather followed. Harvested late January 2006.
Spring Cabbage (variety Wintergreen)
Transplanted 20 September 2005. Harvested early March 2006.

Pre-transplanting oxadiargyl alone performed better than trifluralin but under dry conditions was less effective than at Kirton. It did not control chickweed and a follow-up treatment was needed post-planting. Oxadiargyl followed by Butisan provided excellent weed control with no damage to the crop and plots remained clean up to harvesting cauliflower in late January 2006. Butisan post-planting also provided very good weed control with no crop damage.

Post-weed-emergence treatments were applied 40 or 42 days after transplanting in cauliflower and cabbage respectively when crop plants were large. Fox 1.0 L/ha gave poor weed control overall and chickweed remained but it was safe to cauliflower and cabbage. Oxyfluorfen was very effective on weeds but all dose rates caused severe crop damage (reduction in growth, development and number of marketable heads) in cauliflower and cabbage.

The treatments were reviewed after 2005, the first year

In the second year 2006, treatments included Stomp + Defy, oxadiargyl and tank-mixes, Butisan, DFF tank-mixed with Fox. Oxadiargyl was tested at a lower dose rate at one site. New herbicides with potential for brassicas were tested: 212 H, BUK 9900H both in FV 256 screening trial 2006, BUK 9800H (one site) and GF-1049.

MATERIALS and METHODS 2006

Crop details 2006

Crop	Site	Soil Type (ADAS

		scale)
Cauliflower & cabbage	1. Warwick HRI Kirton Research Centre, Lincs	Silt Loam (light soil)
Cauliflower	2. Holbeach Hurn, Lincolnshire	Silt Loam (light soil)
Cauliflower, cabbage demonstration	3. Duchy of Cornwall	

Sowing date and crop variety 2006

1. Site 1 transplanted 30 May 2006 with summer/early autumn maturing cauliflower (variety Fredom). Oilseed rape and charlock sown on 23 May.
2. Site 2 transplanted 28 June commercial crop with autumn maturing cauliflower (variety Pavillon).
3. Site 1 transplanted 5 June with early autumn maturing Savoy cabbage (variety Famosa). Oilseed rape and charlock sown on 5 June.
4. Duchy of Cornwall early July-planted cauliflower (variety Alpen) and August-planted spring greens (variety Wintergreen).

Charlock and oilseed rape do not occur on the Kirton trial site, therefore seeds were sown on a small area on each plot and raked into the soil surface before planting cauliflower or cabbage. This did not represent a normal volunteer weed situation because none emerged from depth, therefore results should be treated with caution.

Herbicide Treatments 2006 (+ denotes a tank-mix, & denotes followed by)

Site 1 Kirton	**cauliflower**		**cabbage**	
Herbicide	**g a.i/ha**	**L or kg/ha**	**g a.i/ha**	**L or kg/ha**
1. untreated	-	-	-	-
Pre-transplant				
2. Treflan incorporated	1104	2.3		
3. Stomp	1320	3.3		
4. Stomp + Defy	1320 + 3200	3.3 + 4.0		
5. GF-1049	480	1.0		
6. 212H	30	0.06 kg		
7. BUK 9900H		4.0		
8. oxadiargyl	400	1.0		
Pre-transplant followed by pre-weed- emergence 2 days post-transplant				
9. oxadiargyl & Ramrod	400 & 4500	1.0 & 9.0		
10. oxadiargyl & Butisan	400 & 750	1.0 & 1.5		
Pre-weed- emergence 2 days post-transplant				
11. untreated	-	-	-	-
12. Butisan	750	1.5	750	1.5
13. BUK 9900H		2.5		2.5
14. 212H	30	0.06 kg	30	0.06 kg
Post-weed- emergence after planting				
15. Fox	500	1.0	500	1.0
16. Fox + Alpha DFF	500 + 100	1.0 + 0.5	500 + 100	1.0 + 0.5
17. Alpha DFF	150	0.3	150	0.3
18. GF-1049	120	0.25	120	0.25
19. GF-1049	240	0.5	240	0.5

Site 2 Holbeach Hurn (silt loam)	**cauliflower**	
Herbicide	**g a.i/ha**	**L or kg/ha**
1. untreated	-	-
Pre-transplant		
2. Treflan incorporated	1104	2.3

3. Stomp	1320	3.3
4. Stomp + Defy	1320 + 3200	3.3 + 4.0
5. GF-1049	480	1.0
6. 212H	30	0.06 kg
7. BUK 9900H		4.0
8. oxadiargyl	200	0.5
9. oxadiargyl	400	1.0
Pre-transplant followed by Pre-weed- emergence 2 Days post-transplant		
10. oxadiargyl & Butisan	200 & 750	0.5 & 1.5
11. oxadiargyl & Butisan	400 & 750	1.0 & 1.5
Pre-weed- emergence 2 Days post-transplant		
12. untreated	-	-
13. Butisan	750	1.5
14. BUK 9800H	500/500	2.5
15. 212H	30	0.06 kg
Post-emergence 14 Days After Planting		
16. Fox	500	1.0
17. Fox + Alpha DFF	500 + 100	1.0 + 0.5
18. GF-1049	120	0.25
19. GF-1049	240	0.5

Trial Design Sites 1 and 2

Each plot was 6 m long x 1.83 m wide with 3 rows per plot and 3 replicates of each treatment. The trial layout was in two blocks – herbicides applied pre-transplanting/ pre-weed-emergence and post-weed-emergence, untreated plots in each replicate (1 or 12 respectively on each area).

Application Details 2006

Sprays were applied using a gas pressurised Azo precision sprayer with a 1.8 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.

Date applied	Weather	Growth Stage weed TL (true leaves)
Kirton cauliflower planted 30 May		
30 May Treatments 2 – 10 pre-transplant. Treatment 2 soil	11.8ºC; RH% 61; cloud cover 4; soil surface moist fine seedbed; rain after application 0.2 mm, total rainfall in June 7.5mm	none

incorporated.		
1 June Treatments 9 – 10, 12 - 14	15ºC; RH% 80; overcast cloud cover 8; soil surface wet; leaf surface dry; rain after application 0.2 mm, no significant rainfall in June; irrigated 15 June	none, charlock emerged 31 May
20 June Treatments 15 - 19	22.8ºC; RH%64; sunny, cloud cover 3; soil surface moist; rain a few hours later 2.1mm	OSR 2-4 TL; charlock 4 -5Tl, some in bud; knotgrass 3 TL, pale persicaria & redshank 2 TL; shepherd' s purse cotyledon, speedwell 2 TL, chickweed 6TL
Holbeach cauliflower planted 28 June		
28 June Treatments 2 – 11 pre-transplant. Treatment 2 soil incorporated.	22ºC; RH% 65; sunny, cloud cover 2; soil surface very dry, fine seedbed; no rain after application.	none
30 June Treatments 10, 11, 13, 14, 15	26ºC; RH% 45; sunny, cloud cover 3; soil surface very dry; no rain day of application	none
22 August Treatments 16 - 19	20ºC; RH% 75; sunny, cloud cover 3; soil surface moist; no rain until the next day	Groundsel, small nettle cotyledon-2-4 TL; smooth sow-thistle mayweeds 2 TL; Fat-hen 2-4 TL; nightshade, chickweed cotyledon
Kirton cabbage planted 5 June		
7 June Treatments 12 - 14	23.3ºC; RH% 64; sunny cloud cover 3; soil surface very dry; no rain until 12 June 2.6mm; irrigated 15 June	A few charlock emerging
20 June Treatments 15 - 19	22.8ºC; RH%64; sunny, cloud cover 3; soil surface moist; rain a few hours later 2.1mm	OSR cotyledon – 1 TL, charlock cotyledon - 2 TL; redshank, knotgrass 1- 2TL

Records/Assessments

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

- Weather during and after application.
- 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.
- 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

RESULTS 2006

Crop Safety 2006

Site 1 Kirton cauliflower: crop safety (Table 2)

Table 2. Kirton cauliflower (planted 30 May). Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent crop cover or area of leaf damaged in parentheses

Herbicide	L or kg/ha	23 June	7 July	20 July	1 Aug	11 August
1. untreated	-	10	10	10 (cover 70%)	10 (cover 80%)	10 (cover 90%)
Pre-transplant 30 May						
2. Treflan incorporated	2.3	10	10	10	10	10
3. Stomp	3.3	10	10	10	10	10
4. Stomp + Defy	3.3 + 4.0	10	10	10	10	10
5. GF-1049	1.0	10	10	10	10	10
6. 212H	0.06 kg	10	10	10	10	10
7. BUK 9900H	4.0	10	10	10	10	10
8. oxadiargyl	1.0	10	10	10	10	10
Pre-transplant &Pre-weed- emergence 2 Days post-transplant 1 June						
9. oxadiargyl & Ramrod	1.0 & 9.0	10	10	10	10	10
10. oxadiargyl & Butisan	1.0 & 1.5	10	10	10	10	10
Pre-weed- emergence 2 Days post-transplant 1 June						
11. untreated	-	10	10	10	10	10
12. Butisan	1.5	10	10	10	10	10
13. BUK 9900H	2.5	10	10	10	10	10
14. 212H	0.06 kg	#7.3 st	10	10	10	10
Post-weed-emergence 20 June		***3 DAT***	***17 DAT***	***30 DAT***	***42 DAT***	***52 DAT***
15. Fox	1.0	8 sp	9	10	10	10
16. Fox + Alpha DFF	1.0 + 0.5	5.3 sp, bl	4.3 sp bl	7 bl	8 bl	9.7
17. Alpha DFF	0.3	6 bl	5.3 bl	8	9 slight bl	10
18. GF-1049	0.25	6 (20% sp)	7	10	10	10
19. GF-1049	0.5	4.3 (50% sp)	5 d	9 (60% cover)	10 (80% cover)	10

DAT days after treatment post-emergence; bl bleached areas; sp spotting; d distortion growing point; # lower leaf loss, stem base distorted; st stunting

There was no crop damage at any stage from herbicides applied pre-transplanting cauliflower: Treflan, Stomp, Defy, 212 H, BUK 9900 or oxadiargyl, or from pre-weed-emergence applications of Ramrod, Butisan or BUK 9900 (Table 2). 212 H applied 2 days after transplanting caused a temporary growth check and some leaf loss, but the plants recovered after 14 days.

Post-weed-emergence herbicides, assessed 23 June 3 days after treatment (DAT): Fox (tr 15) caused slight transient damage in the form of scorched spots on leaves; Alpha DFF (tr 17) caused more effects as bleached patches on cauliflower leaves, and the combination (tr 16) was much more damaging and took over 30 days to grow out. The new growth was not affected by any of these treatments but damage was unacceptable from DFF (tr 16 and 17).

Damage observed 3 DAT from GF-1049 0.5 L/ha was severe - scorched spots affected 50% of the leaf area and there was some distortion of the growing point (Table 2). Although there was good recovery, on 20 July there was a reduction in ground cover by the crop compared with untreated plots. The crop recovered after 42 days. There was less damage from the lower dose of 0.25 L/ha and plants recovered after 30 days. New growth was not affected by GF-1049 (tr 18 and 19).

Cauliflower development was uneven on all plots irrespective of weeds or herbicide treatment and on 1 August size of head ranged from 0 to 6 cm. This was probably a result of higher than average temperatures. Harvest stage for the earliest cauliflower to mature was 11 August

Site 2 Holbeach Hurn cauliflower: crop safety (Table 3)

Table 3. Holbeach Hurn cauliflower (planted 28 June). Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent area of leaf damaged in parentheses

Herbicide	L or kg/ha	20 July	1 Aug	22 Aug	29 Aug	13 Sept	26 Sept
1. untreated	-	10	10	10	10	10	10
Pre-transplant 28 June							
2. Treflan incorporated	2.3	10	10	10	10	10	10
3. Stomp	3.3	10	10	10	10	10	10
4. Stomp + Defy	3.3 + 4.0	10	10	10	10	10	10
5. GF-1049	1.0	10	10	10	10	10	10
6. 212H	0.06 kg	10	10	10	10	10	10
7. BUK 9900H	4.0	10	10	10	10	10	10
8. oxadiargyl	0.5	10	10	10	10	10	10
9. oxadiargyl	1.0	10	10	10	10	10	10
Pre-transplant & Pre-weed- emergence 2 Days post-transplant 30 June							
10. oxadiargyl & Butisan	0.5 & 1.5	10	10	10	10	10	10
11. oxadiargyl & Butisan	1.0 & 1.5	10	10	10	10	10	10
Pre-weed- emergence 2 Days post-transplant 30 June							
12. untreated	-	10	10	10	10	10	10
13. Butisan	1.5	10	10	10	10	10	10
14. BUK 9800H	2.5	10	10	10	10	10	10
15. 212H	0.06 kg	10	10	10	10	10	10
Post-weed-emergence post-transplant 22 August					***7 DAT***	***22 DAT***	***35 DAT***
16. Fox	1.0				6.3 (20% sc sp) d	7 d sp	9.5
17. Fox + Alpha DFF	1.0 + 0.5				5 (50% bl) d	5 (40% bl)	6 (20% bl)
18. GF-1049	0.25				7 (17% sc sp)	8 d	9.5
19. GF-1049	0.5				4.7 (33% sc sp)	6 d sp	8 d

DAT days after treatment post-emergence; sc scorch; bl bleached; sp spotting; d distortion

No damage was observed from any of the herbicides (tr 2 – 11 and 13 - 15) applied pre-transplanting or pre-weed-emergence at any stage.

Few weeds emerged in the very dry conditions following planting. The post-emergence applications were delayed in the hope that more weeds would appear, thus by 22 August the cauliflower were large (crop cover 60%) and caught more spray than an earlier application. On 29 August crop cover was 80%. There was more damage to inner leaves, which were less well waxed. GF-1049 at 0.25 and 0.5 L/ha caused scorch spots and distortion and 1% and 5% area of outer leaves, and 17% and 33% of inner leaf area respectively was affected.

Fox alone caused no damage to outer leaves but 20% scorch and distortion to inner ones. The addition of Alpha DFF (tr 17) caused the most severe damage and 70% of the inner leaves were bleached.

Crop cover on 13 September was 100%, heads *c.* 2cm diameter. The vigorous crop smothered weeds. There was no damage to new growth or heads from any treatment but damage from the post-emergence treatments was still visible on older leaves and was the most severe from Fox + Alpha DFF (treatment 17) with 20% of older leaf area bleached. The cauliflower treated with GF-1049 at the low dose (tr 18) had recovered but there was slight distortion of older leaves, at the higher dose (tr 19) older leaves suffered distortion and more leaf speckling at a similar level to Fox alone.

On 26 September no herbicide treatment had affected cauliflower growth. Size of cauliflower heads was uneven within the plots, irrespective of herbicide treatment. Bleached areas caused by Alpha DFF (tr 17) were still apparent and unacceptable to the grower although the affected old leaves would be removed at harvest. Harvesting of the surrounding commercial crop began on 5 October.

Site 3 Kirton cabbage: crop safety (Table 4)

Table 4. Kirton cabbage (planted 5 June): Crop tolerance score (0=complete kill; 7=acceptable damage; 10=no damage); percent crop cover or area of leaf damaged in parentheses

Herbicide	L or kg/ha	24 June	20 July	1 Aug	11 Aug
Pre-weed- emergence 2 Days post-transplant 7 June		***17 DAT***	***43 DAT***	***55 DAT***	***65 DAT***
11. untreated	-	10	10 (80%cover)	10 (90%cover)	10 (100% cover)
12. Butisan	1.5	10	10	10	10
13. BUK 9900	2.5	10	10	10	10
14. 212H	0.06 kg	5 L st	10	10	10
Post-weed-emergence post-transplant 20 June		***4 DAT***	***30 DAT***	***42 DAT***	***52 DAT***
15. Fox	1.0	5.7 sc sp	10	10	10
16. Fox + Alpha DFF	1.0 + 0.5	5.3 bl sp	9 slight bl	9	10
17. Alpha DFF	0.3	6 bl	9.7	10	10
18. GF-1049	0.25	#5 (30% sc sp)	10	10	10
19. GF-1049	0.5	#3 (60% sc sp)	7 (crop cover 70%)	9 (80% cover)	9.5 (90% cover)

DAT days after treatment; #growing point distorted and scorched; sc sp scorch spots; L leaf loss; bl bleached; st stunted

There was no crop damage from BUK 9900 or Butisan. 212 H caused some leaf loss and slight growth check initially but plants recovered later.

Post-weed-emergence, Fox caused scorch spots on 10% of leaf area, Alpha DFF caused bleaching. The tank-mix was more damaging and bleaching was still observed 30 DAT.

Damage from GF 1049 to Savoy cabbage was initially more severe than to cauliflower i.e. the growing points suffered scorch and distortion. Subsequent growth was not affected. The cabbage recovered from the 0.25 L/ha dose by 20 July, the effects of the 0.5 L/ha dose persisted and crop cover was less than untreated cabbage at harvest stage although there was no apparent delay in maturity or effect on yield or quality.

Weed control 2006 (Latin names for weed species on the trial site are given in Appendix 2)

Site 1 Kirton cauliflower: weed species (Table 5)

Table 5. Kirton cauliflower (planted 30 May): Numbers of weed species/m^2 (mean of 3 replicates, 3 counts of 0.33 m^2 per plot) on 23 June treatments 1-14, 10 July treatments 15-19

Herbicide	**L or kg/ha**	**Knotgrass**	**Redshank**	**Pale persicaria**	**Shepherd's purse**	**Field speedwell**	**Groundsel**	**Fat-hen**	**Chickweed**	**Pineapplewee d**	**TOTAL**
1. untreated	-	43	5.7	2.7	13.3	18	2.7	2.3	2.7	0.7	**91.1**
Pre-transplant 30 May											
2. Treflan incorporated	2.3	13.7	9	3.3	2	0	1.3	0	0	0.3	**29.7**
3. Stomp	3.3	0	1.3	0.3	0	1.3	2.3	0	0	0	**5.3**
4. Stomp + Defy	3.3 + 4.0	0.3	0	0	0	0	1.3	0	0	0	**1.6**
5. GF-1049	1.0	0.7	0	0	0	0	0.3	0	1.3	0	**2.3**
6. 212H	0.06 kg	14	2	0	1.3	3	0	0	1	0	**21.3**
7. BUK 9900H	4.0	0.3	0.3	0	0	0	0	0	0	0	**0.6**
8. oxadiargyl	1.0	3.7	0	0	0	2	0	0	3	0	**8.7**
Pre-transplant 30 May & Pre-weed- emergence 2 days post-transplant 1 June											
9. oxadiargyl & Ramrod	1.0 & 9.0	0.7	0.3	0	0	0	0	0	0.3	0	**1.3**
10. oxadiargyl & Butisan	1.0 & 1.5	1.3	0	0	0	0	0	0	0	0	**1.3**
Pre-weed- emergence 2 days post-transplant 1 June											
11. untreated	-	14.7	5.3	1.3	20	17.7	2.7	0	4	1.3	**67**
12. Butisan	1.5	2.7	1.3	0.7	0.3	0	0	0	0	0	**5**
13. BUK 9900H	2.5	0	0	0.7	0	0	0	0	0	0.7	**1.4**
14. 212H	0.06 kg	5.7	5	0	2.7	3	0.3	0	0.7	0	**17.4**
Post-weed-emergence post-transplant 20 June											
15. Fox	1.0	4	6.7	0.3	3	1	2	0.7	2	0	**19.7**
16. Fox + Alpha DFF	1.0 + 0.5	5.7	1	0	1	4	1.7	0	0	0	**16.4**
17. Alpha DFF	0.3	11	8.7	2.3	0	3	1.7	2	1.7	0	**30.4**
18. GF-1049	0.25	6	3	0	0	0	0	0	1.7	0	**10.7**
19. GF-1049	0.5	5st	0	0	0	0	0	0	0.7	0	**5.7**

st stunted

The weather after transplanting was warmer and drier than the long-term average and weed populations were lower than usual on this site. The post-weed-emergence treatments 15 – 19 were delayed in the expectation of further emergence following irrigation and more shepherd's purse germinated, but by this time some of the redshank and knotgrass were at 3 true-leaf stage. The predominant species were knotgrass (higher numbers on tr 1 in the pre-transplant area than tr 11), field speedwell and shepherd's purse.

Treflan, usually has good efficacy on polygonums but control was poor in this trial, and control of shepherd's purse was better than anticipated. 212 H failed to control knotgrass and it was ineffective on redshank pre- or post-transplanting. Stomp controlled knotgrass and most species except groundsel. The addition of Defy gave only slight improvement. Oxadiargyl 1.0 L/ha (tr 8) had no effect on chickweed, which was controlled by the follow-up application of Ramrod (tr 9) or Butisan (tr 10). BUK 9900 was the most effective pre- or post-transplanting treatment and the 2.5 L/ha dose rate (tr 13) appeared to be adequate except for oilseed rape and charlock (Table 7).

Post-weed-emergence Alpha DFF applied alone gave poor control of the large redshank and knotgrass, or fat-hen. Fox was more effective than DFF on knotgrass. The tank-mix with DFF did not perform much better. Weed control was unacceptable from all three treatments.

GF-1049 at 0.25 L/ha controlled all weeds except chickweed or the larger knotgrass and redshank. GF-1049 at 0.5 L/ha performed best – redshank was killed and the knotgrass severely stunted.

Site 1 Kirton cauliflower: weed scores (Table 6)

Table 6. Kirton cauliflower: weed control scores (0=untreated no control, 7=acceptable control, 10=complete control) excluding the sown oilseed rape and charlock

Herbicide	L or kg/ha	23 June	7 July	20 July
1. untreated	-	0	0	0
Pre-transplant 30 May				
2. Treflan incorporated	2.3	5	5	3
3. Stomp	3.3	9.7	9.3	9
4. Stomp + Defy	3.3 + 4.0	10	9.5	9.3
5. GF-1049	1.0	9.8	9	8
6. 212H	0.06 kg	6	5.5	4.3
7. BUK 9900H	4.0	10	9.8	9.5
8. oxadiargyl	1.0	9	8	7
Pre-transplant & Pre-weed- emergence 2 Days post-transplant 1 June				
9. oxadiargyl & Ramrod	1.0 & 9.0	9.8	8.7	8
10. oxadiargyl & Butisan	1.0 & 1.5	10	9	8.7
Pre-weed- emergence 2 Days post-transplant 1 June				
11. untreated	-	0	0	0
12. Butisan	1.5	9.5	8.5	8.3
13. BUK 9900H	2.5	10	9.5	9
14. 212H	0.06 kg	7	6	5
Post-weed-emergence 20 June				
15. Fox	1.0		5	4
16. Fox + Alpha DFF	1.0 + 0.5		6	4.3
17. Alpha DFF	0.3		3.3	3
18. GF-1049	0.25		6.3	6
19. GF-1049	0.5		9.3	9

On 7 July crop cover on untreated plots was 50%, weed cover 50% - this was mainly due to knotgrass on the pre-weed-emergence area.

The best weed control treatments were those that controlled the high population of knotgrass: pre-transplanting BUK 9900, Stomp + Defy, Stomp; pre-weed-emergence BUK 9900, post-weed-emergence GF-1049 at 0.5 L/ha.

At harvest stage (11 August) cauliflower untreated or treated with Treflan, 212 H, Fox alone or with Alpha DFF or DFF alone were overgrown by weeds.

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

The post-weed-emergence treatments 15 – 19 were delayed until 20 June, in the expectation of further emergence of indigenous weeds. Assessments of weed numbers were made on 23 June, and % control was calculated (Table 7). Estimates of % control were made on 20 July.

Table 7. Kirton cauliflower (planted 30 May): percent control of oilseed rape and charlock on 23 June, 7 July and 20 July

Herbicide	**L or kg/ha**	**OSR**	**Charlock**	**OSR**	**Charlock**
		23 June	***23 June***	***20 July***	***20 July***
1. untreated	-	0	0	0	0
Pre-transplant 30 May					
2. Treflan incorporated	2.3	0	0	0	0
3. Stomp	3.3	80	50	80	50
4. Stomp + Defy	3.3 + 4.0	95	92	98	83
5. GF-1049	1.0	40	76	38	73
6. 212H	0.06 kg	61	37	60	30
7. BUK 9900H	4.0	80	85	83	85
8. oxadiargyl	1.0	70	68	60	70
Pre-transplant & Pre-weed-emergence 2 Days post-transplant 1 June					
9. oxadiargyl & Ramrod	1.0 & 9.0	72	70	60	75
10. oxadiargyl & Butisan	1.0 & 1.5	74	80	67	80
Pre-weed- emergence 2 Days post-transplant 1 June					
11. untreated	-	0	0	0	0
12. Butisan	1.5	0	8	0	10
13. BUK 9900H	2.5	50	59	50	60
14. 212H	0.06 kg	22	11	30	29
Post-weed- emergence post-transplant 20 June		***7 July***	***7 July***	***20 July***	***20 July***
15. Fox	1.0	0	50	0	45
16. Fox + Alpha DFF	1.0 + 0.5	20	60	50	63
17. Alpha DFF	0.3	10	60	40	60
18. GF-1049	0.25	40	60	40	65
19. GF-1049	0.5	70	73	70	80

The standard brassica herbicides Treflan and Butisan did not control oilseed rape, although Butisan gave some control of charlock. Applied pre-transplanting, Stomp 3.3 L/ha alone was effective on oilseed rape but charlock control was poor, the addition of Defy as a tank-mix (tr 4) resulted in excellent control of both weeds. Under dry soil conditions oxadiargyl 1.0 L/ha (tr 8) was less effective than in 2005, a follow-up treatment with Ramrod (tr 9) had little effect, with Butisan (tr 10) gave some improvement on charlock control. GF-1049 at 1.0 L/ha gave good control of charlock. 212 H pre-transplanting (tr 6) gave some control of oilseed rape, but for some unexplained reason was less effective 2 days post transplanting (tr 14). BUK 9900 at 4.0 L/ha (tr 5) pre-transplanting gave excellent control but efficacy post-transplanting with the lower dose 2.5 L/ha (tr 13) was inadequate.

The post-weed-emergence treatments (15 - 19) were applied when charlock plants, which emerged early, were at advanced growth stages (4 true leaves and some in bud), oilseed rape at 2 – 4 true leaves and were too large for good control. Leaf wax of rape was also good during the warm weather. In spite of this, GF-1049 at 0.5L/ha achieved very good control of charlock but it was less effective on the waxy-leaved rape. Fox did not control oilseed rape and was less effective on the larger charlock. Alpha DFF gave some control of both weeds, which suffered gradual bleaching.

Site 2 Holbeach Hurn cauliflower: weed species (Table 8)

Table 8. Holbeach Hurn cauliflower: Numbers of weed species/m^2 (mean of 3 replicates, 3 counts of 0.33 m^2 per plot) counts 22 August (treatments 1-15) and 29 August (treatments 16-19)

Herbicide	L or kg/ha	Groundsel	Small nettle	Smooth sow-thistle	Scentless mayweed	Shepherd's purse	Fat-hen	Green nightshade	TOTAL
1. untreated	-	4	8	4	3	2	2	3	**26**
Pre-transplant 28 June									
2. Treflan incorporated	2.3	2.7	1.3	3.7	6.3	2.3	0	1.7	**18**
3. Stomp	3.3	3	0	0	1	0	0.7	0.7	**5.4**
4. Stomp + Defy	3.3 + 4.0	2	0	0.3	0	0	0	0.3	**2.7**
5. GF-1049	1.0	0	0	0	0	0	0	0	**0**
6. 212H	0.06 kg	0	0	0.3	0.3	0	0	0	**0.7**
7. BUK 9900H	4.0	1	0	0.3	0	0	0	1	**2.3**
8. oxadiargyl	0.5	0	0.3	0.3	0.7	0	0	0	**1.4**
9. oxadiargyl	1.0	0	0	0	0	0	0	0	**0**
Pre-transplant & Pre-weed- emergence 2 Days post-transplant 30 June									
10. oxadiargyl & Butisan	0.5 & 1.5	0	0	0	0	0	0	0	**0**
11. oxadiargyl & Butisan	1.0 & 1.5	0	0	0	0	0	0	0	**0**
Pre-weed- emergence 2 Days post-transplant 30 June									
12. untreated	-	6	8.7	8.7	7	0	2.7	5	**38**
13. Butisan	1.5	0.7	0	0	0	0	0	2	**2.7**
14. BUK 9800H*	2.5	0	0	0	0	0	0	0	**0**
15. 212H	0.06 kg	0	0	0	0	0	0	0	**0**
Post-weed-emergence post-transplant 22 August									
16. Fox	1.0	0	0	0	0	0	0	0	**0**
17. Fox + Alpha DFF	1.0 +	0	0	0	0	0	0	0	**0**

	0.5								
18. GF-1049	0.25	0	0	0	0	0	0	0	**0**
19. GF-1049	0.5	0	0	0	0	0	0	0	**0**

* treatment at this site only

June and July were very dry, hot months and the site was not irrigated. Weeds were very slow to emerge. Weed numbers were low and unevenly distributed, predominantly small nettle (Table 8). Soil conditions were too dry for good residual herbicide activity.

Treflan was the least effective herbicide, failing to control mayweeds, groundsel and shepherd's purse. It controlled fat-hen. Stomp alone or with Defy gave poor control of the low numbers of groundsel.

All other treatments controlled the low weed numbers, including small nettle. It was not possible to compare efficacy of the two dose rates of oxadiargyl because weed populations were low.

Site 2 Holbeach Hurn cauliflower: weed control scores (Table 9)

Table 9. Holbeach Hurn cauliflower: weed control scores (0=untreated no control, 7=acceptable control, 10=complete control)

Herbicide	**L or kg/ha**	**20 July**	**1 Aug**	**22 Aug**	**29 Aug**	**13 Sept**
1. untreated	**-**	0	0	0		0
Pre-transplant 28 June						
2. Treflan incorporated	2.3	10	10	3		2
3. Stomp	3.3	10	10	9		9
4. Stomp + Defy	3.3 + 4.0	10	10	9.9		9.5
5. GF-1049	1.0	10	10	10		10
6. 212H	0.06 kg	10	10	10		10
7. BUK 9900H	4.0	10	10	9.9		9.9
8. oxadiargyl	0.5	10	10	9.7		9.5
9. oxadiargyl	1.0	10	10	10		10
Pre-transplant followed by Pre-weed- emergence 2 Days post-transplant 30 June						
10. oxadiargyl & Butisan	0.5 & 1.5	10	10	10		10
11. oxadiargyl & Butisan	1.0 & 1.5	10	10	10		10
Pre-weed- emergence 2 Days post-transplant 30 June						
12. untreated	-	0	0	0	0	0
13. Butisan	1.5	10	10	9.5		10
14. BUK 9800H*	2.5	10	10	10		10
15. 212H	0.06 kg	10	10	10		10
Post-weed-emergence post-transplant 22 August					***7 DAT***	***22 DAT***
16. Fox	1.0				10	10
17. Fox + Alpha DFF	1.0 + 0.5				10	10
18. GF-1049	0.25				10	10
19. GF-1049	0.5				10	10

* treatment this site only

No weeds grew above the crop and weed populations were low on untreated plots. The vigorous crop suppressed weeds up until harvest on 4 October.

Weed control with Treflan was poor.

Site 3 Kirton cabbage: weed species (Table 10)

Soil conditions were dry and the weed population on the trial area was low. The main species were redshank, shepherd's purse, knotgrass and field speedwell. Following irrigation on 15 June there was a late germination of shepherd's purse.

Table 10. Kirton cabbage planted 5 June**:** Numbers of weed species/m^2 (mean of 3 replicates, 3 counts of 0.33 m^2 per plot) counts on 23 June treatments 11-14, 10 July treatments 15-19

Herbicide	L or kg/ha	Redshank	Knotgrass	Field speedwell	Shepherd's purse	Fat-hen	Groundsel	Black-bindweed	Chickweed	Black nightshade	TOTAL
Pre-weed- emergence 2 days post-transplant 7 June											
11. untreated	-	28	11	7	21	0.7	0.7	0.7	0.3	0.7	**69**
12. Butisan	1.5	6	3	0	0	0.7	0	0	0	0	**9.7**
13. BUK 9900H	2.5	0.7	1.3	0	0	0	0	0.7	0	0	**2.7**
14. 212H	0.06 kg	8.7	4	0	0	0	0	0.3	0	0	**13**
Post-weed-emergence post transplanting 20 June											
15. Fox	1.0	9.7	7.3	0	0	2	0	0	1	0	**21**
16. Fox + Alpha DFF	1.0 + 0.5	10.3	6.3	0	0.7	1.3	0	0	0	0	**18.6**
17. Alpha DFF	0.3	24.7	6.3	0	0	2	0	0	0	0	**33**
18. GF-1049	0.25	4 st	2.3 st	0	0	0	0	0	0.3	0	**6.3**
19. GF-1049	0.5	0	2 st	0	0	0	0	0	0	0	**2**

st stunted

Under dry soil conditions efficacy of residual herbicides was reduced. Butisan and 212 H were ineffective on redshank and knotgrass. BUK 9900 had superior efficacy. A few fat-hen remained on plots treated with Butisan. The other species, including shepherd's purse, were well controlled by these herbicides.

The post-weed-emergence treatments Fox, Fox + Alpha DFF and Alpha DFF alone gave poor control of redshank, knotgrass and fat-hen at the dose rates tested. GF-1049 at 0.25 L/ha severely stunted the redshank and knotgrass, but did not kill it all and achieved good control of all other species except chickweed. GF-1049 at 0.5 L/ha stunted knotgrass, which died later, and gave excellent control of other species.

Site 3 Kirton cabbage: weed control scores (Table 11)

The best pre-weed-emergence treatment was with BUK 9900, which performed better than Butisan. Weed control was disappointing from 212 H, where knotgrass and redshank were a problem. The level of weed control was unacceptable from Fox, Fox + DFF and Alpha DFF alone.

Cabbages treated with GF-1049 0.5 L/ha were weed free at harvest (11 August) and only a low number of knotgrass remained where the 0.25 L/ha dose was applied.

At harvest stage redshank and fat-hen had grown above the crop on untreated plots and on plots treated with Fox, Fox + DFF and Alpha DFF alone (tr 15 to 17), redshank was also a problem on tr 14 (212 H).

Table 11. Kirton cabbage: weed control scores (0=untreated no control, 7=acceptable control, 10=complete control) for other weeds excluding charlock and oilseed rape

Herbicide	L or kg/ha	23 June	7 July	20 July
Pre-weed-emergence 2 days post-transplant 7 June				
11. untreated	-	0	0	0
12. Butisan	1.5	8.7	8.5	8
13. BUK 9900H	2.5	9.9	9.5	9.3
14. 212H	0.06 kg	7	6	5
Post-weed-emergence post-transplants 20 June				
15. Fox	1.0		5	4.7
16. Fox + Alpha DFF	1.0 + 0.5		6	5
17. Alpha DFF	0.3		3	2
18. GF-1049	0.25		9	9
19. GF-1049	0.5		10	9.5

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

Oilseed rape and charlock were sown 5 June, pre-transplanting cabbage in an area on each plot. Growth stages at applications of post-weed-emergence treatments 15 - 19 on 20 June were oilseed rape at cotyledon – 1 TL, charlock at cotyledon - 2 TL. Assessments of weed numbers were made on 23 June/7 July, and % control was calculated (Table 12). Estimates of % control were made on 20 July.

Table 12. Kirton Cabbage planted 5 June: Percent control of oilseed rape and charlock on 7 July and 20 July

Herbicide	L or kg/ha	OSR 7 July	Charlock 7 July	OSR 20 July	Charlock 20 July
Pre-weed-emergence 2 days post-transplant 7 June					
11. untreated	-	0	0	0	0
12. Butisan	1.5	0	31	0	27
13. BUK 9900H	2.5	45	72	50	75
14. 212H	0.06 kg	45	39	59	65
Post-weed-emergence post-transplants 20 June					
15. Fox	1.0	18#	75	10#	70
16. Fox + Alpha DFF	1.0 +	80	99	83	100

	0.5				
17. Alpha DFF	0.3	80	97	77	97
18. GF-1049	0.25	85	95	90	93
19. GF-1049	0.5	90	100	95	98

only small oilseed rape with poor leaf wax killed

Butisan, a rape herbicide gave no control of rape and poor control of charlock. BUK 9900 at 2.5 L/ha was more effective on charlock than in the cauliflower trial, but efficacy on oilseed rape was inadequate in this trial. 212 H was slow to act.
The post-weed emergence treatments were all effective on charlock. A few small rape with poor leaf wax were killed by Fox but larger plants were not controlled. Oilseed rape was controlled by the other post-emergence herbicides. GF-1049 at 0.5 L/ha performed best.

Summary conclusions from single observation plots, Duchy demonstration site in Cornwall in 2006

Cauliflower (variety Alpen)
Transplanted 11 July 2006 - a long period of very dry weather followed and weeds were slow to emerge. Weed species on untreated plots were mainly annual nettle, chickweed, shepherd’s purse and annual meadow-grass.

Pre-transplanting treatments (applied 10 July): All performed better than Treflan, where some annual nettle, chickweed, shepherd’s purse escaped control. Stomp + Defy (3.3 + 4.0) L/ha was safe to the cauliflower, and effective on all species except groundsel. BUK 9900H 2.5 L/ha gave excellent control and no damage. Oxadiargyl at 1.0 L/ha controlled all except chickweed and was safe to the crop. GF-1046 at 1.0 L/ha caused slight stunting and only chickweed remained.

Pre-weed-emergence treatments (applied 19July)**:** The programme of oxadiargyl at 0.5 or 1.0 L/ha pre-transplanting, followed by Butisan 1.5 L/ha pre-weed-emergence were safe treatments and all weeds were controlled irrespective of oxadiargyl dose rate. A few small nettle and annual meadow-grass remained after application of Butisan alone.

Post-weed-emergence treatments (applied 22 August 2006): Fox at 1.0 L/ha was safe to the cauliflower but was ineffective on chickweed and shepherd’s purse. GF-1049 did not control chickweed or annual meadow-grass and at 0.25 or 0.5 L/ha caused distortion of older leaves but new growth was not affected and the crop recovered.

Spring Cabbage (variety Wintergreen)
Transplanted 8 September 2006. Only post-weed-emergence treatments were applied in cabbage. Weed species on untreated plots were small nettle, chickweed, groundsel, fat hen, shepherd’s purse.

Pre-weed-emergence treatments (applied 16 September): Butisan was safe. 212 H gave good weed control and only slight stunting of the cabbage.

Post-weed-emergence treatments (applied 12 October): Fox did not control chickweed. There was initial scorching on older leaves, and distortion of the growing point but the crop recovered. GF-1049 did not control chickweed and at 0.25 or 0.5 L/ha caused distortion of older leaves but new growth was not affected and the crop recovered.

CONCLUSIONS 2006

Crop safety and weed control

In 2006 the weather conditions were very dry during June and July. As a result few weeds emerged, and populations were particularly low at the Holbeach Hurn site. 212 H and oxadiargyl appeared, in these trials and from work elsewhere, to be more dependent on soil moisture for good efficacy than some other herbicides. Standard herbicides Treflan and Butisan did not control oilseed rape 'volunteers' or charlock. Soil incorporated Treflan normally controls knotgrass, redshank, pale persicaria, but control was poor.

Pre-transplanting or post-transplanting pre-weed-emergence

- Pre-transplanting *BUK 9900* and Stomp + *Defy* performed best and were safe to cauliflower.

- Stomp 400 SC (pendimethalin) at 3.3 L/ha had poor efficacy on charlock, but oilseed rape was well controlled. Tank-mix Stomp + *Defy* 4.0 L/ha was one of the best treatments. It was safe to cauliflower and *Defy* improved control of both charlock and oilseed rape but there was only slight improvement of other species on these sites.

- *BUK 9900* at 4.0 L/ha pre-transplanting was safe and gave excellent control of all weed species in cauliflower sites. *BUK 9900* was the most effective pre- or post-transplanting treatment and *BUK 9900* at 2.5 L/ha applied 2d post-transplanting appeared to be safe. The 2.5 L/ha dose rate (tr 13) appeared to be adequate except for oilseed rape and charlock control.

- *GF-1049* at 1.0 L/ha applied pre-transplanting was safer than the post-weed-emergence application and gave good weed control including charlock. It controlled all species including charlock (but not oilseed rape). It had a weakness on chickweed, present in low numbers.

- *Oxadiargyl* at 1.0 L/ha gave no control of chickweed and was less effective than in 2005 on oilseed rape and charlock. It was not possible at Holbeach to compare efficacy of the two dose rates 0.5 and 1.0 L/ha of *oxadiargyl* because weed populations were too low. Programmes of *oxadiargyl* followed by Ramrod or Butisan controlled chickweed and the latter offered slight improvement in control of charlock. All were very safe to cauliflower at both sites (they were not tested in Savoy cabbage).

- *212 H* caused some initial stunting of cauliflower and cabbage if applied 2 d post-transplanting but the plants soon recovered. *212H* was the least effective treatment pre-transplanting/pre-weed-emergence - failing to control knotgrass, redshank, oilseed rape or charlock and was slightly less effective on some other species.

The data for *BUK 9800H* applied 2d after transplanting at one site only, is limited.

Post-weed-emergence

All post-weed-emergence treatments caused more crop damage when applied 55 days after transplanting (at Holbeach Hurn in 2006) because the large leaves caught more spray. The normal application timing is 14-21 days after transplanting. In Kirton cauliflower the weeds were large and rape leaves were well-waxed 21 days after transplanting - at the post-weed-emergence timing. In 2006, post-emergence treatments had no effect on new crop growth and at harvest stage there appeared to be no effect on maturity or quality in spite of damage observed earlier. Cauliflower and cabbage recovered after *c.* 4-5 weeks.

- Post-emergence *GF-1049* performed best at 0.5 L/ha in cauliflower, controlling a wide range of species including oilseed rape and charlock. Applications in cabbage 15 days after transplanting (to smaller weeds) were more effective and *GF-1049* even at 0.25 L/ha gave 91% control of total weed numbers. However, *GF-1049* at 0.5 L/ha was too phytotoxic to cauliflower and cabbage for grower acceptability. *GF-1049* at 0.25 L/ha caused scorched spotting on cauliflower leaves, and temporary distortion of the growing point in Savoy cabbage.

- *Fox* at 1.0 L/ha was the safest treatment but it caused more damage to Savoy cabbage leaves than cauliflower. It was effective on small charlock but control of several other species was poor, including chickweed. *Alpha DFF* alone caused bleaching and it controlled charlock and small oilseed rape, but not polygonums. There were several gaps in the weed spectrum for *Fox* and *Alpha DFF* including fat-hen and polygonums. The tank-mix of *Fox* + *Alpha DFF* (1.0 + 0.5) L/ha improved control but caused unacceptable damage.

CONCLUSIONS from 2005 and 2006

Herbicides were evaluated in summer and late autumn maturing cauliflower, and (post-weed-emergence herbicides only) in Savoy cabbage. All were single applications except for oxadiargyl programmes. The aim was to identify a Fortrol replacement for control of charlock; a herbicide for control of oilseed rape volunteers, which could become a problem as the rape area increases; to evaluate herbicides for control of fat-hen and polygonums as alternatives to Treflan.
Herbicides in italics below are not yet available for brassicas.

Pre-weed-emergence residual herbicides

- Stomp 400SC (pendimethalin) at 3.3 L/ha had poor efficacy on charlock and groundsel. It was effective on (shallow sown) oilseed rape, which emerged but remained at cotyledon stage and died later, and gave excellent control of knotgrass, pale persicaria and redshank in spite of dry conditions and performed better than Treflan.

- *Defy (prosulfocarb)* at 4.0 L/ha tank-mixed with Stomp (pendimethalin) 3.3 L/ha pre-planting improved control of charlock and possibly oilseed rape, but there was no significant improvement on other weeds in these trials.

- *Oxadiargyl* 1.0 L/ha applied pre-planting in 2005 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. Under dry conditions in 2006 it was less effective. *Oxadiargyl* is likely to be used at a lower dose rate (because of cost) in a programme to control chickweed. Programmes of *oxadiargyl* followed by Ramrod (propachlor) 9.0 L/ha, Centium (2005 only) 0.25 L/ha, or Butisan (metazachlor) 1.5 L/ha controlled remaining chickweed. In both years the *oxadiargyl* and Butisan programme performed best overall, with cauliflower remaining weed free until harvest in 2005.

- *BUK 9900* at 4.0 L/ha pre-transplanting was safe and gave excellent control of weed species at the 2006 sites. *BUK 9900* at 2.5 L/ha applied 2d post-transplanting appeared to be safe. The 2.5 L/ha dose rate appeared to be adequate for good control of all species, except for oilseed rape and charlock.

- *GF-1049* 1.0 L/ha applied pre-transplanting was safer than the post-weed-emergence application and gave good weed control including charlock but not oilseed rape. It controlled all other species, but may have a weakness on chickweed, which was present in low numbers.

- *212 H* at 0.06 L/ha, caused some initial stunting of cauliflower and cabbage if applied 2 d post-transplanting but the plants soon recovered. *212 H* appears to be very dependent on moisture for good activity. It was the least effective treatment pre-transplanting/pre-weed-emergence, failing to control knotgrass, redshank, oilseed rape or charlock and was slightly less effective on some other species.

The data for *BUK 9800H* applied 2d after transplanting at one site only in 2006 is limited.

Post-weed-emergence herbicides

All post-weed-emergence treatments caused more crop damage when applied 55 days after transplanting (at Holbeach Hurn in 2006) because the large leaves caught more spray. This was also the case at the Duchy observation trial. The normal application timing is 14-21 days after transplanting.

- *Fox (bifenox)* at 1.0 L/ha was the safest post-weed emergence treatment but in 2006 it caused more damage to Savoy cabbage leaves than cauliflower.

- *Fox* 1.0 L/ha controlled small charlock and could be a useful alternative to Fortrol (cyanazine). It has a SOLA for use in rape at 6 true leaves, but it killed small (unwaxed) oilseed rape. In 2005 it also controlled small nettle.

- *Fox* needs a partner for other species – control of chickweed, knotgrass, redshank, pale persicaria, mayweeds, smooth sow-thistle, fool's parsley was poor and it was inadequate on large fat-hen. In 2005, Shield or DFF were useful partners with Fox 0.5 L/ha and improved control of some species. However in 2006 the tank-mix of Fox + Alpha DFF (1.0 + 0.5) L/ha improved control but caused unacceptable damage.

- *Oxyfluorfen* has residual soil, as well as foliar, activity. In 2005, the 240g/L EC formulation applied post-weed-emergence at 1.0 L/ha, 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. Recovery of the autumn cauliflower from oxyfluorfen damage was much slower than in the faster-maturing summer cauliflower crop grown in warmer weather and harvest delay was considerable. *Oxyfluorfen* could be safer when applied pre-transplanting.

- *GF-1049* at 0.5 L/ha was the most effective post-emergence treatment in 2006, controlling a wide range of species including oilseed rape and charlock but this dose rate was too phytotoxic for grower acceptability. *GF-1049* even at 0.25 L/ha gave 91% control of total weed numbers. It caused scorched spotting on cauliflower leaves, and temporary distortion of the growing point in Savoy cabbage. Early application 2-3 weeks after transplanting would improve efficacy and crop safety.

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

The following are not yet available for use in brassicas:
Prosulfocarb is registered in the UK for cereals and there is a SOLA for onions. It is supported in the EC Review but not yet on Annex 1. Residues studies are required.
Oxadiargyl is on the EC Annex 1 (positive list) but not registered in the UK on any crop, it is registered in Spain for use in lettuce. The company (Bayer CropScience) aims to register oxadiargyl in the UK.
BUK 9900 is a confidential mixture (both actives on Annex 1) and residue data will be needed.
Fox (bifenox) is registered for UK cereals and has a SOLA for use in UK oilseed rape (safe at 6-leaf stage if well-waxed). It is supported in the EC Review but is not on Annex 1 yet. Metabolism studies and residues data are needed.
Oxyfluorfen 240g/L EC formulation is not yet registered in the UK, but is registered in Spain for brassicas and onions. It is supported in the EC Review but is not on Annex 1 yet. Residues data for N Europe are needed
GF-1049 is not yet registered in the UK. It is supported in the EC Review but is not on Annex 1 yet. Metabolism data are available but residues data for N Europe are needed.

Approval status is shown in Table 1.

Table 1. Herbicide Current Approval Status (December 2006)

Herbicide active	*EC Review status*	*Product*	*Company*	*Formulation*	*Approval Status*

ingredient					
trifluralin	List 2	Alpha Treflan	Makhteshim	480 g/L EC	UK Approval for brassicas
pendimethalin	Annex 1	Stomp 400	BASF	400 g/L SC	UK Approval for brassicas
prosulfocarb	List 3	Defy	Syngenta	800 g/L SC	UK Approval for wheat
oxadiargyl	Annex 1	-	Bayer	400 g/L SC	no UK Approval for any crop, Spain Approval lettuce
propachlor	List 3	Ramrod Flowable	Monsanto	480 g/L SC	UK Approval for brassicas
clomazone	List 3	Centium 360CS	Belchim	360 g/L CS	SOLA 1031/04 for brassicas
metazachlor	List 3	Butisan S	BASF	500 g/L SC	UK Approval for brassicas
bifenox	List 3	Fox	Makhteshim	500 g/L SC	SOLA for oilseed rape
clopyralid	Annex 1	Dow Shield	Dow	200 g/L SC	UK Approval for brassicas
oxyfluorfen	List 3	-	Makhteshim	240 g/L EC	no UK Approval for any crop, Spain approval brassicas, onions
diflufenican	List 3	Alpha DFF	Makhteshim	500 g/L SC	UK Approval for cereals
212 H	Annex 1	-	confidential	confidential	no UK Approval for any crop
BUK 9900H	Annex 1/Annex 1	-	confidential	confidential	no UK Approval for any crop
GF-1049	List 3	-	confidential	confidential	no UK Approval for any crop
BUK 9800H	List 3 / Annex 1	-	confidential	confidential	UK Approval for oilseed rape
cyanazine	Not supported	Fortrol	Makhteshim	500 g/L SC	SOLA1074/03 cauliflower etc. Essential Use until end 2007

SOLA Specific Off-label Approval

RECOMMENDATIONS

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. Importantly, work has been done to look at alternatives to trifluralin if it fails to achieve Annex 1 listing. The European Commission has stated that ‘Essential Uses’ cannot be extended and that no further ‘Essential Use’ derogations will be granted for supported List 1, 2 or 3 actives that fail Annex 1 inclusion.

Promising safe treatments for brassicas have been identified:
pre-transplanting oxadiargyl, Defy in tank-mix with Stomp, BUK 9900, GF-1049;
pre- followed by post-transplanting programme: oxadiargyl + Butisan
post-weed-emergence Fox, GF-1049.
However, they are cannot be used in brassicas yet and it may take some time before they are available.

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 these uses could continue until the end of 2007.

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TECHNOLOGY TRANSFER

2005
Field demonstration of trials:
28 June 2005 HDC open day at Kirton
June separate visits to Kirton by Crop Protection companies (Bayer, Syngenta, Makhteshim, BASF)

Article FV 270 results 2005 trial in HDC News No. 118 December 2005.
7 March: presentation to UAP at Alconbury on HDC herbicide work in vegetables.

2006
Field demonstration of trials:
28 June 2006: HDC open day at Kirton.
June & July separate visits to Kirton by Crop Protection companies (Syngenta, Dow, Inter-Farm, Belchim, BASF), Hutchinsons group and a local grower.

18 September 2006: Kirton, presentation ADAS meeting brassica growers.
(Article FV 270 results 2006 trial in HDC News to be done).

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-weedem	Pre-weedem	Pre-weedem	Pre-weedem	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	1.5 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	S	R	MR		S
Bugloss									S				S
Charlock	R	S		R	S	R			S	MS	MS	S	S
Chickweed, common	S	R	S	S	S	S	S		R	MS	S	MR	S
Cleavers	R			S	S	S	MR		S 2 whorl	MS	MS		R
Corn marigold	R		S	S				S					
Corn spurrey	MS	S		S					S	MR/MS	MS	S	
Crane's-bill, cut-leaved							MR		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			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		R	R		S?	MR	MR	S	S
Gallant -soldier				S								S	
Groundsel	R	S	R	S	R	S	S	S		MR	MR/MS	S	S
Hemp-nettle, common	S	R	S	S					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						S	S

Nightshade black	R			MS									S
Orache, common	MS		S	MR		R			S				S
Pansy, field	S		S	S	R		R		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	MS		MS	MR	MR	S	S
Redshank	S	S		R		S		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
Wild-oat	MS			R	R							S	R
Vol OSR	R	S	MS		S	R	R	R		MS/S	S	S	R
Vol Potatoes												suppression	

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 sow-thistle	*Sonchus oleraceus*
Speedwell, common field	*Veronica persica*
Speedwell, ivy-leaved	*Veronica hederifolia*
Sun spurge	*Euphorbia helioscopia*