Project title	Lettuce (transplanted outdoor): evaluation of new herbicides for crop safety and weed control.
Project number:	FV 310
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Grower Summary

Headline

There are potential herbicide solutions for weed control in lettuce but residues data will be needed:

- Pre-planting on a mineral (light silt) soil with BUK 9900 1.25 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha. Dimethachlor 1.5 L/ha also looked promising but was only evaluated in one trial. Post-planting post-weed-emergence on organic or mineral soil, foliar-acting A7881 (ethametsulfuron) at 20 g/ha, or as a split dose but there are gaps in the weed spectrum and a tank-mix (not tested) with chlorpropham or s-metolachlor will be needed.

Defy post-planting was not safe to lettuce at either site.

Background and expected deliverables

Poor weed control can result in reductions in yield and quality of lettuce. There is zero tolerance of weeds whose seed contaminants reduce product quality or hinder hand harvesting (nettles and thistles).

Herbicides propyzamide, chlorpropham and pendimethalin are all on Annex 1 (the positive list of the 91/414/EEC review programme). A decision for non-inclusion of trifluralin on Annex 1 has been made and it cannot be used after 20 March 2009. Propachlor (List 3B) also failed Annex 1 inclusion and uses cease 18 March 2010. Growers of transplanted lettuce will then have only 3 options with approval (two of them SOLAs) for weed control.

Propachlor (SOLA) causes a growth check and the delay in maturity is usually 'built into' the sequence of croppings. It can be applied pre- or post-emergence but at the low dose rates used it only stunts Compositae. Propyzamide at 1.5 kg/ha now has a 24-day harvest interval but it is persistent in the soil, and this poses limitations on the following crops (e.g. wheat). Chlorpropham can be damaging and efficacy may be poor in the summer months (residue trials to support a SOLA for post-planting use are being conducted). Only a narrow range of weeds is susceptible to propyzamide and chlorpropham and neither control mayweeds; propachlor does not kill cruciferous species or Polygonums; pendimethalin (SOLA) controls polygonums but has weaknesses on groundsel, mayweeds and charlock.

There is a need to investigate alternatives that may extend the weed spectrum. In this project new soil-acting residual herbicides and a new sulfonylurea (in 2008) with potential for lettuce in the HDC FV 256 herbicide screens were evaluated for crop safety and weed control. The overall aim is:

- To further investigate new potential alternative herbicides identified in FV 256.
- To assess crop safety or 'phytotoxicity' to herbicides and assess efficacy against weeds and review the treatments after the first year and amend if necessary.
- To find new solutions for weed control in transplanted outdoor lettuce as quickly as possible and through HDC, to obtain Specific Off-Label Approvals (SOLAs).

Summary of the project and main conclusions

New potential herbicides for lettuce were compared with the commercial standard, Kerb + Ramrod post-planting for efficacy and crop safety. In 2007 all treatments were applied either pre-transplanting or post-transplanting to established lettuce but before weed-emergence. There were different results for crop safety between the sites in 2007 and herbicides did not perform consistently. Although several treatments were safe at the first site, all treatments caused damage in the other trials and this may have been the result of extremely wet weather conditions. Soil containing oxadiargyl splashed onto lettuce by rain or irrigation, or

blown by wind, resulted in damage at all sites. It was therefore decided not to proceed with evaluation of oxadiargyl in 2008.

Products containing propachlor (e.g. Ramrod) cannot be used after 18 March 2010. This meant that post-planting alternatives were needed. In 2008 a trial on organic soil was carried out and a foliar-acting herbicide ethametsulfuron that looked promising on lettuce in the FV 256 screen in 2007 was evaluated. The trial on mineral soil continued to evaluate pre- and post-planting and post-weed-emergence herbicides.

Herbicide Treatments 2008 *(+ denotes a tank-mix, & denotes followed by)*

Site 1. Pre- and post-planting, and post-weed-emergence on mineral soil (light silt)

Herbicide	**g a.i./ha**	**L or g product/ha**
1. untreated		-
T1Pre-transplant		
2. dimethachlor	750	1.5L
3. s-metolachlor	672	0.7L
4. s-metolachlor + Stomp	672 + 600	0.7L + 1.5L
5. BUK 9900		1.25L
6. Defy	3200	4L
T1 Pre-transplant & T2 6 days post-transplant (crop established)		
7. T1 s-metolachlor & T2 Defy	672 & 3200	0.7L & 4.0L
T2 6 days post-transplant & T3 emerged weeds		
8. T2 Kerb + Ramrod	800 + 1440	2.0L + 3.0L
9. T2 dimethachlor	750	1.5L
10. T2 s-metolachlor	672	0.7L
11. T2 s-metolachlor + Defy	672 + 3200	0.7L+ 4.0L
12. - *T3 emerged weeds* A7881	15	20g
13. T2 s-metolachlor & *T3 emerged weeds* A7881	672 & 15	0.7L & 20g

Ramrod Flowable (propachlor 480g/L); Kerb Flo (propyzamide 400g/L SC); Stomp 400SC (pendimethalin 400g/L); Defy (prosulfocarb 800 g/L)

Site 2. Post-transplanting on organic soil

Herbicide	**g a.i/ha**	**L or g product/ha**
1. untreated	-	-
T_1 4 to 7days post-plant & T2 (T_1 + 7 to 10 days emerged weeds)		
2 .T1 Ramrod + Jupiter 40EC & T2 Ramrod + Jupiter 40EC	1440 + 800 & 1440 + 800	3.0L + 2.0L & 2.0L + 2.0L
3. T1 Defy & T2 Defy	1600 & 1600	2.0L & 2.0L
4. T1 Ramrod + Jupiter 40EC & T2 Defy	1440 + 800 & 3200	3.0L + 2.0L & 4.0L
5. T1 Defy + Jupiter & T2 Defy + Jupiter	1600 + 800 & 1600 + 800	2.0L + 2.0L & 2.0L + 2.0L
6. - T2 emerged weeds A7881	15g	- & 20g
7. T1 A7881 & T2 A7881	7.5 & 7.5	10g & 10g
8. T1 s-metolachlor & T2 A7881	672 & 15	0.7L & 20g

Jupiter 40EC (chlorpropham 400 g/L)

In the trials in 2008 the best post-planting treatment was with standard Kerb (propyzamide) + Ramrod on mineral soil, and on organic soil with Ramrod + Jupiter (chlorpropham) followed by Ramrod + Jupiter. The loss of propachlor, a safe, foliar-acting herbicide, will be a particular problem on organic soils where activity of residual soil-acting herbicides is reduced or are damaging (BUK 9900) if applied post-planting to lettuce. Company data suggests that activity of residual herbicides dimethachlor and s-metolachlor is reduced on organic soils and that neither control emerged weeds.

Crop safety

At Site 1 on a light silt soil applications pre-planting BUK 9900, s-metolachlor 0.7 L/ha alone or in tank-mix with Stomp 1.5 L/ha, or dimethachlor were safe in Romaine lettuce on a light silt soil. The latter has only been tested in one trial.

On the mineral soil site Defy 4.0 L/ha post-planting, alone in a programme, or in tank-mix with s-metolachlor 0.7 L/ha caused severe damage, initially as scorch and blackening of leaf margins followed by stunting and distortion. Effects were more severe for the tank-mix and 47% of plants were unmarketable (undersized or distorted) compared with 15% for Defy as part of the programme. Dimethachlor tested at site 1 only, applied at 1.5 L/ha post-planting also gave unacceptable damage: leaf margins were black and plants were stunted. At harvest stage 31% of plants were unmarketable – undersized or distorted.

At Site 2 on organic soil Defy treatments post-planting also caused some scorch and stunting of lettuce. It was not applied in hot weather, there was frequent rainfall and irrigation - the lettuce recovered in good growing conditions, but the effects could be more severe in adverse weather.

Post-planting s-metolachlor was also safe at both sites (mineral and organic soil). Applied to emerged weeds A7881 was also very safe at 20 g/ha and as a split dose, to Romaine and Iceberg lettuce.

Weed control

At Site 1 on untreated plots the main weed species were shepherd's purse, redshank, knotgrass and small nettle with a low numbers of groundsel and mayweeds.
Pre-planting BUK 9900 1.25 L/ha, dimethachlor 1.5 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha gave very good control of these weeds. S-metolachlor at the low dose of 0.7 L/ha applied alone pre-planting (treatment 3) was the least effective treatment on knotgrass and redshank but it controlled small nettle, mayweed and groundsel. Stomp was an obvious tank-mix partner, improving control of knotgrass and also shepherd's purse. Defy 4 L/ha did not control the low numbers of groundsel or mayweed but was effective on shepherd's purse.

In this trial the standard, Kerb + Ramrod post-planting controlled all weed species. The programme of s-metolachlor followed by Defy (treatment 7) post-planting controlled all weed species, and the tank-mix (treatment 11) was also very effective, but both damaged the lettuce. S-metolachlor alone (treatment 13) was inadequate –small nettle and knotgrass remained. Dimethachlor performed well at T2 but was too phytotoxic to the crop. Dimethachlor and s-metolachlor have very little foliar activity but at the T2 post-planting timing very few weeds had emerged.

A7881 has foliar action only – applied post-planting at T3 to emerged weeds at a dose of 20 g/ha it gave a rapid kill of redshank but was weak on groundsel and knotgrass, and the programme of s-metolachlor followed by A7881 also left knotgrass.

At Site 2 on organic soil the main weed species were redshank, black-bindweed, groundsel, annual meadow-grass, field speedwell, fat-hen and fig-leaved goosefoot.

Post-planting Defy 2.0 followed by 2.0 L/ha gave no control of groundsel and was ineffective on annual meadow-grass but it controlled redshank and black-bindweed. The tank-mix programme with Defy + Jupiter was marginally better - it was more effective on redshank but activity was also poor on groundsel and annual meadow-grass.

On the organic soil site foliar-acting A7881 was very effective on redshank. A7881 at 20 g/ha at the later post-planting timing was poor, groundsel, black-bindweed and fat-hen remained. The split dose of A7881 performed slightly better on fat-hen, field speedwell, annual meadow-grass and black-bindweed but groundsel was resistant.
Although s-metolachlor has little foliar activity on emerged weeds, when applied at 0.7 L/ha early post-planting (in the programme with A7881) it controlled groundsel and field speedwell and improved annual meadow-grass and black-bindweed control but it did not control fat-hen.

In some years a third herbicide application may be needed on organic soil if there are several weed flushes, here A7881 could be useful depending on the weed species.

Potential herbicide solutions for weed control that are safe to lettuce are:
Mineral (light silt) soil

- Pre-planting the best weed control was with BUK 9900 1.25 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha. Dimethachlor 1.5 L/ha also looked promising but was only evaluated in one trial.
- Post-planting s-metolachlor at 0.7 L/ha and post-weed-emergence, foliar-acting A7881 (ethametsulfuron) at 20 g/ha were safe to lettuce. A programme of s-metolachlor followed by A7881 looked promising but not as effective as the standard Kerb + Ramrod.

Organic soil

- Foliar-acting A7881 (ethametsulfuron) applied post-planting post-weed-emergence at 20 g/ha, or as a split dose 10 g/ha followed by 10 g/ha was safe to lettuce and controls emerged weeds. It is extremely effective on redshank, pale persicaria, shepherd's purse, chickweed and charlock (company data) but there are several gaps in the weed spectrum including groundsel and knotgrass.
- Post-planting A7881 in tank-mixes (not tested in the trial) with chlorpropham or s-metolachlor, or in a programme.

None of the new herbicides are available to growers yet and residue trials will be needed before requests for SOLAs are made.

The herbicides were evaluated in Romaine and Iceberg lettuce and further information is needed on tolerance of other lettuce types. This work was deferred until 2010, following equivocal results on herbicides in the 2007 trials. It is suggested that lettuce types as requested by growers are screened on a silt soil site for tolerance to: pre-planting s-metolachlor + Stomp ((0.7 + 1.5) L/ha, BUK 9900 1.25 L/ha and possibly dimethachlor 1.5 L/ha and post-weed-emergence A 7881 (ethametsulfuron).

New Herbicides: Current Approval Status (December 2008)

Herbicide Product	***Company***	***active substance & formulation***	***EU active status***	**Registered now *or in future?***
BUK 9900H	Confidential	Confidential	Annex 1	*No EU registration yet*,
A5089H	Syngenta	dimethachlor 500 g/L SC	List 3B	*No UK registration yet*, EU for oilseed rape
(Dual Gold)	Syngenta	s-metolachlor 960 g/L EC	Annex 1	*Submitted UK registration maize,* sugar beet Belgium; dwarf beans, maize France
Defy	Syngenta	prosulfocarb 800 g/L SC	Annex 1	UK Approval for wheat
A7881	Dupont	ethametsulfuron 75% wg	-	*No EU registration yet*,

(names) are for products registered in other EU states

Financial benefits

Herbicide development for such a minor, high value crop as lettuce will not be done by Crop Protection Companies and without development work through HDC the numbers of weed control options will diminish.
An important widely used herbicide propachlor cannot be used after 18 March 2010. A potential post-emergence alternative has been found.

New pre-emergence herbicides could also provide growers with alternatives that may extend the weed spectrum and improve crop profitability and competitiveness.

Action points for growers

There are potential herbicides that appear sfe to Romaine and Iceberg lettuce.but other lettuce types need to be tested. These herbicides will not be instantly available because:

- Four have no UK registration yet for any crop although two of them are available elsewhere in the EU.
- Residues data for SOLAs for lettuce will be required for s-metolachlor, ethametsulfuron, dimethachlor and BUK 9900H.

Science Section

Introduction

Outdoor lettuce is grown from transplants in blocks. Continuous lettuce production is carefully planned and any crop check or maturity delay caused by weed competition or herbicide must be avoided. Lettuce crops are short-term so several are grown on the same land in a single season. Continuous cropping on the same land and the short-term crop are limiting factors and there are few herbicide options. Poor weed control results in reductions in yield and quality of lettuce and cause delayed maturity thus affecting crop scheduling. There is zero tolerance of weeds whose seed contaminants reduce product quality or hinder hand harvesting (nettles and thistles).

The CSL Pesticide Usage Survey for 2007 shows that propachlor was used on 2125 ha of lettuce. The use of chlorpropham was also extensive, on 1194 ha, most of the area grown receiving two applications at approximately half rate. Propyzamide was used on 648 ha. Tank-mixes of propachlor with propyzamide or chlorpropham at reduced dose rates are often used.

Herbicides propyzamide, chlorpropham and pendimethalin are all on Annex 1 (the positive list of the 91/414/EEC review programme). A decision for non-inclusion of trifluralin on Annex 1 has now been made and uses will cease in March 2010. Propachlor (List 3B) also failed Annex 1 inclusion and uses will cease in September 2010. Growers of transplanted lettuce will then have only 3 options with approval (two of them SOLAs) for weed control. Propachlor (SOLA) causes a growth check and the delay in maturity is usually 'built into' the sequence of croppings. It can be applied pre- or post-emergence but at the low dose rates used it only stunts Compositae. Propyzamide at 1.5 kg/ha now has a 24-day harvest interval but it is persistent in the soil, and this poses limitations on the following crops (e.g. wheat). Chlorpropham can be damaging and efficacy may be poor in the summer months (residue trials to support a SOLA for post-planting use are being conducted). Only a narrow range of weeds is susceptible to propyzamide and chlorpropham and neither control mayweeds; propachlor does not kill cruciferous species or Polygonums; pendimethalin (SOLA) controls polygonums but has weaknesses on groundsel, mayweeds and charlock.

The risk of damage to tender leaves and harvest intervals required prevents the use of late herbicide applications. A residual herbicide that: covers a wide weed spectrum; avoids or reduces the need for post-weed-emergence applications, and does not persist and impose restrictions on following cropping would be useful. New soil-acting residual herbicides with potential for lettuce looked promising in the HDC FV 256 herbicide screens. Two replicated screening trials for efficacy and safety in each year, 2007 and 2008 were conducted to establish their potential as alternative herbicides. This work is needed before residue work for SOLAs is undertaken. The aim of the project is to:

- assess crop safety or 'phytotoxicity' to potential alternative herbicides in outdoor lettuce and assess efficacy against weeds in 2007 and 2008.
- review the treatments after the first year and amend if necessary.
- test the best treatments for safety in a range of lettuce types
- select the most promising candidates with the aim of obtaining residues data (use data from Crop Protection Companies if available) so that HDC (Vivian Powell) can submit applications for SOLAs.

New potential herbicides for lettuce (oxadiargyl, BUK 9900, s-metolachlor, Defy) were compared with the commercial standard, Kerb + Ramrod post-planting for efficacy and crop safety in 2007. Treatments were applied either pre-transplanting or post-transplanting to established lettuce but before weed-emergence. There were different results for crop safety between the sites in 2007 and herbicides did not perform consistently. This may have been the result of extremely wet weather conditions. Bayer CropScience has registered oxadiargyl

(on Annex 1) for lettuce in Spain, but in the 2007 UK trials soil containing oxadiargyl splashed onto lettuce by rain or irrigation, or blown by wind, resulted in damage at all sites. Growers therefore agreed that evaluation of oxadiargyl should not to continue in 2008.

The non-inclusion on Annex 1 of propachlor and loss in 2010, meant that post-planting options were needed. In 2008 a trial on organic soil was carried out and a foliar-acting herbicide A7881 (ethametsulfuron) that looked promising on lettuce in the FV 256 screen in 2007 was evaluated. The trial on mineral soil continued to evaluate pre- and post-planting and post-weed-emergence herbicides. Residual herbicide dimethachlor was also included.

Materials and methods

Trial sites were in commercial lettuce crops Site 1 was on a light silt soil (ADAS classification) at Holbeach St. Marks, Site 2 at Little Ouse near Littleport on an organic soil. Both sites were typical of the main lettuce growing areas.

Herbicide Treatments 2008 *(+ denotes a tank-mix, & denotes followed by)*

Site 1 Holbeach St. Marks

Herbicide	**g a.i./ha**	**L product/ha**
1. untreated		-
T1Pre-transplant		
2. dimethachlor	750	1.5
3. s-metolachlor	672	0.7
4. s-metolachlor + Stomp	672 + 600	0.7 + 1.5
5. BUK 9900		1.25
6. Defy	3200	4
T1 Pre-transplant & T2 6 days post-transplant		
7. T1 s-metolachlor & T2 Defy	672 & 3200	0.7 & 4.0
T2 6 days Post-transplant & T3 emerged weeds		
8. T2 Kerb + Ramrod	800 + 1440	2.0 + 3.0
9. T2 dimethachlor	750	1.5
10. T2 s-metolachlor	672	0.7
11. T2 s-metolachlor + Defy	672 + 3200	0.7+ 4.0
12. - T3 A7881	15	20
13. T2 s-metolachlor & T3 A7881	672 & 15	0.7 & 20

Ramrod Flowable (propachlor 480g/L); Kerb Flo (propyzamide 400g/L SC); Stomp 400SC (pendimethalin 400g/L)

Site 2. Littleport: Post-transplanting on organic soil

Herbicide	**g a.i/ha**	**L or g product/ha**
1. untreated	-	-
T_1 4 to 7days post-plant & T2 (T_1 + 7 to 10 days emerged weeds)		
2 .T1 Ramrod + Jupiter 40EC & T2 Ramrod + Jupiter 40EC	1440 + 800 & 1440 + 800	3.0 + 2.0 & 2.0 + 2.0
3. T1 Defy & T2 Defy	1600 & 1600	2.0 & 2.0
4. T1 Ramrod + Jupiter 40EC & T2 Defy	1440 + 800 & 3200	3.0 + 2.0 & 4.0
5. T1 Defy + Jupiter & T2 Defy + Jupiter	1600 + 800 & 1600 + 800	2.0 + 2.0 & 2.0 + 2.0
6. - T2 A7881	15g	- & 20g
7. T1 A7881 & T2 A7881	7.5 & 7.5	10g & 10g
8. T1 s-metolachlor & T2 A7881	672 & 15	0.7 & 20g

Jupiter 40EC (chlorpropham 400 g/L)

New Herbicides: Current Approval Status *(December 2008)*

Herbicide Product	***Company***	***active substance & formulation***	***EU active status***	**Registered now *or in future?***
BUK 9900H pre-transplant	Confidential	Confidential	Annex 1	*No EU product registration yet*,
A5089H post-weed-emergence	Syngenta	dimethachlor (500 g/L SC)	List 3B	*No UK registration yet*, registered in EU for oilseed rape
(Dual Gold) pre- and post-transplant	Syngenta	s-metolachlor 960 g/L EC	Annex 1	*Submitted UK registration maize,* sugar beet Belgium; Dwarf beans, maize France
Defy pre- and post-transplant	Syngenta	prosulfocarb 800 g/L SC	Annex 1	UK Approval for wheat
A7881 post-weed-emergence	Dupont	ethametsulfuron 75% wg	-	*No EU registration yet*,

(names) are for products registered in other EU states

Records/Assessments

Appendix 1 shows Common and Latin weed names.

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 per plot.
- Numbers of small undersized or unmarketable distorted lettuce per plot in the three replicates (total 150 plants) were counted just before harvest and the % calculated for each treatment.

Trials Design
There were three replicates of each treatment and an untreated plot. Each plot was 4 m long x 1.83 m wide bed with 5 rows per plot at site 1. At Site 2 Lettuce was grown on the flat and plots were 4 m long and 2 m wide with 4 rows per plot.

Site, soil type, planting date and crop variety 2008
In 2008 the sites were in commercial crops.
Site 1. Majors Farm, Holbeach St. Marks, Lincs. silt loam (light soil), transplanted Romaine lettuce (cv. Daytona) on 2 May.
Site 2. Plantation Farm, Little Ouse, Littleport, Cambs., fen soil 17% organic matter, transplanted Iceberg lettuce (cv. Silverado) on 22 May.

Application Details
Sprays were applied using an Oxford precision sprayer with a 2 m boom and four 110º flat fan nozzles (BCPC code F110/0.80/3) delivering 300 L/ha water volume at 2 bar pressure to give fine spray quality.

Date applied	Weather	Weeds Growth Stages True leaves (TL)
Site 1. Holbeach St. Marks planted 8 May		
8 May T1 pre-plant. Treatments 2 – 7	16.6ºC; RH% 73; sunny cloud cover 1; soil surface dry fine seedbed; no rain after application.	none
14 May T2 post-plant Treatments 7, 8, 9, 10, 11, 13.	12.8ºC; RH% 77; cloud cover 7; soil surface dry; leaf surface dry; no rain after application.	none
2June T3 post-weed-emergence Treatments 12,13	15.3ºC; RH 87%; overcast cloud cover 8; soil surface wet; 8.1mm rain on 3 June, 13.5mm on 3 June.	small nettle 2TL, groundsel 1-2 TL Shepherd's purse 4TL, redshank 1TL,
Site 2. Litleport planted 22 May		
2 June T_1 4 to 7days post-plant. Treatments 2, 3, 4, 5, 7, 8	15.3ºC; RH 87%; overcast cloud cover 8; soil surface wet; 8.1mm rain on 3 June, 13.5mm on 3 June	mustard 2 TL, tiny weeds of other species.
11 June T2 (T_1 + 7 to 10 days emerged weeds) Treatments 3, 4, 5, 6, 7, 8	17.0ºC, 19.4ºC max later; sunny, cloud cover 2; soil surface dry; rainfall later 2.5 mm	cot black-bindweed, chickweed; cot-1TL groundsel; speedwell cot-2TL, mustard 2TL, annual meadow-grass 2L

Irrigation was applied at both sites: Site 1 30mm in May; 17mm in June; Site 2 15mm applied 23 May, 15mm 30 June.

Results and Discussion

Crop safety

Site 1, Holbeach St. Mark (lettuce transplanted 8 May)

Table 1. Site 1: Crop tolerance to herbicides, score (0 plant death, 7 acceptable damage, 10 no damage=untreated); growth stage of untreated crop; % plot cover; % by number of dead, or unmarketable (undersized or distorted) lettuce in the four rows/plot for the three replicates (total 150 plants) on 23 June (harvest stage)

Herbicide	*Product L/ha*	*19 May score*	*27 May score*	*8 June score*	*8 June % plot cover*	*16 June score*	*16 June % plot cover*	*23 June % dead/ unmktable*
1. untreated	-	10	10	10	70	10	95	0
T1 Pre-plant 8 May								
2. dimethachlor	1.5	10	10	10	70	10	95	0
3. s-metolachlor	0.7	10	10	10	70	10	95	0
4. s-metolachlor + Stomp	0.7 + 1.5	10	10	10	70	10	95	0
5. BUK 9900	1.25	10	10	10	70	10	95	0
6. Defy	4	10	10	10	70	10	95	0
T1 Pre-plant & T2 post-transplant 14 May								
7. T1 s-metolachlor & T2 Defy	0.7 & 4.0	10	7.3 bl cl sc st	7cl st	50	6	73.3	15
T2 Post-transplant & T3 emerged weeds 2 June								
8. T2 Kerb + Ramrod	2.0 + 3.0	10	9.3	9.3st	70	9.7	92	0
9. T2 dimethachlor	1.5	10	8 st bl	6.7st	40	5st	70	31
10. T2 s-metolachlor	0.7	10	10	10	70	10	95	0
11. T2 s-metolachlor + Defy	0.7+ 4.0	10	6 bl cl st	4.7	40	3	47	47
12. - & T3 A7881	20	-	-	10	70	10	95	0
13. T2 s-metolachlor & T3 A7881	0.7 & 20	10	10	10	70	10	92	0

Key: bl blackened leaf margins; st stunting; sc scorch; cl plants erect/closed up appearance

No damage to Romaine lettuce was observed from the pre-planting treatments on the 14 May or at any later assessment dates (Table 1).

Post-planting Defy at 4.0 L/ha either following s-metolachlor (treatment 7) or in tank-mix with s-metolachlor (treatment 11) caused unacceptable damage in the form of scorch, stunting and blackening of leaf margins (27 May). Plants closed up, were more erect, and plot cover was less than on untreated plots, a few had died (8 June) others were stunted, distorted and unmarketable. Effects were more severe for the tank-mix and 47% of plants were dead or unmarketable (stunted or distorted) compared with 15% for Defy as part of the programme.

Dimethachlor applied at 1.5 L/ha post-planting also gave unacceptable damage: leaves were darker in colour initially, margins were black and plants were stunted. By 8 June some leaves were dead, plants closed up and crop cover was less than on untreated plots. At harvest stage 31% of plants were unmarketable (undersized or distorted).

There was a slight growth check from the post-planting treatment Kerb + Ramrod.

S-metolachlor at 0.7 L/ha, applied alone to established lettuce six days after transplanting, caused no damage and appears safe to lettuce.

A7881 (ethametsulfuron), a sulfonylurea, applied at 20 g/ha post-weed-emergence 25 days after planting was safe to lettuce.

Weed control
Site 1, Holbeach St. Mark

Table 2 Site 1 Holbeach St. Marks: Weed species numbers/m^2 (mean of 3 counts in 0.33m^2 quadrats for 3 replicates) 8 (T1 and T2 treatments) and 16 June (T3 in italics)

Herbicide	*Product L/ha*	*Shepherd's purse*	*Small nettle*	*Black bindweed*	*Redshank*	*Groundsel*	*Knotgrass*	*Mayweed*	*Fat-hen*	***TOTAL***
1. untreated	-	39.3	4	1	8.7	3	9.3	2	1	**68.3**
T1 Pre-plant 8 May										
2. dimethachlor	1.5	0	0	1	1	0	0.3	0	0	**2.3**
3. s-metolachlor	0.7	7	0	0.3	2	1	3	0	0	**13.3**
4. s-metolachlor + Stomp	0.7 + 1.5	0.3	0	0	2	1	0	0	0	**3.3**
5. BUK 9900	1.25	0.3	0	0.3	0.7	1	0	0	0	**2.3**
6. Defy	4	0.3	1.7	0	2	3.3	1.7	2	0	**11**
T1 Pre-transplant & T2 6 days post-transplant 14 May										
7. T1 s-metolachlor & T2 Defy	0.7 & 4.0	0	0	0	0	0	0	0	0	**0**
T2 6 days Post-transplant & T3 emerged weeds										
8. T2 Kerb + Ramrod	2.0 + 3.0	0	0	0	0	0	0	0	0	**0**
9. T2 dimethachlor	1.5	0	0	0	1.3	0	2	0	0	**3.3**
10. T2 s-metolachlor	0.7	6	2	0.3	5.3	0.3	7.3	0	0	**21.3**
11. T2 s-metolachlor + Defy	0.7+ 4.0	0	1.3	0	0	0	0	0	0	**1.3**
12. T3 A7881	*20*	*1.7*	*3.3#*	*1.3*	*0*	*5.3*	*8.3*	*0.7*	*0*	***20.7***
13. T2 s-metolachlor	0.7	7.3	4	0	2.7	0.7	6.7	2	0	**24**
& T3 A7881	*& 20*	*0*	*1.7*	*0*	*0*	*1.7*	*7*	*0*	*0*	***10.4***

stunted and chlorotic

Numbers of each weed species remaining after each herbicide application were counted on 8 June, except for the T3 timing on the 16 June (Table 2). The predominant weed species at this site were shepherd's purse, redshank, knotgrass and small nettle. Total weed numbers on untreated plots were low, 68.3/m^2. May was a dry month but the crop was irrigated after the herbicides were applied.

Pre-planting BUK 9900 1.25 L/ha, dimethachlor 1.5 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha gave excellent weed control.

S-metolachlor at the low dose of 0.7 L/ha applied alone pre-planting (treatment 3) was the least effective treatment pre-planting. Efficacy on knotgrass and redshank was poor but it controlled small nettle, mayweed, groundsel and 82% of shepherd's purse. The tank-mix + Stomp (treatment 4) performed better on knotgrass (and shepherd's purse).
Defy 4 L/ha pre-planting did not control the low numbers of groundsel or mayweed.

The programme of s-metolachlor followed by Defy (treatment 7) post-planting controlled all weed species, and the tank-mix (treatment 11) was also very effective, but both damaged the lettuce. S-metolachlor alone (treatment 13) was inadequate –small nettle and knotgrass remained. Dimethachlor performed well at T2 but was too phytotoxic to the crop. Dimethachlor and s-metolachlor have very little foliar activity but at the T2 post-planting timing very few weeds had emerged.

In this trial the standard, Kerb + Ramrod post-planting controlled all weed species.

A7881 has foliar action only – applied to emerged weeds at a dose of 20 g/ha it gave a rapid kill of redshank but was weak on groundsel and knotgrass, and the programme of s-metolachlor followed by A7881 also left knotgrass.

Table 3. Site 1: Weed control scores (0 no control, 7 acceptable control, 10 complete control) assessed on several dates; % weed cover. Harvest stage 23 June

Herbicide	*Product L/ha*	*31 May score*	*8 June score*	*16 June score*	*16 June % weed cover*	*23 June score*
1. untreated	-	0	0	0	30	0
T1Pre-plant 8 May						
2. dimethachlor	1.5	10	10	9.9	0.03	9.9
3. s-metolachlor	0.7	7.3	7.3	7	2.2	6.7
4. s-metolachlor + Stomp	0.7 + 1.5	9.3	9.3	9.3	0.7	9.3
5. BUK 9900	1.25	10	9.7	9.7	0.2	9.7
6. Defy	4	8.7	8.7	8.5	1.2	8.5
T1 Pre-transplant & T2 6 days post-transplant (crop established) 14 May						
7. T1 s-metolachlor & T2 Defy	0.7 & 4.0	10	10	10	0	9.5
T2 6 days Post-transplant & T3 emerged weeds						
8. T2 Kerb + Ramrod	2.0 + 3.0	9	9.7	10	0	10
9. T2 dimethachlor	1.5	9.3	6	9.5	0.5	9
10. T2 s-metolachlor	0.7	7	6	4.7	7.3	4.3
11. T2 s-metolachlor + Defy	0.7+ 4.0	9.3	10	10	0	9
12. - & T3 A7881	20	-	-	3.7	8.3	4
13. T2 s-metolachlor & T3 A7881	0.7 & 20	-	5.7	7	2.7	6.3

Weed control scores are shown in Table 3. The best weed control pre-planting was with dimethachlor, BUK 9900 and s-metolachlor + Stomp tank-mix. The best treatment post-planting was with Kerb + Ramrod.

Defy pre-planting gave acceptable control except for groundsel, and a few nettle. Weed control with s-metolachlor 0.7 L/ha alone was unacceptable pre- or post-planting. Remaining weeds were knotgrass and redshank, and these were a greater problem on post-planting treatment 10. Treatments 7 and 11 with post-planting Defy were effective but not crop safe.

Although A7881 controlled shepherd's purse and removed redshank which might have interfered with harvesting, knotgrass remained and control was unacceptable.

A few nettles (a deterrent to hand harvesting) remained on treatments 6, 10, 12 and 13 only.

Crop safety

Site 2, Littleport

Assessments of crop safety are shown in Table 4. There were no effects on the crop from the programme with Ramrod + Jupiter treatment 2 at any stage, or from the T1 treatment 4 when assessed on 7 June.

Applications of Defy at T1 (3 and 5) caused slight stunting and a 'closed up' appearance on 7 June. Applications of Defy alone at 2.0 or 4.0 L/ha (treatments 3 and 4 respectively) or in tank-mix with Jupiter (5) caused chlorosis, scorch and stunting and the most severe scorch was from the higher dose rate of Defy 4.0 L/ha recorded on 23 June. Later the tank-mix caused more stunting. However all new growth appeared normal and by harvest no differences were observed between Defy-treated and untreated plots.

No damage was observed from A7881 at 20 g/ha dose rate (treatments 6 and 8) or as a split dose (treatment 7) appeared very safe at T1 10 days and T2 20 days post-transplanting iceberg lettuce.

There were no visible differences in damage between treated and untreated lettuce at harvest stage.

Table 4 Site 2 (lettuce transplanted 22 May) Crop tolerance to herbicides, score (0 plant death, 7 acceptable damage, 10 no damage=untreated); growth stage of untreated crop; % crop cover. Harvest stage 14 July

Herbicide	L or g product/ha	7 June score	14 June score	20 June score	23 June % cover	2 July score	2 July % cover	11July score	11July % cover
1. untreated	-	10	10	10	50	10	80	10	90
T1 post-plant 2 June & T2 on 11 June									
2 .T1 Ramrod + Jupiter & T2 Ramrod + Jupiter	3.0 + 2.0 & 2.0 + 2.0	10	10	10	50	10	80	10	90
3. T1 Defy & T2 Defy	2.0 & 2.0	9 st	8 cl sc st	6 cl sc st	40	8	75	10	90
4. T1 Ramrod + Jupiter & T2 Defy	3.0 + 2.0 & 4.0	10	8.3 sc	5 severe sc st	33	8	75	10	90
5. T1 Defy + Jupiter & T2 Defy + Jupiter	2.0 + 2.0 & 2.0 + 2.0	9 st	7.3 st	6.3 st	33	7.7st	73	10	90
6. - & T2 A7881	- & 20g	10	10	10	50	10	80	10	90
7. T1 A7881 & T2 A7881	10g & 10g	10	10	10	50	10	80	10	90
8. T1 s-metolachlor & T2 A7881	0.7 & 20g	10	10	10	50	10	80	10	90

Key: T1 4 to 7 days post-transplant; T2 (T1 + 7 to 10 days emerged weeds); sc scorch; cl chlorosis; st stunting

Weed control

Site 2 Littleport

Only few weeds (mainly black mustard) had emerged at the time of the first T1 treatment. Several weeds on untreated plots had emerged by the T2 application on 11 June but some field speedwell and a few more annual meadow-grass and groundsel emerged later. The predominant species were redshank, black-bindweed, annual meadow-grass and groundsel. There were some fat-hen and fig-leaved goosefoot Weed species counts on June 23 are shown in Table 5.

The best weed control was with Ramrod + Jupiter followed by Ramrod + Jupiter (standard for this soil type), or Ramrod + Jupiter followed by Defy, but Defy was not crop safe.

Defy 2.0 followed by 2.0 L/ha gave no control of groundsel and was ineffective on annual meadow-grass, but controlled redshank and black-bindweed. The tank-mix programme with Defy + Jupiter was marginally better - it was more effective on redshank but activity was also poor on groundsel and annual meadow-grass.

At the T2 timing A7881 20 g/ha was ineffective on black-bindweed, mustard and annual meadow-grass (Table 5) and gave no control of groundsel or field speedwell and only stunted fat-hen. It gave a quick kill of redshank. The split dose of A7881 (treatment 7) performed slightly better on fat-hen, field speedwell, annual meadow-grass and black-bindweed but groundsel was resistant.

Although s-metolachlor has little foliar activity on emerged weeds, when applied at 0.7 L/ha at T1 (in the programme with A7881 treatment 8) it controlled groundsel and field speedwell and improved annual meadow-grass control. However, s-metolachlor at 0.7 L/ha did not control fat-hen.

Table 5. Site 2 Littleport: Weed species numbers/m^2 (mean of 3 counts in 0.33m^2 quadrats for 3 replicates) assessed on 23 June

Herbicide	**L or g product/ha**	*Redshank #*	*Black-bindweed*	*Groundsel*	*Chickweed*	*Small nettle*	*Annual meadow-grass*	*Fat-hen##*	*Black mustard*	*Field speedwell*	***TOTAL***
1. untreated	-	13	15	19	1	1.7	24.3	6	3	12	**95**
T1 post-plant 2 June & T2 on 11 June											
2. T1 Ramrod + Jupiter & T2 Ramrod + Jupiter	3.0 + 2.0 & 2.0 + 2.0	0	0	3.3	0	0	0	0.7	2 st	0	**6**
3. T1 Defy & T2 Defy	2.0 & 2.0	1.7	0	18	0	0	9	1	0	0	**29.7**
4. T1 Ramrod + Jupiter & T2 Defy	3.0 + 2.0 & 4.0	0	0.7	2	0	0	2.3	0.3	0	0	**5.3**
5. T1 Defy + Jupiter & T2 Defy + Jupiter	2.0 + 2.0 & 2.0 + 2.0	0	0.3	16	0	0	7.3	0	0	0	**26.6**
6. - & T2 A7881	- 20g	0	12.3	17.3	0	0	15.7	5.7	1.3	12.6	**65.0**
7. T1 A7881 & T2 A7881	10g & 10g	0	8	18	0	0	3.3	0.3	2	7	**38.6**
8. T1 s-metolachlor & T2 A7881	0.7 & 20g	0	7	1	0	0.3	1.3	4	2	0	**15.6**

Key: T1 4 to 7 days post-transplant; T2 (T1 + 7 to 10 days emerged weeds); st stunted; # and some pale persicaria in one replicate; ## and fig-leaved goosefoot

Table 6. Site 2 Littleport: Weed control scores (0 = no control, 7 = acceptable control, 10 = complete control); % weed cover on plots. Harvest stage 14 July

Herbicide	L or g product/ha	23 June score	23 June % plot cover	2 July score	11 July % plot cover
1. untreated	-	0	10	0	90
T 1 post-transplant 2 June & T2 emerged weeds 11 June					
2. T1 Ramrod + Jupiter & T2 Ramrod + Jupiter	3.0 + 2.0 & 2.0 + 2.0	9	0.1	8	7
3. T1 Defy & T2 Defy	2.0 & 2.0	5.3	1	4	50
4. T1 Ramrod + Jupiter & T2 Defy	3.0 + 2.0 & 4.0	9.5	0	9	4
5. T1 Defy + Jupiter & T2 Defy + Jupiter	2.0 + 2.0 & 2.0 + 2.0	7	0.3	6	20
6. T2 A7881	- & 20g	3	10	2.7	67
7. T1 A7881 & T2 A7881	10g & 10g	4.7	2.5	3	53
8. T1 s-metolachlor & T2 A7881	0.7 & 20g	6.3	0.4	4.3	37

Key: T1 4 to 7 days post-transplant; T2 (T1 + 7 to 10 days emerged weeds

Weed control scores and % of weed cover per plot are shown in Table 6. Growth was very vigorous and by harvest weeds covered 90% of untreated plots - redshank, fat-hen, nettle and even groundsel were above lettuce height, and black-bindweed had over-run the crop.

The only acceptable weed control on 11 July was from the standard, treatment 2 and treatment 4. The high population of groundsel not controlled by Defy or Jupiter (treatments 3 and 5) grew above crop height and annual meadow-grass was also a problem on these plots. The treatments with A7881 (6, 7 and 8) were very effective on redshank. Weed

control with A7881 at 20 g/ha at the T2 timing was very poor, black bindweed and fat-hen were the main problem weeds. There were fewer fat-hen on plots treated with the split dose A7881 (7),

Conclusions

Propachlor failed Annex 1 inclusion. It cannot be used after 18 March 2010 and it will be difficult to replace. In the trials 2008 post-planting the best treatment was with Kerb + Ramrod (propachlor) on mineral soil, and on organic soil with Ramrod + Jupiter (chlorpropham) followed by Ramrod + Jupiter. The loss of propachlor will be a particular problem on organic soils where activity of residual soil-acting herbicides is reduced or cause damage if applied post-planting to lettuce (BUK 9900). Company data suggests that residual activity of herbicides dimethachlor and s-metolachlor is poor on organic soils and neither control emerged weeds.

Applied pre-planting on a light silt soil, BUK 9900 1.25 L/ha, s-metolachlor 0.7 L/ha alone or in tank-mix with Stomp 1.5 L/ha, or dimethachlor 1.5 L/ha were safe in Romaine lettuce on a light silt soil. The latter has only been tested in one trial. BUK 9900 1.25 L/ha, dimethachlor 1.5 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha gave very good weed control of species at Site 1: shepherd's purse, redshank, knotgrass and small nettle. S-metolachlor at the low dose of 0.7 L/ha applied alone pre-planting was safe, but less effective on knotgrass and redshank was poor but it controlled small nettle, mayweed and groundsel. Stomp was an obvious tank-mix partner, improving control of knotgrass and also shepherd's purse. Defy 4.0 L/ha was also safe pre-planting but failed to control groundsel or mayweeds.

On the silt soil site Defy 4.0 L/ha post-planting, alone in a programme, or in tank-mix caused severe damage initially scorch, stunting and blackening of leaf margins followed by stunting and distortion. Effects were more severe for the tank-mix and 47% of plants were unmarketable (undersized or distorted) compared with 15% for Defy as part of the programme. Dimethachlor tested at site 1 only, applied at 1.5 L/ha post-planting also gave unacceptable damage: leaf margins were black and plants were stunted. At harvest stage 31% of plants were unmarketable – undersized or distorted.

On organic soil Defy post-planting also caused some scorch and stunting of lettuce. The lettuces recovered in good growing conditions, but the effects could be more severe in adverse weather. On organic soil post-planting Defy 2.0 L/ha followed by 2.0 L/ha gave no control of groundsel and was ineffective on annual meadow-grass but it controlled redshank and black-bindweed. The tank-mix programme with Defy + Jupiter was marginally better - it was more effective on redshank but activity was also poor on groundsel and annual meadow-grass.

Post-planting s-metolachlor alone was safe at both sites (mineral and organic soil). Although s-metolachlor has little foliar activity on emerged weeds, when applied at 0.7 L/ha early post-planting on the organic soil site (in the programme with A7881) it controlled groundsel and field speedwell and improved annual meadow-grass control. However, s-metolachlor at 0.7 L/ha did not control fat-hen.

A7881, a sulfonylurea was also very safe at 20 g/ha and as a split dose to Romaine and Iceberg lettuce. It has foliar action only – applied to emerged weeds at a dose of 20 g/ha it gave a rapid kill of redshank but was weak on groundsel at both sites and knotgrass (at Site 1), and the programme of s-metolachlor followed by A7881 also left knotgrass. On the organic soil (Site 2) A7881 at 20 g/ha at the later post-planting timing was poor, black bindweed and fat-hen were the main problem weeds. The split dose of A7881 early and later performed slightly better on fat-hen, field speedwell, annual meadow-grass and black-bindweed but groundsel was resistant.

In some years a third herbicide application may be needed on organic soil if there are several weed flushes, here A7881 could be useful – depending on the weed species.

There are potential solutions for weed control and are safe to lettuce on:
Mineral (light silt) soil

- Pre-planting the best weed control was with BUK 9900 1.25 L/ha or s-metolachlor + Stomp (0.7 + 1.5) L/ha. Dimethachlor 1.5 L/ha also looked promising but was only evaluated in one trial
- Post-planting s-metolachlor at 0.7 L/ha and post-weed-emergence, foliar-acting A7881 (ethametsulfuron) at 20 g/ha were safe to lettuce. A programme of s-metolachlor followed by A7881 looked promising but not as effective as the standard Kerb + Ramrod.

Organic soil
Potential post-planting solutions on an organic soil safe to lettuce:

- Post-planting post-weed-emergence, foliar-acting A7881 (ethametsulfuron) at 20 g/ha, or as a split dose 10 g/ha followed by 10 g/ha but there are several gaps in the weed spectrum..
- A7881 in tank-mixes with, or in a programme with post-planting chlorpropham (not tested in the trial) or s-metolachlor.

None of the new herbicides are available to growers yet and residue trials will be needed before requests for SOLAs are made.

The herbicides were evaluated in Romaine and Iceberg lettuce and further information is needed on tolerance of other lettuce types. This work was deferred until 2010, following equivocal results on herbicides in the 2007 trials. It is suggested that lettuce types as requested by growers are screened on a silt soil site for tolerance to: pre-planting s-metolachlor + Stomp ((0.7 + 1.5) L/ha, BUK 9900 1.25 L/ha and possibly dimethachlor 1.5 L/ha and post-weed-emergence A 7881 (ethametsulfuron).

Technology transfer

2008
HDC open day at Kirton 25 June 2008, lettuce trials reported.
Sites visited by Crop Protection Companies.

(Article FV 310 results 2008 trial to be submitted for HDC News)

Appendix 1: Weeds found on the untreated trial areas

Latin name	Common name
Brassica nigra	Black mustard
Chenopodium album	Fat-hen
Chenopodium ficifolium	Fig-leaved goosefoot
Capsella bursa-pastoris	Shepherd's purse
Field speedwell	Veronica persica
Matricaria discoidea	Pineappleweed
Persicaria lapathifolium	Pale persicaria
Persicaria maculosa	Redshank
Poa annua	Annual meadow-grass
Polygonum aviculare	Knotgrass
Senecio vulgaris	Groundsel
Sinapis arvensis	Charlock
Stellaria media	Common chickweed
Tripleurospermum inodorum	Scentless mayweed
Urtica urens	Small nettle