PROJECT REPORT

To:
Horticultural Development Council
Bradbourne House
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FV 310

Lettuce (transplanted outdoor): evaluation of new herbicides for crop safety and weed control.

Annual report December 2007

Commercial - in Confidence

Project Title	Lettuce (transplanted outdoor): evaluation of new herbicides for crop safety and weed control.
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Report:	Annual report December 2007/ Final report February 2009
Previous report	none
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Key words:	Lettuce, transplanted, outdoor, soil-acting, residual herbicides, crop safety, weed control, oxadiargyl, BUK 9900H, s-metolachlor, Defy (prosulfocarb), Ramrod Flowable (propachlor); Kerb Flo (propyzamide); Stomp 400SC (pendimethalin)

The results and conclusions in this report are based on a series of experiments 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.

[Name]
[Position]
[Organisation]

Signature .... Date ....

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Grower Summary

Headline

- There were different results for crop safety between the sites and no herbicide treatment performed consistently. Although most treatments were safe at the first site, all treatments caused damage in the other trials. This may have been a result of extremely wet weather conditions.
    - BUK 9900 was very safe to lettuce and gave excellent weed control at Site 1.
    - Water-splash resulted in damage from oxadiargyl at all sites.
    - S-metolachlor and Defy post-emergence post-transplanting may be the safest herbicides and s-metolachlor achieved better control of mayweed than the standard, or Defy.
- Note – None of these actives are currently approved for use on lettuce crops.

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).

Growers of transplanted lettuce have now only 4 options with approval (two of them SOLAs) for broad-leaved weeds and the ones on-label may not be re-registered for this crop. Propyzamide, chlorpropham and pendimethalin are all on Annex 1. A decision for non-inclusion of trifluralin on Annex 1 has now been made and uses will cease on 20 March 2009. There is no decision yet on propachlor (List 3B). 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. 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. New soil-acting residual herbicides with potential for lettuce looked promising in the HDC FV 256 herbicide screen in a range of vegetable crops and will be evaluated for crop safety and weed control. The overall aim is:

- To further investigate in 2007 and 2008 new 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. All treatments were applied either pre-transplanting or post-transplanting to established lettuce but before weed-emergence.

Herbicide Treatments 2007 *(+ denotes a tank-mix, & denotes followed by)*

Herbicide	*g a.i/ha*	*L/ha*
1. untreated	-	-
Pre-transplant		
2. oxadiargyl	160	0.4
3. oxadiargyl + Stomp 400SC	160 + 600	0.4 + 1.5
4. oxadiargyl + Kerb Flo	160 + 800	0.4 + 2.0
5. s-metolachlor	672	0.7
6. s-metolachlor + Stomp 400SC	672 + 600	0.7 + 1.5
7. BUK 9900	-	1.25
13. Defy #	3200	4.0
Pre-transplant & + 7d post-transplant (crop established) pre-weed- emergence		
8. oxadiargyl & Ramrod Flowable	160 & 2250	0.4 & 3.0
9. s-metolachlor & Ramrod Flowable	672 & 2250	0.7 & 3.0
10. BUK 9900 & Ramrod Flowable *Pre-weed- emergence 7 days post-transplant*	- & 2250	1.25 & 3.0
11.Standard Kerb Flo + Ramrod Flowable	800 + 1440	2.0 + 3.0
12. s-metolachlor	672	0.7
14. Defy #	3200	4.0

Ramrod Flowable (propachlor 480g/L); Kerb Flo (propyzamide 400g/L SC); Stomp 400SC (pendimethalin 400g/L); # extra treatments sites 2 and 3

Results for crop safety and weed control were as expected at Site 1. Very high rainfall events caused flooding at Site 2 and there was severe damage at some stage from all herbicides except post-planting s-metolachlor. The trial was therefore repeated at Site 3. However, severe distortion effects began to appear in lettuce and by 4 September distorted, unmarketable lettuce plants were seen on plots treated with s-metolachlor (5, 6, 9 and 12), BUK 9900 (7 and 10) and very surprisingly Kerb (propyzamide) + Ramrod (propachlor) (11). These treatments were all chloroacetanilide herbicides except Kerb (a benzamide). The damaged lettuce all occurred randomly over the plot. These results cannot be explained. There were no distorted plants on plots treated with oxadiargyl (an oxadiazole), oxadiargyl followed by Ramrod, or Defy((prosulfocarb a thiocarbamate), pre- or post-transplanting (although some were observed from the latter at Site 2).

Oxadiargyl applied at 0.4 L/ha pre-transplanting achieved very good weed control at Sites 1 and 3. It is effective on mayweed, which frequently occurs in lettuce but needed a tank-mix partner where weed populations were very high at Site 2 and it does not control chickweed. Stomp 1.5 L/ha was the most suitable partner. Oxadiargyl caused severe damage where soil was blown or splashed onto plants, and although lettuce recovered quickly at the earliest planted Site 1, the plants remained stunted and harvest was delayed at the other two sites. Oxadiargyl is authorised for use on lettuce in Spain, where irrigation is applied through tapes, but it may be less suitable for the UK, given that current practice is to apply irrigation soon after transplanting. However, oxadiargyl has an advantage over standard Kerb - it does not persist in soil, and there are no restrictions on following crop.

S-metolachlor applied at 0.7 L/ha had weaknesses on cruciferous weeds (white mustard, charlock and shepherd's purse) and knotgrass (Site 2, project FV 256). In these trials mayweed control was variable, although those remaining were stunted. At Sites 1 and 2, s-metolachlor was the safest treatment, but at Site 3, damage developed later on 4 September when some lettuce became distorted.

BUK 9900 applied at 1.25 L/ha gave variable results - at Site 1 weed control was excellent and there was no crop damage at any stage. At Site 2 weed control was also excellent and it initially appeared safe, but after flooding there was severe necrosis and stunting. There was no recovery and it was the most damaging pre-transplanting treatment. At Site 3, control of mayweed and shepherd's purse was poor, and damage in the form of stunting, was unacceptable. Several plants became distorted, and there were harvest delays.

Defy applied at 4.0 L/ha gives poor control of weed species commonly found in lettuce crops (mayweeds, groundsel). It was applied at Sites 2 and 3. For some reason it was more effective applied post-transplanting (six days later), than pre-transplanting. Defy 4.0 L/ha applied pre-transplanting caused early symptoms of severe stunting and necrosis at both sites but there was some recovery. Post-emergence Defy caused less damage – only slight necrosis and stunting, but at Site 2 distorted plants appeared later, and there were none at Site 3.

The standard Kerb + Ramrod (2.0 + 3.0) L/ha applied post-planting, was ineffective (because of the low dose of Ramrod) on mayweeds at all sites but the weeds remained stunted. The tank-mix caused no damage at Site 1, but at sites where rainfall was high there were more effects: at Site 2 scorch and severe stunting after flooding and there was some recovery, at Site 3 there was some scorch, and early severe effects in the form of distortion.

In conclusion, there were different results for crop safety between the sites and no herbicide treatment performed consistently. Although most treatments were safe at the first site, all treatments caused damage in the other trials. This may have been a result of extremely wet weather conditions. BUK 9900 was very safe to lettuce and gave excellent weed contol at Site 1. Water-splash resulted in damage from oxadiargyl at all sites. S-metolachlor and Defy post-emergence post-transplanting may be the safest herbicides, and s-metolachlor achieved better control of mayweed than the standard, or Defy.

New Herbicides: Current Approval Status (December 2007), all are on Annex 1

Herbicide Product	***Company***	***active substance & formulation***	***Registered now or in future?***
(Raft) pre-transplant	Bayer CropScience	**oxadiargyl** 400 g/L SC	*No UK registration yet*, Lettuce Spain (registration for 0.4 L); sunflowers Italy
BUK 9900H pre-transplant	Confidential	**Confidential**	**-**
(Dual Gold) pre-transplant	Syngenta	**s-metolachlor** 960 g/L EC	*No UK registration yet*, sugar beet Belgium etc.; Dwarf beans France
Defy pre- and post-transplant	Syngenta	**prosulfocarb** 800 g/L SC	UK Approval for wheat

(names) are for products registered in other EU states

Financial benefits

There are no financial benefits from this project at present.

Action points for growers

There were different results for crop safety between the sites and all treatments caused damage in one or more trials. This may have been a result of extremely wet weather conditions. It is too early to recommend action. Further work is needed before residue studies are undertaken.

The herbicides will not be instantly available because:

- three have no UK registration yet for any crop although two are available elsewhere in the EU.
- residues data for SOLAs may be required.

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 can result in reductions in yield and quality of lettuce and cause delayed maturity affecting crop scheduling. There is zero tolerance of weeds whose seed contaminants reduce product quality or hinder hand harvesting (nettles and thistles).

The last published CSL Pesticide Usage Survey for 2003 showed that 273% of the area grown receives herbicide sprays. Propachlor was used on 84% of the area grown, with most crops receiving a single application. The use of chlorpropham was also extensive, with 59% of the area grown receiving two applications at approximately half rate. Propyzamide was used on 26%, trifluralin on 4% of the crop. Tank-mixes of propachlor with propyzamide or chlorpropham at reduced dose rates are often used.

Growers of transplanted outdoor lettuce will have only 4 options with approval (two of them SOLAs) for broad-leaved weeds and the ones on-label may not be re-registered for this crop. A decision for non-inclusion of trifluralin on Annex 1 has now been made and uses will cease 20 March 2009. 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 is not effective on 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. 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) has weaknesses on groundsel, mayweeds, 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. Three new soil-acting residual herbicides with potential for lettuce looked promising in the HDC FV 256 herbicide screen and will be tested. Two replicated screening trials for efficacy and safety in each of two years will be conducted to establish the potential of oxadiargyl, BUK 9900H and s-metolachlor as alternative herbicides. This work is needed before residue work for SOLAs is undertaken.

There is some work by Crop Protection Companies in a different climatic zone/in other crops: Bayer CropScience has now registered oxadiargyl (on Annex 1) for lettuce in Spain; Syngenta s-metolachlor is approved in dwarf French beans in France, BUK 9900, company is confidential. All actives in the trial are on Annex 1 except propachlor (List 3B).

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.
- To review the treatments after the first year and amend if necessary.
- To 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.

Materials and Methods

Trial Site 1 was on a light silt soil in a commercial lettuce crop at Holbeach St. Marks, Sites 2 and 3 on light silt loam soil (ADAS classification) at Warwick HRI, Kirton, Boston, Lincolnshire, UK, was typical of the South Lincolnshire agricultural area where lettuce is grown.

Herbicide Treatments 2007 *(+ denotes a tank-mix, & denotes followed by)*

Herbicide	*g a.i/ha*	*L/ha*
1. untreated	-	-
Pre-transplant		
2. oxadiargyl *	160	0.4
3. oxadiargyl * + Stomp	160 + 600	0.4 + 1.5
4. oxadiargyl * + Kerb	160 + 800	0.4 + 2.0
5. s-metolachlor	672	0.7
6. s-metolachlor + Stomp	672 + 600	0.7 + 1.5
7. BUK 9900	-	1.25
13. Defy #	3200	4.0
Pre-transplant & + 7d post-transplant (crop established) pre-weed- emergence		
8. oxadiargyl & Ramrod	160 & 2250	0.4 & 3.0
9. s-metolachlor & Ramrod	672 & 2250	0.7 & 3.0
10. BUK 9900 & Ramrod	- & 2250	1.25 & 3.0
Pre-weed- emergence 7 days post-transplant		
11.Standard Kerb + Ramrod	800 + 1440	2.0 + 3.0
12. s-metolachlor	672	0.7
14. Defy #	3200	4.0

Ramrod Flowable (propachlor 480g/L); Kerb Flo (propyzamide 400g/L SC); Stomp 400SC (pendimethalin 400g/L); # extra treatments sites 2 and 3, 1 replicate only; * only safe pre-transplanting

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.

Site, soil type, sowing date and crop variety 2007

Site 1. Majors Farm, Holbeach St. Marks, Lincs. silt loam (light soil), transplanted Romaine lettuce (cv. Daytona) 2 May 2007 in a commercial crop.
Site 2. Kirton Research Centre, silt loam (light soil), transplanted Iceberg lettuce (cv. Challenge) on 12 June.
Site 3. Kirton Research Centre, silt loam (light soil), transplanted Iceberg lettuce (cv. Diamond) on 25 July.

Trials Design

Each plot was 4 m long x 1.83 m wide bed with 5 rows per plot at site 1, and 4 rows per plot at Sites 2 and 3. There were three replicates of each treatment.

Rainfall and Irrigation

Appendix 2 shows rainfall and irrigation applied (overhead fine spray) at Kirton Research Centre.

Application Details

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
Site 1. Holbeach St. Marks planted 2 May	
2 May Treatments 2 – 10 pre-transplant.	9.9ºC; RH% 81; overcast cloud cover 8; soil surface dry fine seedbed; no rain after application; 12mm irrigation 1-2 days after planting;
8 May Treatments 8 – 12	11.8ºC; RH% 75; cloud cover 7; soil surface dry; leaf surface dry; rain after application 8.1 mm 8/9 May, total rainfall 2- 31 May 110mm, 27 May 32.7mm.
Site 2. Kirton planted 12 June	
12 June Treatments 2 – 10, 13 pre-transplant	19ºC; RH% 82; sunny, cloud cover 8; soil surface very dry, fine seedbed; rain 13 June 6.8mm, 14 June 16.7mm.
18 June Treatments 8 – 12, 14	14.4ºC, 19ºC max later, RH% 88; sunny, cloud cover 7; soil surface moist 1; 21.4ºC, 21.9ºC, 22ºC on 19, 20 and 21 June respectively; rain day of application 3.7mm; 24 June 42.4mm site flooded. Total from 12-30 June 126mm.
Site 3. Kirton planted 25 July	
25 July Treatments 2 – 10, 13 pre-transplant	15.8ºC; RH% 79; overcast cloud cover 8; soil surface moist; rain 25-26 July 10.8mm;
31 July Treatments 8 – 12, 14	16.5ºC max 22.3ºC later, RH% 72; sunny, light cloud cover 2; soil surface moist; 23.2ºC, 21ºC, 24.2ºC. 25ºC, 29.6ºC on 1, 2, 3, 4, 5 August respectively; 12mm irrigation on 3 and 8 August no rain until 12 August; 17.4mm rain 15 August; 21.3mm rain 19 August; irrigation 12mm on 6 September

There were no emerged weeds at any application stage at Sites 1 and 3. A few cotyledon shepherd's purse appeared at Site 2 on 19 June.

Results and Discussion

Crop safety

Site 1, Holbeach St. Mark

The lettuce was transplanted into dry soil – rain in April was negligible and there was none until 6 May. May was very wet from 6th onwards with 16.7 mm rainfall on 13 May and 32.7 mm on 27 May (Kirton met data).

Soil blow and water splash from irrigation occurred soon after application of pre-transplanting herbicides and resulted in damage from oxadiargyl in the form of necrotic areas and spots from soil-blasting on the underside of leaves and on the leaf vein. Laminar expansion was restricted, and stunting, leaf crinkling and distortion followed. The numbers of undamaged leaves compared with the untreated lettuce (7 to 8 leaves) were recorded on 23 May (Table 1). New growth was unaffected. There was some recovery by 31 May and by 20 June there was no difference between oxadiargyl-treated and untreated lettuce, except where oxadiargyl was followed by Ramrod. Harvest stage was 28 June.

The addition of Stomp (treatment 3) or Kerb (4) in tank-mix with oxadiargyl did not increase crop damage.

The follow-up after oxadiargyl with post-transplanting application with Ramrod (treatment 8) caused very severe crinkling, leaf spotting and stunting, few leaves (0 to 4) were undamaged and a few plants died. Although new growth was unaffected, the lettuces were slow to recover, crop cover was less than other treatments on 20 July and there was a harvest delay.

The commercial standard post-emergence Kerb + Ramrod caused negligible crop effects.

No damage to lettuce was observed at any growth stage from BUK 9900 or s-metolachlor alone or in tank-mix with Stomp applied pre-transplanting, or from s-metolachlor applied post-transplanting. Ramrod applied as a follow-up, after pre-transplanting application of BUK 9900 or s-metolachlor was also safe.

The numbers of undersized lettuce (compared with untreated plants) in the middle three rows for the three replicates were counted on 20 June, one week before harvest, and was calculated as a % for each treatment. Factors other than herbicide damage were involved on untreated and other plots, the only undersized lettuce resulting from herbicide damage was from oxadiargyl + Ramrod (treatment 8) 12% more than untreated. Lettuce on all other treatments had recovered from earlier herbicide damage and percentage of undersized lettuce was similar to the untreated.

Table 1. Site 1 (lettuce transplanted 2 May) Crop tolerance to herbicides, score (0 plant death, 7 acceptable damage, 10 no damage=untreated); growth stage of untreated crop; number of undamaged leaves in brackets; number of small undersized lettuce (less ground cover compared with untreated plants) in the middle three rows for the three replicates (total 108 plants) were counted on 20 June (harvest date 28 June) and the % calculated for each treatment

Herbicide	*Product L/ha*	*16 May 5 ½ TL*	*23 May 7 ½ TL*	*31 May*	*8 June*	*8 June*	*20 June*	*20 June*	*20 June*
			score (number undamaged leaves)	*score*	*score*	*% plot cover*	*score*	*% plot cover*	*small (%)*
1. untreated	-	10	10 (7-8)	10	10	80	10	95	5.5
Pre-plant 2 May									
2. oxadiargyl	0.4	7 cr st	5.3 (3-5)	6.7	7.7	67	10	95	5.5
3. oxadiargyl + Stomp	0.4 + 1.5	7 cr st	5.3 (3-5)	6.7	7.7	70	10	95	3.7
4. oxadiargyl + Kerb	0.4 + 2.0	7 cr st	5.3 (3-5)	6.7	7.7	70	10	95	6.0
5. s-metolachlor	0.7	10	10 (7-8)	10	10	80	10	95	5.5
6. s-metolachlor + Stomp	0.7 + 1.5	9.7 slight st	10 (7-8)	10	10	80	10	95	4.6
7. BUK 9900	1.25	10	10 (7-8)	10	10	80	10	95	3.7
Pre-plant 2 May & + 6d post-plant 8 May									
8. oxadiargyl & Ramrod	0.4 & 3.0	5.7 st cr spot	4 # (0-4)	5	5	53.3	6	83.3	17.6
9. s-metolachlor & Ramrod	0.7 & 3.0	10	10 (7-8)	10	10	80	10	95	6.5
10. BUK 9900 & Ramrod	1.25 & 3.0	10	10 (7-8)	10	10	80	10	95	5.5
Post-plant 8 May									
11. Kerb + Ramrod	2.0 + 3.0	10	slight cl 9.7 (7-8)	10	10	80	10	95	5.5
12. s-metolachlor	0.7	10	10 (7-8)	10	10	80	10	95	6.5

cr crinkled leaves; st stunting; # new growth undamaged; cl chlorosis;

Weed control

Site 1, Holbeach St. Mark

Weed counts were made on 31 May when weeds were at the 2-4 true-leaf stage. The predominant weed species at this site were scentless mayweed and small nettle, with lower numbers of white mustard, charlock, chickweed, groundsel and shepherd's purse. Total weed numbers on untreated plots were low, 65/m^2. Table 2 shows the numbers of each species remaining after each herbicide application.

Table 2. Site 1: Weed species numbers/m^2 (mean of 3 counts in 0.33m^2 quadrats for 3 replicates) on 31 May

Herbicide	*Product L/ha*	*Mayweed, scentless#*	*Small nettle*	*White mustard*	*Charlock*	*Groundsel*	*Shepherd' s purse*	*TOTAL*
1. untreated	-	29	16.7	8	6.3	3	2	65
Pre-plant 2 May								
2. oxadiargyl	0.4	2.3	0	0	0	0.7	0	3
3. oxadiargyl + Stomp	0.4 + 1.5	1.7	0	1	0.7	0.7	0	4.1
4. oxadiargyl + Kerb Flo	0.4 + 2.0	4.3	0	0	0	0.3	0	4.7
5. s-metolachlor	0.7	7.7	2.3	5	4.3	1.7	0.3	21.3
6. s-metolachlor + Stomp	0.7 + 1.5	4.7	1	2.3	1	2.7	0	11.7
7. BUK 9900	1.25	1.3	0	0.3	0.3	0	0	2
Pre-plant 2 May & + 6d post-plant 8 May								
8. oxadiargyl & Ramrod	0.4 & 3.0	1.3	0	0.3	0	0	0	1.7
9. s-metolachlor & Ramrod	0.7 & 3.0	4.7	1.3	2.3	2	0	0	10.3
10. BUK 9900 & Ramrod	1.25 & 3.0	0	0	1	0.3	0.3	0	1.7
Post-plant 8 May								
11. Kerb + Ramrod	2.0 + 3.0	16.7	0.3	4	5	4.7	0	30.7
12. s-metolachlor	0.7	1.7	6.7	9	3.3	2.7	0	23.4

mayweeds on all treated plots were stunted compared with untreated plots

Oxadiargyl at 0.4L/ha was effective on most species and only a few stunted mayweeds and groundsel remained. The tank-mix with Kerb did not improve control of the weed spectrum at this site. The tank-mix with a low dose of Stomp 1.5 L/ha improved mayweed control..

S-metolachlor 0.7 L/ha applied pre-transplanting had poor efficacy on cruciferous weeds (white mustard, charlock and shepherd's purse); scentless mayweed was only moderately susceptible with 73% control and some small nettle remained. The addition of Stomp gave some improvement except on groundsel.

BUK 9900 1.25 L/ha gave excellent control of the species at this site.

Follow-up treatments with Ramrod post-transplanting in programmes with oxadiargyl, BUK 9900 and s-metolachlor only improved control in the case of s-metolachlor.

The commercial post-transplanting treatment, Kerb + Ramrod (2.0 + 3.0) L/ha, controlled small nettle but efficacy on other species was poor.

S-metolachlor post-transplanting failed to control white mustard and charlock, efficacy on small nettle was poor but it appeared to be more effective on mayweed than the earlier application

Table 3. Site 1: Percentage plot cover for the main weed spp. on 20 June

Herbicide	*Product L/ha*	*Mayweed, scentless*	*Small nettle*	*White mustard*	*Charlock*	*Groundsel*	*TOTAL*
1. untreated	-	3.7	6.7	10	0.7	2.7	23
Pre-plant 2 May							
2. oxadiargyl	0.4	0.07	0	0	0	0.05	0.13
3. oxadiargyl + Stomp	0.4 + 1.5	0.05	0	0.07	0	0.03	0.15
4. oxadiargyl + Kerb Flo	0.4 + 2.0	0.4	0	0	0	0.05	0.5
5. s-metolachlor	0.7	2	0	6.7	0	0.7	10.3
6. s-metolachlor + Stomp	0.7 + 1.5	0.05	0	0.7	0	0.07	1.68
7. BUK 9900	1.25	0	0	0	0	0	0
Pre-plant 2 May & + 6d post-plant 8 May							
8. oxadiargyl & Ramrod	0.4 & 3.0	0	0	0	0	0	0
9. s-metolachlor & Ramrod	0.7 & 3.0	0.05	0	0	0.02	0.02	0.09
10. BUK 9900 & Ramrod	1.25 & 3.0	0	0	0	0	0	0
Post-plant 8 May							
11. Kerb + Ramrod	2.0 + 3.0	4	0.02	4	0.35	3	12
12. s-metolachlor	0.7	0.02	0.7	19.3	1.7	0.7	22.3

The greatest effect was from white mustard, which was at large-plant stage by 8 June (mayweeds, groundsel and small nettle were 4-6 true-leaves) when ground cover on untreated plots was 5%, two weeks later it was 10%. Table 3 shows the percentage plot cover for the main weed species on 20 June. At this stage lettuce cover was 95% for the untreated and had suppressed the low population of weeds, 23% plot cover. On untreated plots white mustard and groundsel (both flowering) and nettle were above the crop, mayweeds were not in flower and were below crop height.

There was little weed cover on treated plots and the best treatment was with BUK 9900.

Although weed numbers, mainly mayweeds, were highest on plots treated with Kerb + Ramrod (treatment 11) the mayweeds were stunted and weed cover was less than treatment 12 where mustard was a problem. The most weed cover was on plots after application of Kerb + Ramrod or s-metolachlor pre- and post -transplanting (where white mustard remaining had the greatest effect).

Weed control scores are shown in Table 4. Weed control from s-metolachlor pre or post-transplanting, or Kerb + Ramrod was inadequate. The weed populations were low at this site and weed control was excellent for all other treatments, BUK 9900 was outstanding.

Table 4. Site 1: Weed control scores (0 = no control, 7 = acceptable control, 10 = complete control) assessed on several dates. Harvest stage 28 June

Herbicide	*Product L/ha*	*30 May*	*8 June*	*20 June*
1. untreated	-	0	0	0
Pre-plant 2 May				
2. oxadiargyl	0.4	9.5	9.5	9.9
3. oxadiargyl + Stomp	0.4 + 1.5	9.5	9.5	9.9
4. oxadiargyl + Kerb Flo	0.4 + 2.0	9.5	9.5	9.9
5. s-metolachlor	0.7	6.3	6	6
6. s-metolachlor + Stomp	0.7 + 1.5	8	7.7	9
7. BUK 9900	1.25	10	10	10
Pre-plant 2 May & + 6d post-plant 8 May				
8. oxadiargyl & Ramrod	0.4 & 3.0	10	9.5	9.9
9. s-metolachlor & Ramrod	0.7 & 3.0	8.5	9.5	9.9
10. BUK 9900 & Ramrod	1.25 & 3.0	10	10	10
Post-plant 8 May				
11. Kerb + Ramrod	2.0 + 3.0	5.7	5.3	5.7
12. s-metolachlor	0.7	6.7	5.3	5

Crop safety

Site 2. Kirton

Early June was dry and lettuce was planted on 12 June. There was 16.7mm rainfall on 14 June. On 18 June, after post-transplanting application there was intermittent drizzle 3.7mm in total. June 12-30 there was 126mm rain and the site was flooded following 42.4mm on 24 June.

The damage from rain splash of oxadiargyl 0.4 L/ha was worse than at the other sites (28 June): necrotic areas, crinkling and distortion of lettuce leaves, followed by stunting. There was considerable reduction in leaf area (Table 5). Although there was some recovery, harvest was delayed compared with untreated lettuce. The addition of Stomp in tank-mix (treatment 3) gave only a slight increase in stunting and Kerb (4) did not increase damage. At harvest stage there were no distorted plants from these pre-emergence treatments with oxadiargyl: 2, 3 and 4, but maturity was uneven and delayed.

S-metolachlor pre-transplanting initially appeared safe, but after flooding there was necrosis and stunting. The addition of Stomp in tank-mix with s-metolachlor caused a slight temporary growth check. The lettuce made some recovery by harvest and there were no distorted lettuce plants in this trial.

BUK 9900 at 1.25 L/ha pre-transplanting initially appeared safe, but after flooding there was severe necrosis and some stunting (28 June). There was no recovery and stunting increased.

In this trial Ramrod 3.0 L/ha post-transplanting appeared to have some severe effects, this may have been because there was drizzle soon after application and flooding six days later.

Where oxadiargyl or s-metolachlor was followed by Ramrod 3.0 L/ha (treatment 8 and 9) damage was very severe indeed in the form of scorch on 23 June and all plants died by 28 June after flooding. Effects were initially less severe for the follow-up application after BUK 9900 with Ramrod (treatment 10), which caused necrosis and some plants remained on 28 June, but all died later.

Defy 4.0 L/ha applied pre-transplanting, caused early symptoms of severe stunting on 23 June, but there was good recovery by harvest stage 10 August and no distorted plants were observed. Post-transplanting Defy caused less damage initially – necrosis and stunting. However some lettuces became distorted later (13 July) and were unmarketable.

There was some scorch from post-planting standard Kerb + Ramrod (2.0 + 3.0) L/ha. Damage increased after flooding and plants were stunted. The lettuce recovered later but maturity was delayed.

S-metolachlor post-planting appeared very safe to lettuce but after flooding there was some necrosis and stunting on 28 June. The lettuce recovered and this was the safest treatment at this site.

In contrast with Site 3, there were no distorted plants from any herbicide treatment at site 2, with the exception of Defy post-transplanting.

Table 5. Site 2 Kirton: Crop tolerance to herbicides, score (0 plant death, 7 acceptable damage, 10 no damage as untreated), percentage reduction in leaf area
(compared with untreated =100%, at 4 ½ - 5 ½ leaves) on 28 June

Herbicide	*Product L /ha*	*23 June*	*28 June*	*28 June % reduction leaf area*	*13 July*	*30 July*	*10 August*
1. untreated	-	10	10	0	10	10	10
Pre-plant 12 June							
2. oxadiargyl	0.4	5.3 st cr	3.7 cr nec	63.3	5.7	6.3.	7del un
3. oxadiargyl + Stomp	0.4 + 1.5	5 st cr	3.3 cr nec	66.7	5.3	6	7 del un
4. oxadiargyl + Kerb	0.4 + 2.0	5.3 st cr	3.7 cr nec	63.3	5.7	6.3	7 del un
5. s-metolachlor	0.7	9	6 nec st	40	7	7.3	8
6. s-metolachlor + Stomp	0.7 + 1.5	8	6 nec st	40	7	7.3	8
7. BUK 9900	1.25	9	5 nec	50	4	4	4 severe del
13. Defy #	4.0	6 st	4 severe st	60	7	8	9 slight del
Pre-plant 12 June & + 6d post-plant 18 June							
8. oxadiargyl & Ramrod	0.4 & 3.0	3.7 nec	1 nec	0 (99% dead)	0	0	0
9. s-metolachlor & Ramrod	0.7 & 3.0	3 nec st cl	0 nec	0 (100% dead)	0	0	0
10. BUK 9900 & Ramrod	1.25 & 3.0	5.3 nec	2 nec	43.3 remainder (67%dead)	0	0	0
Post-plant 18 June							
11. Kerb + Ramrod	2.0 + 3.0	7 nec	5 nec	50	6	7.5	8 del
12. s-metolachlor	0.7	10	8 st nec	15	9.5	10	10
14. Defy #	4.0	8	6 nec st	40	6	6	6*

extra treatments 1 replicate only; st stunting; cr leaf crinkling; nec necrosis; *some distorted unmarketable plants; del maturity delay; un uneven maturity

Weed control

Site 2, Kirton

Weed numbers on untreated plots were extremely high: 318 plants/m^2 (Table 6). The weed spectrum was predominantly mayweed (mainly pineappleweed, some scentless), annual meadow-grass and shepherd's purse and some chickweed, knotgrass and groundsel. The population of groundsel and shepherd's purse was low on the third replicate.

Table 6. Site 2 Kirton: Weed species numbers/m^2 (3 counts in 0.33m^2 quadrats, mean of 3 replicates) 13 July

Herbicide	*Product L/ha*	*Mayweeds**	*Annual meadow-grass*	*Shepherd' s purse*	*Chickweed*	*Knotgrass*	*Groundsel*	*Small nettle*	*Field speedwell*	*TOTAL*
1. untreated	-	122	140	31	7	9	7	0.7	1.3	318
Pre-plant 12 June										
2. oxadiargyl	0.4	8.7st	20	0	2.7	0	0.3	0	0	31.7
3. oxadiargyl + Stomp	0.4 + 1.5	4 st	0	0	0	0	0.3	0	0	4.3
4. oxadiargyl + Kerb	0.4 + 2.0	8.7 st	0	0	0	0	0.7	0	0	9.4
5. s-metolachlor	0.7	19.3	0	5	0.7	5	1	0	0	31
6. s-metolachlor + Stomp	0.7 + 1.5	6.3	0	0.7	0	0	1.3	0	0	8.3
7. BUK 9900	1.25	1	0	0	0	0	0	0	0	1
13. Defy #	4.0	77	0	0	0	0	2	0	0	79
Pre-plant 12 June & + 6d post-plant 18 June										
8. oxadiargyl & Ramrod	0.4 & 3.0	0	0	0	0	0	0	0	0	0
9. s-metolachlor & Ramrod	0.7 & 3.0	0	0	0	0	0	0	0	0	0
10. BUK 9900 & Ramrod	1.25 & 3.0	0	0	0	0	0	0	0	0	0
Post-plant 18 June										
11. Kerb + Ramrod	2.0 + 3.0	19	0	0	0	1	4	0	0	24
12. s-metolachlor	0.7	9.3	0	10	0	7	1	0	0	27.3
14. Defy #	4.0	60 st	0	0	0	2	2	0	0	64

extra treatments on 3rd replicate only; st stunted; * mainly pineappleweed, some scentless

Rainfall after application on 13 and 14 June resulted in optimum efficacy from residual herbicides.

Oxadiargyl (treatment 2) alone was very effective on knotgrass and only a few stunted mayweeds remained. It did not control chickweed and gave 79% control of annual meadow-

grass. The tank-mix with Kerb (treatment 4) controlled the annual meadow-grass but not the mayweed; the tank-mix with Stomp (treatment 3) also controlled the annual meadow-grass and improved mayweed control. Both tank-mixes controlled chickweed.
S-metolachlor (treatment 5) alone gave 85% control of the high population of mayweeds, but poor control of knotgrass and some shepherd's purse remained. The addition of Stomp (treatment 6) in tank-mix greatly improved control of both.
BUK 9900 completely controlled all weed species.
Defy 4.0 L/ha pre-transplanting (only one plot) gave poor control of mayweeds and a few groundsel remained.

No weeds (or crop) remained where Ramrod applied six days post-planting followed oxadiargyl, BUK 9900 or s-metolachlor.

Kerb + Ramrod (2.0 + 3.0) L/ha post-planting was also damaging to the crop and groundsel and several mayweed were not controlled. However, Kerb + Ramrod was effective on shepherd's purse in this trial.
S-metolachlor post-planting had weaknesses on shepherd's purse and knotgrass.
Defy post-planting gave poor control of mayweed numbers, but they were stunted.
Defy pre- or post-planting appeared to achieve better control of scentless mayweed than of pineappleweed.

Mayweeds that escaped control with herbicides were stunted compared with untreated mayweeds.

Table 7. Site 2: Percentage plot cover for the main weed spp. on 10 August

Herbicide	*Product L/ha*	*Mayweeds*	*Annual meadow-grass*	*Shepherd' s purse*	*Chickweed*	*Knotgrass*	*Groundsel*	*TOTAL*
1. untreated	-	57	23	7	1	10	2	100
Pre-plant 12 June								
2. oxadiargyl	0.4	3	20	0	1	0	0	24
3. oxadiargyl + Stomp	0.4 + 1.5	0.2	0.5	0	0	0	0	0.7
4. oxadiargyl + Kerb	0.4 + 2.0	4	0	0	0	0	0	4
5. s-metolachlor	0.7	2	2	1	0	3	0.5	8.5
6. s-metolachlor + Stomp	0.7 + 1.5	0.3	0.5	0	0	0	0.5	1.3
7. BUK 9900	1.25	0.5	0.5	0	0	0	0	1.0
13. Defy #	4.0	30	5	0	0	2	0	37
Pre-plant 12 June & + 6d post-plant 18 June								
8. oxadiargyl & Ramrod	0.4 & 3.0	0	0	0	0	0	0	0
9. s-metolachlor & Ramrod	0.7 & 3.0	0	0.2	0	0	0	0	0.2
10. BUK 9900 & Ramrod	1.25 & 3.0	0	0	0	0	0	0	0
Post-plant 18 June								
11. Kerb + Ramrod	2.0 + 3.0	20	0	0	0	0.5	1	21.5
12. s-metolachlor	0.7	2	3	3	0	8	0	16
14. Defy #	4.0	20	2	0	0	10	1	33

extra treatments 1 replicate only

Percentage plot cover for different weed species at lettuce harvest stage is shown in Table 7. Untreated plots were completely covered by weeds mainly mayweeds (pineappleweed, some scentless). Scentless mayweed shepherd's purse, knotgrass and groundsel were above crop height. Annual meadow-grass was the main problem on oxadiargyl plots, knotgrass and shepherd's purse for s-metolachlor and mayweeds on plots treated with Kerb + Ramrod or Defy. Where Defy was applied pre-planting mayweed plants were as large as those on untreated plots. Defy post-transplanting stunted the mayweeds.

Table 8. Site 2: Weed control scores (0 = no control, 7 = acceptable control, 10 = complete control) assessed on several dates. Harvest stage 10 August

Herbicide	*Product L/ha*	*13 July*	*20 July*	*30 July*	*10 Aug*
1. untreated	-	0	0	0	0
Pre-plant 12 June					
2. oxadiargyl	0.4	6.5	8	5	5
3. oxadiargyl + Stomp	0.4 + 1.5	9.5	9.5	9	9
4. oxadiargyl + Kerb	0.4 + 2.0	7	9	8.3	8.3
5. s-metolachlor	0.7	4.7	7	6	6
6. s-metolachlor + Stomp	0.7 + 1.5	8.8	9	9	9
7. BUK 9900	1.25	10	10	9.7	9.5
13. Defy#	4.0	2	4	4	4
Pre-plant 12 June & + 6d post-plant 18 June					
8. oxadiargyl & Ramrod	0.4 & 3.0	10	10	10	10
9. s-metolachlor & Ramrod	0.7 & 3.0	10	10	10	9.7
10. BUK 9900 & Ramrod	1.25 & 3.0	10	10	10	10
Post-plant 18 June					
11. Kerb + Ramrod	2.0 + 3.0	4	6	6	6
12. s-metolachlor	0.7	4.5	8	6	6
14. Defy#	4.0	4	6	5	5

extra treatments 1 replicate only

The weed species present were typical of those encountered in a lettuce rotation but populations were extremely high. Scores (Table 8) show weed control was unacceptable for oxadiargyl alone, s-metolachlor or Defy pre- or post-transplanting, Kerb + Ramrod post-transplanting. The most effective were BUK 9900 alone, the pre-emergence tank-mixes or the programmes with Ramrod. The latter were very damaging to lettuce.

Crop safety

Site 3, Kirton

The lettuce was planted on 25 July into moist soil. Intermittent light rain followed and there was 10.1mm the next day. It was noted that the blocks of transplants were rather dry and roots exposed. Post-planting treatments were applied on 31July. Temperatures on the days after post-emergence applications were from 22ºC up to 30ºC. There was heavy rain on 15 August (17.4mm) and 19 August (21.3mm) with very dry periods before and after, when irrigation was applied.

Rain splash resulted in large necrotic areas, crinkling and distortion of lettuce leaves on plots treated with oxadiargyl 0.4 L/ha, followed by stunting. The addition of Stomp in tank-mix (treatment 3) gave a slight temporary increase in stunting on 10 August, but Kerb (4) did not increase damage (Table 9). The lettuces were very slow to recover at this later planted site and on 4 September percentage plot cover was 43.3%, much less than untreated lettuce (70%). Where oxadiargyl was followed by Ramrod 3.0 L/ha (treatment 8) 6 days later, damage was very severe indeed in the form of scorch on 6 August, two leaves were dead. Necrosis and stunting increased (24 August) and there was only 30% average cover on 4 September when the untreated was 70%. Some plants were affected more than others - 15% were very small 29 September. Harvest delay was greater compared with oxadiargyl treatments 2, 3 and 4. The main effects from oxadiargyl were stunting and delayed harvest (estimated 10 days for 2, 3 and 4; 17 days for 8) - there were no distorted unmarketable lettuce plants on plots treated with 2, 3, 4 or 8.

S-metolachlor pre-planting initially appeared safe, with only slight necrosis. The addition of Stomp in tank-mix produced a slight temporary stunting. These treatments (5 and 6) made some recovery on 24 August but on 4 September several crinkled, distorted plants were observed – the numbers increased and at harvest stage on 29 September there were 9.8 and 8.3% respectively (Table 9). The % cover from the other plants on 4 and 21 September was slightly less than untreated lettuce. A follow-up application with Ramrod (treatment 9) increased necrosis and stunting and numbers of distorted plants were higher.

S-metolachlor post-planting appeared very safe to lettuce until 4 September, when a few (less than treatments 5 and 6) crinkled, distorted plants were observed. The numbers increased and the % at harvest was similar to 5 and 6 pre-transplanting. The other plants were not stunted or delayed and % plant cover on 4 and 21 September was the same as untreated lettuce. There was no harvest delay from the s-metolachlor post-planting.

BUK 9900 1.25 L/ha pre-planting (treatment 7) caused slight necrosis on 30 July, but plants became stunted by 10 August. On 24 August, plots were uneven with occasional stunted plants. Stunting was less than from oxadiargyl. A follow-up application with Ramrod (treatment 10) increased necrosis and stunting. On 4 September severely distorted, unmarketable lettuce plants were seen on plots treated with BUK 9900 (7 and 10). Stunting and harvest delays were recorded on 21 September from both treatments (7 and 10).

Defy 4.0 L/ha applied pre-planting caused early damage symptoms of severe stunting and necrosis but there was some recovery later. Post-emergence Defy caused less damage – only slight necrosis and stunting. Plot cover and maturity was the same as the untreated on 29 September, harvest stage. It was the safest treatment at this site. There were no distorted plants on plots treated with Defy pre- or post-transplanting (although some were observed from the latter at site 2).

There was some scorch on 10 August from the post-planting standard, Kerb + Ramrod (2.0 + 3.0) L/ha but some severe effects began to appear on 24 August in the form of distortion on random individual plants. The numbers (29 September) were much higher than for any other treatment and cannot be explained.

Table 9. Site 3: Crop tolerance to herbicides, score (0 plant death, 7 acceptable damage, 10 no damage, as untreated); percentage plot cover and percentage (by number) of distorted unmarketable lettuce. Harvest stage 29 September

Herbicide	*Product L/ha*	*30 July*	*10 Aug*	*24 Aug*	*4 Sept score*	*4 Sept (% plot cover)*	*21 Sept score*	*21 Sept (% plot cover)*	*29 Sept % distorted unmarketable*
1. untreated	-	10	10	10	10	(70)	10	(90)	0
Pre-plant 25 July									
2. oxadiargyl	0.4	5	6 nec st	5	5	(43.3)	6 st del	(70)	0
3. oxadiargyl + Stomp	0.4 + 1.5	5	6 nec st	5	5	(43.3)	6 st del	(70)	0
4. oxadiargyl + Kerb	0.4 + 2.0	5	6 nec st	5	5	(43.3)	6 st del	(70)	0
5. s-metolachlor	0.7	10	8.3 nec	8.7	7.3	(63.3)	7.3 dis	(87)	9.8
6. s-metolachlor + Stomp	0.7 + 1.5	10	8 st nec	8.7	7.3	(63.3)	7.3 dis	(87)	8.3
7. BUK 9900	1.25	9	6.3 st nec	7	6	(50)	6 st del dis	(73)	14.1
13. Defy #	4.0	6	6.5 st nec	7.5	7.5	(55)	8 st del	(80)	0
Pre-plant 25 July & + 6d post-plant 31 July									
8. oxadiargyl & Ramrod	0.4 & 3.0	5	4.3 severe nec st	3	3	(30)	4 st del	(60)	0 (15% small)
9. s-metolachlor & Ramrod	0.7 & 3.0	10	7.3nec	8	6	(60)	6 dis del	(80)	15.9
10. BUK 9900 & Ramrod	1.25 & 3.0	9	5.3 nec	6.7	5	(45)	5 st dis del	(63)	12.9
Post-plant 31 July									
11. Kerb + Ramrod	2.0 + 3.0		8.7nec	4.3	1	(15)	1dis del	(20)	74.2
12. s-metolachlor	0.7		10	10	9	(70)	9 dis	(90)	9.1
14. Defy #	4.0		9 nec	9 st	9	(70)	10	(90)	0

extra plots replicates 1 and 2.
nec necrosis; st stunting; dis distortion; del delay; scores on 4 and 21 September reflect stunting and distorted plants (where they occur).

Weed control

Site 3, Kirton

The total weed number on untreated plots was 140 plants/m^2 (Table 10), much lower than Site 2, but the weed spectrum was similar - predominantly mayweed (mainly scentless), annual meadow-grass and shepherd's purse. There were some chickweed and groundsel with low numbers of knotgrass and small nettle.

Table10. Site 3: Weed species numbers/m^2 (mean of 3 counts in 0.33m^2 quadrats per plot in 3 replicates) on 4 September

Herbicide	*Product L/ha*	*Mayweeds**	*Annual meadow-grass*	*Shepherd' s purse*	*Chickweed*	*Knotgrass*	*Groundsel*	*Small nettle*	*TOTAL*
1. untreated	-	73	30	19	7	2	7	2	140
Pre-plant 25 July									
2. oxadiargyl	0.4	2	1	0	5.7	0	2.7	0	11.4
3. oxadiargyl + Stomp	0.4 + 1.5	0	0.3	0	0	0	1	0	1.3
4. oxadiargyl + Kerb Flo	0.4 + 2.0	2.7	0	0	0	0	1	0	3.7
5. s-metolachlor	0.7	10.3 st	0	11	1.7	1	3	0	27
6. s-metolachlor + Stomp	0.7 + 1.5	2 st	0	3	0	0	3.7	0	8.7
7. BUK 9900	1.25	17.7 st	0	10	0.3	0	2	0.3	30.3
13. Defy #	4.0	47	0	0.5	1	0	3	0	51.5
Pre-plant 25 July & + 7d post-plant 31 July									
8. oxadiargyl & propachlor	0.4 & 3.0	0.3	0	0	2	0	0	0	2.3
9. s-metolachlor & propachlor	0.7 & 3.0	11.7 st	0	8.7st	0.7	0.3	1.3	0	22.7
10. BUK 9900 & propachlor	1.25 & 3.0	13 st	0	8 st	0	0	0.3	0	21.3
Post-plant 31 July									
11.Standard Kerb + Ramrod	2.0 + 3.0	49 st	0	7	0.3	0	1	0	57.3
12. s-metolachlor	0.7	3	0.3	4.7	1	1	3	0	12
14. Defy #	4.0	25 st	0	0	0	0	4	0	29

extra treatments 2 replicate only; * mainly scentless, a few pineappleweed

Oxadiargyl did not control chickweed and some groundsel remained but it was effective on the other species. Stomp or Kerb in tank-mix with oxadiargyl (treatments 3 and 4 respectively) controlled chickweed.

Efficacy of s-metolachlor 0.7 L/ha applied pre-planting was poor on shepherd's purse, several mayweed seedlings emerged but died later – those remaining (counts on September 4) were stunted and at a less advanced growth stage than untreated mayweed. The addition of Stomp in tank-mix improved control of most species except groundsel. S-metolachlor post-planting (treatment 12) performed better than the pre-transplanting application, as at Site 2.

Efficacy of BUK 9900 on mayweed and shepherd's purse was poor at this site.
Follow-up applications with Ramrod after s-metolachlor or BUK 9900 offered little improvement on numbers of shepherd's purse or mayweeds. It did not completely control the chickweed that remained after oxadiargyl (treatment 8).

Defy pre-transplanting did not control mayweeds or groundsel but was effective on other species - annual meadow-grass and shepherd's purse. Defy post-transplanting performed better on mayweed, as at Site 2.

Mayweeds and shepherd's purse were the main weeds remaining after application of the standard, Kerb + Ramrod.

Most remaining mayweeds remained stunted on all treatments, with the exception of plots treated with Defy pre-planting.

Table 11. Site 3: Percentage plot cover for the main weed spp. on 18 September

Herbicide	*Product L/ha*	*Mayweeds*	*Annual meadow-grass*	*Shepherd's purse*	*Chickweed*	*Groundsel*	*TOTAL*
1. untreated	-	23	2	2	2	5	34
Pre-plant 25 July							
2. oxadiargyl	0.4	0.1	0.1	0	1	0.4	1.6
3. oxadiargyl + Stomp	0.4 + 1.5	0	0	0	0	0.1	0.1
4. oxadiargyl + Kerb	0.4 + 2.0	0.1	0	0	0	0.1	0.2
5. s-metolachlor	0.7	3.3	0	3	0	0.4	6.7
6. s-metolachlor + Stomp	0.7 + 1.5	0.07	0	0.1	0	0.2	0.4
7. BUK 9900	1.25	7	0	2	0	1	10
13. Defy #	4.0	20	0	0	0	0.5	20.5
Pre-plant 25 July & + 6d post-plant 31 July							
8. oxadiargyl & Ramrod	0.4 & 3.0	0	0	0	0.2	0	0.2
9. s-metolachlor & Ramrod	0.7 & 3.0	2	0	0.1	0	0	2.1
10. BUK 9900 & Ramrod	1.25 & 3.0	7	0	1	0	0.3	8.3
Post-plant 31 July							
11. Kerb + Ramrod	2.0 + 3.0	20	0	2	0	0	22
12. s-metolachlor	0.7	0.03	0	0.2	0	0	0.2
14. Defy #	4.0	10	0	0	0	1.5	11.5

Percentage plot cover for different weed species in lettuce 10 days before harvest is shown in Table 11, and at this stage crop cover was 90% on untreated plots. Weed cover on untreated plots was mainly with mayweeds and less than at Site 2. Mayweeds did not flower and were below crop height. Plot cover with mayweeds was high on plots treated with Kerb + Ramrod or Defy and higher than at other sites for BUK 9900. Where Defy was applied pre-planting mayweed plants were as large as those on untreated plots. Defy post-transplanting stunted the mayweeds and so did all other treatments.

Weed control scores are shown in Table 12. The weed species present were typical of those encountered in a lettuce rotation with high population of mayweeds, but total populations were low. The best weed control was with oxadiargyl treatments, s-metolachlor + Stomp pre-transplanting.

Weed control was unacceptable for: pre-transplanting s-metolachlor because of shepherd's purse and groundsel; for Defy pre-planting - a reflection of mayweed and groundsel remaining, and also BUK 9900, which did not perform well at this site. Kerb + Ramrod was also unacceptable because some mayweed and shepherd's purse were not well controlled. The follow-up treatments with Ramrod (8, 9 and 10) did not improve weed control scores.

Defy and s-metolachlor post-transplanting both gave acceptable weed control, better than the pre-transplanting applications. S-metolachlor, where weed numbers were low, performed best. There was less damage from these treatments and the lettuce treated with Defy suppressed weed growth.

Table 12. Site 3: Weed control scores (0 = no control, 7 = acceptable control, 10 = complete control) assessed on several dates. Harvest stage 29 September

Herbicide	*Product L/ha*	24 Aug	4 Sept	21 Sept
1. untreated	-	0	0	0
Pre-plant 25 July				
2. oxadiargyl	0.4	9.2	9.2	9.2
3. oxadiargyl + Stomp	0.4 + 1.5	9.9	9.8	9.8
4. oxadiargyl + Kerb Flo	0.4 + 2.0	9.9	9.5	9.5
5. s-metolachlor	0.7	9	6.7	6.7
6. s-metolachlor + Stomp	0.7 + 1.5	10	8.5	9.5
7. BUK 9900	1.25	10	7	6
13. Defy #	4.0	6	3	3
Pre-plant 25 July & + 6d post-plant 31 July				
8. oxadiargyl & propachlor	0.4 & 3.0	10	9.5	9.2
9. s-metolachlor & propachlor	0.7 & 3.0	9.3	8	7.7
10. BUK 9900 & propachlor	1.25 & 3.0	10	7.3	6.3
Post-plant 31 July				
11.Standard Kerb + Ramrod	2.0 + 3.0	9.3	6	4
12. s-metolachlor	0.7	9	9	9.2
14. Defy #	4.0	6	7	8

extra treatments 2 replicates

Conclusions

All treatments were applied either pre-transplanting or post-transplanting to established lettuce but before weed-emergence, although a few were beginning to emerge at Site 2..

Results for crop safety and weed control were as expected at Site 1. Very high rainfall events caused flooding at Site 2 and there was severe damage at some stage from all herbicides except post-planting s-metolachlor. At Site 3 distortion effects began to appear in lettuce and by 4 September severely distorted, unmarketable lettuce plants were seen on plots treated with s-metolachlor (treatments 5, 6, 9 and 12), BUK 9900 (7 and 10) and very surprisingly Kerb (propyzamide) + Ramrod (propachlor) (11). These treatments were all chloroacetanilide herbicides except Kerb (a benzamide). The damaged lettuce all occurred randomly over the plot. These results cannot be explained, but it is possible that the blocks had dried out exposing roots, were transplanted into moist soil and quickly absorbed herbicide, and were also exposed to post-transplant sprays. Distorted plants had developed taproots, but lateral roots were dead. There were no distorted plants on plots treated with oxadiargyl (an oxadiazole), including oxadiargyl followed by Ramrod (other damage scorch and stunting was severe), or Defy (prosulfocarb, a thiocarbamate), pre- or post-transplanting although some were observed from the latter at Site 2.

Oxadiargyl applied at 0.4 L/ha pre-transplanting achieved very good weed control at Sites 1 and 3. It is effective on mayweed, which frequently occurs in lettuce but needed a tank-mix partner where weed populations were very high at Site 2 and it does not control chickweed. Stomp 1.5 L/ha was the most suitable partner. Oxadiargyl caused severe damage where soil was blown or splashed onto plants, and although lettuce recovered at Site 1, the plants remained stunted and harvest was delayed at the other two sites. Oxadiargyl is authorised for use on lettuce in Spain, where irrigation is applied through tapes, but it may be less suitable for the UK, given that current practice is to apply irrigation soon after transplanting. However, oxadiargyl has an advantage over standard Kerb in that it does not persist in soil, and there are no following crop restrictions.

S-metolachlor, like propachlor, is a chloroacetanilide. S-metolachlor applied at 0.7 L/ha has weaknesses on cruciferous weeds (white mustard, charlock and shepherd’s purse) and knotgrass (site 2, project FV 256). In these trials mayweed control was variable, although those remaining were stunted. At Sites 1 and 2, s-metolachlor was the safest treatment, but at site 3, damage developed later on 4 September when some lettuce became distorted.

BUK 9900 applied at 1.25 L/ha gave variable results, at site 1 weed control was excellent and there was no crop damage at any stage. At Site 2 weed control was again excellent, it initially appeared safe, but after flooding there was severe necrosis and stunting, there was no recovery, harvest was delayed - it was the most damaging pre-transplanting treatment. At Site 3, control of mayweed and shepherd's purse was poor, and damage in the form of stunting, was unacceptable and several plants became distorted later, and there were also harvest delays.

Defy applied at 4.0 L/ha gives poor control of weed species commonly found in lettuce crops (mayweeds, groundsel). It was applied at Sites 2 and 3. For some reason it was more effective applied post-transplanting (six days later), than pre-transplanting. Defy 4.0 L/ha applied pre-transplanting caused early symptoms of severe stunting and necrosis at both sites but there was some recovery. Post-emergence Defy caused less damage – only slight necrosis and stunting, however, at site 2 distorted plants appeared later, but there were none at site 3.

The standard Kerb + Ramrod (2.0 + 3.0) L/ha applied post-planting, was ineffective (because of the low dose of Ramrod) on mayweeds at all sites but the weeds remained stunted. The tank-mix caused no damage at Site 1, but at sites where rainfall was high there were more effects: at Site 2 scorch and severe stunting after flooding and there was some recovery, at Site 3 there was some scorch, and severe effects in the form of distortion and these results cannot be explained.

No treatment performed consistently. S-metolachlor and Defy post-emergence post-transplanting may be the safest, and s-metolachlor achieved better control of mayweed than the standard, or Defy.

Technology transfer 2007

Field demonstration of trial:
3 July 2007: HDC open day at Kirton,
several visits from lettuce growers and Crop Protection Companies.

(The trials gave such inconsistent results that an Article FV 310 for HDC News would be confusing for Growers)

Appendix 1: Weeds found on the untreated trial areas

Latin name	Common name
Capsella bursa-pastoris	Shepherd's purse
Field speedwell	Veronica persica
Matricaria discoidea	Pineappleweed
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

Appendix 2. Rainfall and Irrigation at Kirton