PROJECT REPORT

To:
Horticultural Development Council
Bradbourne House
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FV 236b

To investigate safe and effective new herbicides, for weed control in Carrots and Parsnips to replace those lost through the EC Review

Final report December 2006

Commercial - in Confidence

To investigate safe and effective new herbicides, for weed control in Carrots and Parsnips to replace those lost through the EC Review

Project FV 236b

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Final report: completed December 2006, second year of a 2-year project

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Carrots, parsnips, crop safety, annual broad-leaved weed control, herbicides, pre-emergence, post-emergence, pendimethalin (Stomp 400SC), aclonifen, metribuzin (Sencorex), clomazone (Centium 360 CS or Gamit), linuron (Alpha Linuron 50 SC), metamitron (Goltix WG, Goltix Flow), metribuzin (Sencorex), prosulfocarb (Defy), diflufenican (Alpha DFF 500 SC), phenmedipham (Betanal Flow), phenmedipham/desmedipham (Betanal Carrera), SOLA (Specific Off-label Approval)

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Grower Summary

FV 236b

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Project title:	**To investigate safe and effective new herbicides, for weed control in Carrots and Parsnips to replace those lost through the EC Review**
Project number:	**FV 236b**
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Final report:	completed December 2006, second year of a 2-year project
Previous report:	Annual Report FV 236b; some potential alternatives were identified in project FV 256 (2004)
Key workers:	Joe Martin, Agrisearch UK Ltd. Cathy Knott, Herbicide Consultant
Locations:	Carrots: Lincs, Norfolk, Suffolk, Cambs; Parsnips: Yorks, Suffolk.
Project coordinator:	David Martin, Plantsystems Ltd., Emneth, Wisbech
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Keywords:	Carrots, parsnips, crop safety, annual broad-leaved weed control, pre-emergence, post-emergence herbicides, pendimethalin (Stomp 400SC), aclonifen, metribuzin (Sencorex), clomazone (Centium 360 CS or Gamit), linuron (Alpha Linuron 50 SC), metamitron (Goltix WG, Goltix Flow), metribuzin (Sencorex), prosulfocarb (Defy), diflufenican (Alpha DFF 500 SC), phenmedipham (Betanal Flow), phenmedipham/desmedipham (Betanal Carrera), SOLA (Specific Off-label Approval)

FV 236b To investigate safe and effective new herbicides, for weed control in Carrots and Parsnips to replace those lost through the EC Review

Headline

Derogations for the 'Essential Uses' of metoxuron, prometryn and pentanochlor expire 31 December 2007. Linuron forms the basis for pre- and post-emergence weed control in parsnips and carrots. It is on Annex 1 of the EC positive list but when it is re-registered the dose rate will be restricted to 950 g a.i./ha per year. It is worth considering a different approach - using other residual herbicides pre-emergence (e.g. aclonifen when available) and saving linuron for post-emergence use.

Volunteer potatoes were present in low numbers and unevenly distributed at two sites. No treatment seemed as effective as Dosaflo used on the surrounding crop. In 2006 post-emergence Alpha DFF + linuron (0.3 + 1.0) L/ha gave some suppression.

No programmes were evaluated in these trials – all treatments were single applications. A '+' denotes a tank-mix. Product approval status, active ingredients, formulations and company names are given in Table 1. HDC obtained a SOLA No.1637/06 for Goltix WG in parsnips (not carrots), following good results in the 2005 trial. Herbicides in italics below are not available.or cannot be used at this timing yet.

Parsnips
The safest effective treatments, tested on a sandy loam and a loamy sand soil were:

- Pre-emergence Stomp + *aclonifen* + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha, which gave the best weed control including groundsel (from Goltix). I t is suggested that on very light soil the maximum dose of Goltix WG should not exceed 2.0 kg/ha. Stomp 400 SC + linuron (2.5 + 1.0) L/ha and Stomp + *aclonifen* (2.0 + 2.0) L/ha were also safe but less effective.
- Post-emergence *Alpha DFF* + linuron (0.1 + 0.2) L/ha applied when parsnips were at 2 true-leaf stage was effective on most species except groundsel and large annual meadow-grass.

The following were too phytotoxic:

- Pre- or post-emergence Sencorex – even at the very low dose rate of 0.25 kg/ha.
- Pre-emergence Centium 0.2 L/ha.
- Post-emergence at 2 true-leaves *Aclonifen* + linuron (0.5 + 0.4) L/ha caused severe damage, and the parsnips did not recover. *Aclonifen* 1.0 L/ha, *Stomp* + linuron (0.5 + 0.4) L/ha could perhaps be used as a 'fire engine' treatment where there was a specific weed problem, and at a later parsnip growth stage. Aclonifen controlled fumitory.

Carrots
The safest effective treatments were:

- Pre-emergence Stomp + *aclonifen* + Centium (1.5 + 1.5 + 0.2) L/ha, which gave the best weed control. Stomp + linuron (2.5 + 1.0) L/ha and Stomp + *aclonifen* (2.0 + 2.0) L/ha were also safe.
- Post-emergence *Stomp* + linuron (0.5 + 0.4) L/ha applied at 1 true-leaves or 2 true-leaves.
- Post-emergence *Alpha DFF* + linuron (0.3 + 0.4) L/ha applied at 2 true-leaves, if large annual meadow-grass is present the dose of linuron can be increased to 1.0 L/ha although the risk of damage will increase.
- Sencorex applied post-emergence at 0.3 kg/ha at 2 true-leaves or 0.5 kg/ha later than 3 true-leaves gave excellent weed control except for nightshades.

The following were less safe:

- Pre-emergence Stomp + *aclonifen* + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha or Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha. Both caused stunting, due to Sencorex, but no plant loss. The level of weed control was similar to the Stomp + *aclonifen* + Centium tank-mix but it is suggested that Sencorex is best applied post-emergence.
- Post-emergence at 2 true-leaves *aclonifen* (1.0) L/ha; *aclonifen* + linuron (0.5 + 0.4) L/ha was generally more damaging. They are likely to have a wider margin of crop safety if applied at a later carrot growth stage – further work is required. *Aclonifen* + linuron (0.5 + 0.4) L/ha gave excellent weed control (except groundsel) including fumitory and could prove useful on organic soils, where pre-emergence herbicides are ineffective.

The following were too phytotoxic:

- Pre-emergence tank-mixes containing 1.5 kg/ha Goltix WG or Sencorex at 0.5 kg/ha.

Note: *Aclonifen* is registered for use in carrots in other N EU Member States (Denmark for use pre- and post-emergence) but it may not be available for the UK until after 2008. There are residues data for *aclonifen*.
Further work is needed for metabolism and residues studies before SOLAs can be requested for *DFF* (Crop Protection Company and HDC).
Stomp + linuron post-emergence in carrots was also promising, but at this timing further residues data would be needed for *Stomp*.

Background and commercial objectives

Poor weed control can result in reductions in yield and quality. Carrot and parsnip growers rely on programmes and repeat low doses of post-emergence herbicides and tank-mixes to cover the weed spectrum. Dosaflo (metoxuron), 14,389 ha, the next most widely used herbicide after linuron (CSL Pesticide Usage 2003 Survey), is used to control mayweeds or, in tank-mix with linuron, to suppress potatoes, products containing pentanochlor control polygonums, Gesagard (prometryn) controls fumitory – an increasing problem probably because it is tolerant of most sulfonylureas used in cereals. These herbicides were not supported in the EC pesticide review and the derogations for the 'Essential Use' of metoxuron, prometryn and pentanochlor expire 31 December 2007. Research is needed to find effective alternatives.

The early stage screening HDC trial FV 256 at Warwick HRI Kirton in the first year (2004) identified the safety of some alternative herbicides, e.g. aclonifen, which controlled mayweed, for carrots and parsnips. Parsnips are inherently more sensitive to herbicides than carrots. Further development is needed in commercial crops and on different soil types. *However, it will take time before some of these herbicides are available to the grower.*
The objectives of this project were: -

- To further investigate in 2005 and 2006 new alternative herbicides identified in FV 256, for carrots (three sites) and parsnips (one site) and to evaluate dose-rates and tank-mixes for efficacy and crop safety. Target weeds were mayweeds, groundsel, fool's parsley, fumitory.
- To find new solutions for weed control in carrots and parsnips as quickly as possible, to select the most promising candidates and encourage Crop Protection Companies to make label recommendations, to seek Specific Off-Label Approvals (SOLAs) through HDC.
- To demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so they can continue until the end of 2007.

Table 1. Herbicide Current Approval Status (November 2006)

a.i.	*EC review*	*Product*	*Company*	*Formulation*	*UK Approval Status*
pendimethalin	Annex 1	Stomp 400 SC	BASF	400 g/L SC	UK approval carrots, parsnips
aclonifen	List 3	(Challenge)	Bayer CropScience	600 g/L SC	no UK approval for any crop, unlikely UK until 2008; registered Denmark carrots; registration sought France
metribuzin	List 2	Sencorex WG	Bayer	70% w/w WDG	SOLA for carrots; parsnips
diflufenican	Lst 3	Alpha DFF 500	Makhteshim	500 g/L SC	UK approval for cereals
linuron	Annex 1	Alpha linuron	Makhteshim	500 g/L SC	UK approval carrots and parsnips
clomazone	List 3	Centium 360 CS, Gamit #	Belchim	36 g/L CS	UK approval carrots
metamitron	List 3	Goltix WG	Makhteshim	700 g/L DG	UK SOLA parsnips new
prosulfocarb	List 3	Defy	Syngenta	800 g/L SC	UK approval cereals, SOLA onions

(Product) name in other EU member state no UK registration; SOLA Specific Off-Label Approval; # do not use on sands, very light soils

Summary of the project and main conclusions 2005 and 2006 *(please note Approval status Table 1)*

Linuron forms the basis for weed control in parsnips and carrots. It is on Annex 1 of the EC positive list but when it is re-registered the dose rate will be restricted to 950 g a.i./ha per year.
In this project there was a different approach - using other residual herbicides pre-emergence and saving the option of linuron for post-emergence use. However, aclonifen may not be available until after 2008. No programmes were evaluated in these trials – all treatments were single applications.

Parsnips

Safe effective treatments:

- Pre-emergence Stomp + linuron (2.5 + 1.0) L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha and Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha caused no damage to parsnips at any stage on a light (sandy loam) soil in 2005 or on a very light soil (loamy sand) in 2006. Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha x 2 at double this dose rate were both safe to the parsnip crop on the light soil, but caused stunting on the loamy sand.

- Post-emergence DFF + linuron (0.1 + 0.2) L/ha applied at 2 true-leaf stage (a higher dose is safe to carrots) caused slight bleaching (from DFF) initially but appeared very safe to parsnips in both years.

- In 2006 all other post-emergence herbicides applied at 2 true-leaves caused scorch and leaf loss although the parsnips recovered a month after application. Aclonifen 1.0 L/ha, Stomp + linuron (0.5 + 0.4) L/ha.could perhaps be used as a 'fire engine' treatment where there was a specific weed problem. Aclonifen + linuron (0.5 + 0.4) L/ha caused the most severe damage, and the crop did not recover.

In 2005 the following lacked efficacy or were too phytotoxic to parsnips and, except for Defy, were not tested further:

- In 2005 Sencorex was too damaging to parsnips – even a very low dose rate of 0.25 kg/ha in pre-emergence tank-mixes caused severe damage and reduced plant stand. The low dose of Sencorex 0.25 kg/ha applied to parsnips after 3 true leaves, caused severe necrosis, leaf loss and plant death and also lacked efficacy on weeds.

- In 2005 Centium 0.2 L/ha in tank-mixes caused vigour reduction and there was plant loss and unacceptable stunting from the double dose.

- Post-emergence treatments applied at 1 true-leaf stage: Betanal, Betanal Carrera, Goltix were ineffective on the weed spectrum at this site. Defy applied at 2 true-leaf stage caused more damage to parsnips in the form of leaf crinkling, necrosis and slight, but more persistent, stunting. Defy 4.0 L/ha post-emergence gave poor control of field pansy, annual meadow-grass and groundsel

Carrots

Safe effective treatments:

- Pre-emergence: In both years Stomp + linuron (2.5 + 1.0) L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha and Stomp + aclonifen + Centium tank-mix at (1.5 + 1.5 + 0.2) L/ha were very safe to carrots. The 3-way tank-mix gave the best weed control.

- Post-emergence at 2 true-leaf stage: In 2006, Stomp + linuron (0.5 + 0.4) L/ha was very safe to carrots at all sites, and on organic soil where it was applied at one true-leaf as well. In both years Alpha DFF + linuron (0.3 + 0.4) L/ha was also safe at all sites. A higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha and in the double dose rate of Stomp + linuron (0.5 + 0.4) L/ha increased damage at Swinderby site 2, where carrots were at an earlier growth stage (25% at one true-leaves). Although damage was just acceptable and the carrots recovered later, the 1.0 L/ha linuron was too high.

- In 2005 Sencorex was applied post-emergence at 0.3 kg/ha to carrots at 2 true-leaves or at 0.5 kg/ha later than 3 true-leaves. Weed control was excellent except for nightshades.

The following were less safe, but none caused plant loss in 2006:

- Pre-emergence: In 2006 Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha caused slightly less phytotoxicity than Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha (the reverse was true in 2005), but the reason is not clear. Both treatments caused stunting but no plant loss. The level of weed control was similar to the Stomp + aclonifen + Centium tank-mix.

- Post-emergence at 2 true-leaves: aclonifen (1.0) L/ha caused scorch and stunting; damage from aclonifen + linuron (0.5 + 0.4) L/ha was generally more severe and unacceptable causing leaf loss at two sites. The linuron increased scorch. Damage was more severe when applied at high temperatures 24°C at Higham. However there was less damage at Holme Fen and these treatments, particularly aclonifen + linuron (0.5 + 0.4) L/ha, gave the best weed control including black-bindweed, mugwort, flixweed and possibly cleavers and could prove useful on an organic soil, where pre-emergence herbicides are ineffective. They are likely to have a wider margin of crop safety if applied at a later carrot growth stage – further work is required.

In 2005, the following lacked efficacy or were too phytotoxic and were not evaluated further:

- In 2005, the most damaging pre-emergence treatment for carrots, Stomp + aclonifen + Goltix WG: (2.0 L + 2.0 L + 1.5 kg) /ha, caused vigour loss, and at double this dose rate there was a reduction in plant stand at both sites 2 and 3.
- In 2005, Sencorex at 0.5 kg/ha in pre-emergence double dose tank-mixes Stomp + aclonifen + Sencorex at 2 x (2.0 L + 2.0 L + 0.25 kg) /ha or Stomp + linuron + Sencorex 2 x (2.0 L + 1.0 L + 0.25 kg) /ha caused severe damage and plant loss.

- In 2005, post-emergence treatments applied at 1 true-leaf stage: Goltix, Betanal and Betanal Carrera caused chlorosis followed by stunting. Betanal Carrera caused the most necrosis, Goltix caused vigour loss and thinning of the crop. Defy caused slight damage in the form of necrosis, and leaves had reduced wax and some stuck together. The weed control from these treatments was poor overall.

Weed control parsnip and carrot sites 2005 and 2006

Appendix 1 to this report shows product label claims and some other information on susceptibility of weed species to herbicides. Latin names for weeds are given in Appendix 2.
Species that will be difficult to control after the loss of herbicides at the end of 2007, unless there are alternatives are: mayweeds, fumitory, fool's parsley and groundsel and volunteer potatoes. There are possible solutions except for volunteer potatoes
All herbicide applications were single treatments. For a programme where pre-emergence herbicides are applied, the growth of weeds escaping control may be checked and it would be possible to delay post-emergence treatments until a later (and safer) growth stage than 2 true leaves. On the organic soil a programme with more than one post-emergence application would be needed.

The best weed control overall
Parsnips

- Pre-emergence 3-way tank-mix Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha gave complete control including groundsel.
- Post-emergence Alpha DFF + linuron (0.1 + 0.2) L/ha.
- Post-emergence aclonifen 1.0 L/ha, Stomp + linuron (0.5 + 0.4) L/ha could perhaps be useful as a 'fire engine' treatment later than 2 true leaves where there was a specific weed problem but further work on crop safety is needed.

Carrots

- Pre-emergence 3-way tank-mixes Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha (and the less safe Stomp + linuron + Sencorex, Stomp + aclonifen + Sencorex) gave excellent season-long weed control.
- Post-emergence at 2 true leaves Alpha DFF + linuron (0.3 + 0.4) L/ha; Stomp + linuron (0.5 + 0.4) L/ha.
- Post-emergence weed control with Sencorex was excellent at two sites in 2005, with the higher dose rate 0.5 L/ha applied later than the 3 true-leaf stage of carrots, performing better than the 0.3 L/ha dose at 2 true leaves.
- Post-emergence at 2 true leaves aclonifen + linuron (0.5 + 0.4) L/ha controlled most species except groundsel, but caused damage. It may be safer at a later growth stage.

Weed species controlled in carrots and parsnips (check crop safety)
The following information is from only a few trials, and should be treated with caution.

- There was a high population of **groundsel** 35 plants/m^2 at the parsnip site in 2006. Aclonifen and Stomp have poor activity on groundsel pre- and post-emergence. The addition of Goltix i. e. as Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha applied pre-emergence gave complete control. At the dose rates tested in parsnips all other pre- and post-emergence treatments were ineffective, however, groundsel was at large plant stage when applications were made.

- **Nightshades** (black, green and hairy) emerge in warm weather in June. Stomp at 5.0 L/ha controls nightshade but lower doses pre-emergence were ineffective. Aclonifen pre-emergence did not control nightshades, and neither did Sencorex pre- or post-emergence in

2005. In 2006 post-emergence aclonifen achieved better control and all other post-emergence treatments gave complete control of 13 plants/m^2 at Swinderby.

- The only trial where **fumitory** occurred 19 plants/m^2 was in the post-emergence area at the parsnip site in 2006. Post-emergence aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and Alpha DFF + linuron at (0.2 + 0.4) L/ha gave excellent control of fumitory but were not safe to the crop. DFF + linuron at (0.1 + 0.2) L/ha gave 73% control of fumitory numbers and those remaining were stunted. **Fumitory** was not controlled by Stomp + linuron (0.5 + 0.4) L/ha at single or double dose rates or by Defy 4.0 L/ha.

- In 2005, at the parsnip site there was a very high population 194 plants/m^2 of **field pansy**. The dose of Stomp at 2.0 or 2.5 L/ha was too low to achieve good control and pre-emergence tank-mixes with aclonifen or linuron or low dose 0.25 kg/ha Sencorex were ineffective. Field pansy is resistant to Centium, which did not improve control in the Stomp + aclonifen tank-mix. Post-emergence Alpha DFF + linuron (0.1 + 0.2) L/ha gave complete control in parsnips.

- All pre-emergence treatments gave good control of **annual meadow-grass** in 2005 and in 2006 at carrot site 2, where the population was 162 plants/m^2. Post-emergence Alpha DFF + the lower dose of linuron (0.3 + 0.4) L/ha did not control large annual meadow-grass in 2005 and 2006, but the higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha, tested in 2006, improved control. In 2006 post-emergence aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and Stomp + linuron (0.5 + 0.4) L/ha were also very effective.

- **Small nettle** (up to 8 true-leaves) and was controlled by all pre-emergence treatments in both years, with post-emergence treatments in 2006 and with Sencorex and Defy in 2005.

- **Shepherd's purse** at carrot site 2 was controlled by all pre- and post-emergence treatments.

- All treatments pre- and post-emergence controlled **fat-hen** (up to 6 true leaves) in 2006, although a few escaped control with Stomp alone at site 2, and aclonifen post-emergence at site 4.

- At the organic soil site in 2006 there were a few **cleavers,** but the distribution was uneven. Aclonifen + linuron (0.5 + 0.4) L/ha may be effective.

- Aclonifen + linuron (0.5 + 0.4) L/ha or aclonifen + linuron (0.5 + 1.0) L/ha controlled **black-bindweed** at cotyledon to 3 true-leaves in carrots on the organic soil site in 2006. Populations were too low to assess control of pre-emergence herbicides in other trials.

- Surprisingly there were no **mayweeds** at any of the sites, but pre-emergence Stomp + aclonifen is known to be effective (French data). Pre-emergence Centium controls **fool's parsley** but this weed only occurred in 2006 on the organic soil site and was not controlled by any of the post-emergence treatments.

- There were a few **volunteer potatoes** at two sites but the distribution was uneven. Post-emergence aclonifen had little effect; aclonifen + linuron caused severe scorch and killed shoots but there was regrowth. The greatest effect was from Alpha DFF + linuron (0.3 + 1.0) L/ha or possibly Stomp + linuron (0.5 + 0.4) L/ha x 2 but control was inferior to Dosaflo applied to the commercial crop.

Action Points for Growers

The FV 236b screening trials in two years identified possible alternatives but dose rates, timings and programmes will need to be developed further by agronomists/growers with expert knowledge of herbicides/local weed spectra/soil types etc.

HDC obtained a SOLA for Goltix WG in parsnips No.1637/06, after good results in the 2005 trial

Some promising pre-emergence tank-mixes based on Stomp + aclonifen for parsnips and carrots were evaluated. Aclonifen is registered for use in carrots in other N EU Member States (Denmark for use pre- and post-emergence) but it may not be available for the UK until after 2008. There are residues data for aclonifen.
Post-emergence Alpha DFF + linuron looks promising in both crops but further work is needed for metabolism and residues studies before SOLAs can be requested for DFF but this may be too costly.
Stomp + linuron post-emergence in carrots was also promising, but at this timing further residues data would be needed for Stomp.

- Growers will need to review current weed control strategy for carrots and parsnips because the "Essential Uses" for Dosaflo (metoxuron), and products containing pentanochlor and prometryne will cease 31 December 2007. Linuron is on Annex 1 the EC positive list, but when it is re-registered (possibly late 2007?) the dose rate will be restricted to 950 g a.i./ha per year. It is worth considering a different approach in future - using other residual herbicides pre-emergence and saving linuron for post-emergence use.

The following are at growers risk and some *options are not available yet given in italics*:

- In carrots pre-emergence Stomp + *aclonifen* + Centium (1.5 + 1.5 + 0.2) L/ha is safe and effective. A higher dose rate for Stomp, and up to 2.0 L/ha *aclonifen* could be included. Centium dose must not exceed 0.25 L/ha.

- In parsnips an effective pre-emergence tank-mix is essential because linuron will be the only post-emergence option (unless DFF becomes available). Pre-emergence Stomp + *aclonifen* + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha. A higher dose rate for Stomp, Goltix WG (maximum 2.0 kg/ha on sands) and up to 2.0 L/ha *aclonifen* could be included.

- Before *aclonifen* becomes available - for carrots pre-emergence Stomp + linuron + Centium (2.0 + 1.0 +0.2) L/ha; for parsnips Stomp + linuron + Goltix WG (2.0 L + 1.0 L + 1.5 kg) /ha could be used. This leaves linuron 0.9 L/ha for post-emergence use when the dose is restricted.

- For carrots the only post-emergence options other than linuron available now: Sencorex (SOLA) post-emergence at 0.3 kg/ha at 2 true leaves or at 0.5 kg/ha later than 3 true leaves was very effective on most species except nightshades and in these trials was safe to carrots (but not parsnips). High rainfall/irrigation on very light soil could result in damage.

- The following are not available yet: *Alpha DFF* + linuron (0.3 + 0.4) L/ha or *DFF* + linuron (0.3 + 1.0) L/ha (the higher linuron dose for large annual meadow-grass); *Stomp* + linuron (0.5 + 0.4) L/ha post-emergence at 1 or 2 true-leaves and *Stomp* + linuron (0.5 + 0.4) L/ha x 2 at 2 true-leaves was marginally safe. The earlier timing of *Stomp* + linuron would be useful in carrots on organic soil.

- In parsnips post-emergence: *Alpha DFF* + linuron (0.1 + 0.2) L/ha is not available yet but was safe (at a lower dose than carrots) and effective. *Stomp* + linuron (0.5 + 0.4) L/ha was not quite as safe but worth considering.

- So far a replacement for Dosaflo (metoxuron) used to suppress volunteer potatoes has not been identified. Populations of volunteer potatoes in the carrot trials were low and unevenly distributed but the best treatment appeared to be *Alpha DFF* + linuron (0.3 + 1.0) L/ha.

- Further work needed in carrots on post-emergence *aclonifen* (1.0) L/ha; *aclonifen* + linuron (0.5 + 0.4) L/ha (registered in Denmark). They were too phytotoxic to parsnips but could be considered as a 'fire engine' treatment. *Aclonifen* did not control groundsel or nightshades; *aclonifen* + linuron gave excellent control of a wide range of weed species (except groundsel), some were at advanced growth stages.

- In carrots the following were less safe, but none caused plant loss in 2005 or 2006: pre-emergence Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha and Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha. Both treatments can cause stunting, thinning and vigour loss, and the 'overlap' dose causes crop loss.

- Herbicides that were not safe to parsnips included Centium pre-emergence, Sencorex even at low dose rates pre- and post-emergence. Herbicides that were not safe to carrots included Goltix pre-emergence, and Sencorex pre-emergence at 0.5 kg/ha.

Practical and Financial Benefits from this Study

The UK area of carrots in 2005 was 9,500 ha (Defra Basic Horticultural Statistics, 2006). All conventionally grown carrots and parsnips are dependent on herbicides to control weeds that cause loss of quality, yield and harvesting difficulties – in 2003 (CSL Pesticide Usage Survey 2003) 556% of the crop area received herbicide sprays as repeat low-dose programmes. Without a range of herbicides to control a wide weed spectrum, production could become uneconomic. The carrot maincrop value 2006 (J Nix, Farm Management Pocketbook, 2005) is £6,600/ha. Linuron applied pre- or post-emergence is still the most widely used herbicide, used on 24,477 ha in the 2003 Pesticide Usage Survey. Key herbicides will be lost after 2007: Metoxuron 14,389 ha, is the next most widely used herbicide, pentanochlor 3,854 ha, chlorpropham/pentanochlor 1,767 ha, Gesagard (prometryn) is used on 3,755 ha,

- New herbicides (when available) will provide growers with alternatives for weed control so that crop yield and quality can be maintained.
- HDC has been informed of safe target products for SOLAs. SOLAs are at growers risk and it may prevent financial loss from crop damage if SOLAs are not sought where crop safety is doubtful.
- This work allowed the industry to demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so that these uses could continue until the end of 2007.

Appendix 1. Weed Susceptibility to herbicides. Data from labels UK and other countries, and other information – please treat with caution. Insufficient data for post-emergence aclonifen, aclonifen + linuron. Key: S = Susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant; Dose rates in L or kg/ha

Common name	*linuron* pre 2.2L	*liinuron* post 1.1L	*Sencorex* pre 1 -1.5kg/ha	*Sencorex* post 0.5kg/ha	*Centium* pre 0.25L	*Stomp* pre 5L	*Stomp* pre 1.5 –2 L	*aclonifen* pre 2-2.5L	*Stomp + aclonifen* pre 2 + 2L	*Goltix* pre 2kg	*Alpha dff* post 0.2 L/ha	*Alpha dff* post 0.4 L	*Defy* post 4.0L
Bindweed, black	S	S	MS	S	MR	S	MS	MS	S	MR	R	MR	
Bugloss	S	MR	S	S									
Charlock	S	S	S	S	R		MS	S	S	MS	MS	MS	
Chickweed, common	S	S	S	S	S	S	S	S	S	S	MS	S	S
Cleavers	MR	R	R	R	S	S	R	MS	MS	R	MS	MS	S
Corn marigold	S	R		MS		S				S			
Corn spurrey	S	S	S	S						S	MR/MS	MS	
Crane's-bill, cut-leaved											R	MR	
Dead-nettle, henbit			S	S		S							
Dead-nettle, red	S	MR	S	S	S	S	MS	MS	S	MS	MR/MS	MS	
Dock, broad-leaved										S			
Fat-hen	S	S	S	S	MS	S	S	S	S	S	MR	MR/MS	S
Fool's parsley					S		MS	R	R?	S			
Forget-me-not, field	S	S	S	S		S				S	MS/S	S	
Fumitory, common	R	R	S	S	R	MS	R	R	MS	MS	MR	MR	R
Gallant -soldier	S	S											
Groundsel	S	MR	S	S	S		R	R	R	S	MR	MR/MS	R
Hemp-nettle, common	S	S	S	S		S							
Knotgrass	MS	MR	S	MS	MR	S				S	MR	MR/MS	
Mayweed, scented	S	R	S	S	R	MS	MS	MS	S	S	MR	MR/MS	R
Mayweed, scentless	S	R	S	S	R	MS	MS	MS	S	S	MR	MR/MS	R
Nettle, small	S	S	S	S	MR				S	S			S
Nightshade, black	S	MR	S	S		S	MS	R	MS	MR			
Orache, common	S	S	S	S						S			
Pansy, field	S	S	S	MS	R	S	MS	R	MS	S	S	S	
Parsley piert						S							
Pennycress, field	S	S	S	S						S			
Persicaria, pale	S	S	S	S	MS					MS	MR	MR/MS	
Pimpernel, scarlet	S	S	S	S		S				MR	S	S	
Pineappleweed	S	R			R	MS	MS	MS	S	S	MR	MR	R
Poppy, common	S	S			R	S				S	MR	MR	
Redshank	S	S	S	S	S	S	MS	MS	S	MS			
Shepherd's-purse	S	S	S	S	S	S	S	S	S	S	MS/S	S	
Sow-thistle, smooth	S	S	S	MS	MS	S	R	MS	MS	MR			
Speedwell, common, field	S	S	S	S		S	S	MS	S	S	MS/S	S	S
Speedwell, ivy-leaved			S	S	S	S				MS	MS/S	S	S
Sun spurge			S							S			
Thistle, creeping	R	R			R		R	R	R	R			
Wild radish	S	S	S	S	S		MS	S	S	MR	MS/S	MS/S	
Annual meadow-grass	MS	MR	S	S	MS	S	S	MS	S		R		
Black-grass			S	MS		S				MR			
Wild-oat	R	R								R			
Vol OSR			S	S	R	MS					MS/S	S	

FV 236b To investigate safe and effective new herbicides, for weed control in Carrots and Parsnips to replace those lost through the EC Review

SCIENCE SECTION

INTRODUCTION

The problem

Poor weed control can result in reductions in yield and quality. Carrot and parsnip growers rely on programmes and repeat low doses of post-emergence herbicides and tank-mixes. Without a range of herbicides to control a wide weed spectrum, growing UK carrots and parsnips could become uneconomic. Dosaflo (metoxuron), 14,389 ha, the next most widely used herbicide after linuron (CSL Pesticide Usage 2003 Survey), is used to control mayweeds or, in tank-mix with linuron, to suppress potatoes, Croptex Bronze, Atlas Solan (pentanochlor) and Atlas Brown (chlorpropham/pentanochlor) control polygonums. Gesagard (prometryn) controls fumitory – an increasing problem probably because it is tolerant of most sulfonylureas used in cereals. These herbicides were not supported in the EC pesticide review and the derogations for the "Essential Use" of metoxuron, prometryn and pentanochlor expire 31 December 2007. Control of some weed species will be difficult. Research is needed to find effective alternatives for carrots and parsnips.

Linuron pre- or/and post-emergence has been widely used in carrots for annual meadow-grass and broad-leaved weeds for many years but use will be restricted to 950 g a.i. /ha per year when it is re-registered in the UK. Pre-emergence use of Stomp 400 is increasing but it needs a partner. Pre-emergence Centium is now approved for carrots and control includes cleavers and fools parsley, but it can cause severe damage to parsnips (approved under the Long Term Arrangements for Extension of Use). Sencorex (SOLA) controls fool's parsley, wild mignonette, groundsel, mayweeds and fumitory but there is a risk of damage on light soils and it also causes severe damage to parsnips.

The early stage screening HDC trial FV 256 in 2004 identified the safety of some possible alternative herbicides for carrots and parsnips: aclonifen, which controlled mayweed, diflufenican (Alpha DFF) and Defy (Defy, recently registered for UK cereals). Parsnips are inherently more sensitive to herbicides than carrots. Further development is needed in both crops and on different soil types. However, it will take time before these herbicides are available to growers.

OBJECTIVES

The overall aim in 2005 and 2006 is to further investigate new alternative herbicides identified in FV 256, for carrots (on three sites including very light and highly organic soil) and parsnips (on light soil at one site) and to evaluate dose-rates and tank-mixes for efficacy and crop safety. Target weeds were mayweeds, groundsel, fool's parsley and fumitory.

Objectives are: -

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

Summary for the first year 2005

Herbicide Treatments 2005

No programmes were evaluated in these trials – all treatments were single applications.
A '+' denotes a tank-mix; x 2 an 'overlap' dose.

	Carrots Sites 2 & 3		Parsnips Site 1	
Herbicide	**g a.i/ha**	**L or kg/ha**	**g a.i/ha**	**L or kg/ha**
0. untreated	-	-	-	-
Pre-emergence				
1. Stomp + linuron (standard)	1000+500	2.5+1.0	1000+500	2.5+1.0
2. Stomp + aclonifen	800+1200	2.0+2.0	800+1200	2.0+2.0
3. Stomp + aclonifen + Goltix WG	800+1200+1050	2.0+2.0 + 1.5	800+1200+1050	2.0+2.0+1.5
4. Stomp + aclonifen + Goltix WG	(800+1200+1050) x2	(2.0+2.0+1.5) x2	(800+1200+1050) x2	(2.0+2.0+1.5) x2
5. Stomp + aclonifen + Sencorex	800+1200+175	2.0+2.0 + 0.25	800+1200+175	2.0 +2.0+0.25
6. Stomp + aclonifen + Sencorex	(800+1200+175) x2	(2.0+2.0+0.25) x2	(800+1200+175) x2	(2.0+2.0+0.25) x2
7. Stomp + linuron + Sencorex	800+500+175	2.0+1.0+0.25	800+500+175	2.0+1.0+0.25
8. Stomp + linuron + Sencorex	(800+500+175) x2	(2.0+1.0+0.25) x2	(800+500+175) x2	(2.0+1.0+0.25) x2
9. Stomp + aclonifen + Centium	600+1200+72	1.5+1.5+0.2	600+1200+72	1.5+1.5+0.2
10. Stomp + aclonifen + Centium	(600+1200+72) x2	(1.5+1.5+0.2) x2	(600+1200+72) x2	(1.5+1.5+0.2) x2
Post-emergence 1 true leaf				
11.untreated	-	-	-	-
12. linuron (standard)	200	0.4	200	0.4
13. Goltix WG	1190	1.7	1190	1.7
14. Betanal Flow	240	1.5	240	1.5
15. Betanal Carrera	250/80	2.0	250/80	2.0
Post-em 2 true leaves				
16. Alpha DFF + linuron	150+200	0.3+0.4	50+100	0.1+0.2
17. Defy	3200	4.0	3200	4.0
18. Sencorex	210	0.3	-	-
Post-emergence later than 3 true leaves				
19. Sencorex	350	0.5	175	0.25

	Carrots site 4, peat soil type	
Herbicide	**g a.i/ha**	**L or kg/ha**
1.untreated	-	-
Post-emergence 1 true leaf		
2. linuron (standard)	200	0.4
3. Goltix WG	1190	1.7
4. Stomp + linuron	120+200	0.3+0.4
5. Betanal Flow	240	1.5
6. Betanal Carrera	250/80	2.0
Post-emergence 2 true leaves		
7. Stomp + linuron	200+200	0.5+0.4
8.Alpha DFF + linuron	150+200	0.3+0.4
9.Defy	3200	4.0
10. Sencorex	210	0.3
Post-emergence later than 3 true leaves		
11.Sencorex	350	0.5

Parsnips 2005

Safe effective treatments were:

- Pre-emergence Stomp + linuron (2.5 + 1.0) L/ha and Stomp + aclonifen (2.0 + 2.0) L/ha caused negligible damage.

- Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha and even at double this dose rate were safe to the parsnip crop on the light soil (sandy loam), but needed to be tested on a very light soil type.

- Post-emergence DFF + linuron (0.1 + 0.2) L/ha applied to parsnips at 2 true-leaves caused slight bleaching (from DFF) initially but appeared very safe.

The following were too phytotoxic or lacked efficacy:

- Pre-emergence tank-mixes containing Sencorex WG, even at very low dose rate 0.25 kg/ha (treatments 5, 7) caused severe damage and reduced plant stand, at 0.5 kg/ha (treatments 6, 8) very few parsnips emerged. The low dose 0.25 kg/ha of Sencorex alone, applied to parsnips after 3 true-leaves, caused severe scorch, leaf loss and plant death.

- There was plant loss and unacceptable stunting from Centium in tank-mixes at the double dose 2 x 0.2 L/ha. The single dose also reduced crop vigour.

- Post-emergence treatments Betanal, Betanal Carrera, Goltix applied at 1 true-leaf stage were ineffective on the weed spectrum at this site. Defy applied at 2 true-leaf stage caused more damage in the form of leaf crinkling, necrosis and slight but more persistent stunting. Defy at 4.0 L/ha gave poor control of field pansy, annual meadow-grass and groundsel

Carrots 2005

The safest effective treatments were:

- Pre-emergence Stomp + linuron (2.5 + 1.0) L/ha, and Stomp + aclonifen (2.0 + 2.0) L/ha. Stomp + aclonifen + Centium tank-mix was also very safe to carrots at (1.5 + 1.5 + 0.2) L/ha and at double this dose.

- Post-emergence DFF + linuron (0.3 + 0.4) L/ha applied at 2 true-leaves caused slight transient bleaching (from the DFF) initially but appeared very safe to carrots. It controlled all weeds except large annual meadow-grass.

- Post-emergence Sencorex 0.3 kg/ha applied to carrots at 2 true-leaves, or at 0.5 kg/ha later than 3 true-leaves. Except for slight chlorosis for the latter, no damage was observed. Weed control was excellent.

Possibly safe:

- The single dose of pre-emergence Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha. Further evaluation was needed.
- Post-emergence Stomp + linuron was only tested on the peat soil site. It appeared safe to the crop at both timings but there was slightly more stunting at the earlier 1 true-leaf timing. Further evaluation was needed.

The following were not safe:

- Stomp + aclonifen + Goltix WG was the most damaging pre-emergence treatment for carrots: (2.0 L + 2.0 L + 1.5 kg) /ha caused vigour loss, and at double this dose rate there was a reduction in plant stand at both sites 2 and 3. Damage was very severe at Site 3.

- Pre-emergence tank-mixes containing Sencorex at 0.5 kg/ha as a double dose (treatments 6, 8) caused damage and plant loss: Stomp + aclonifen + Sencorex at 2 x (2.0 L + 2.0 L + 0.25 kg) /ha caused severe phytotoxicity - plant loss was greater than from Stomp + linuron + Sencorex 2 x (2.0 L + 1.0 L + 0.25 kg) /ha, but the reason is not clear. Damage was more severe at Site 3 (about 70% loss) from Stomp + aclonifen + Sencorex at 2 x (2.0 L + 2.0 L + 0.25 kg) /ha, than at Site 2.

Or lacked efficacy:

- Post-emergence treatments applied at 1 true-leaf stage: Goltix, Betanal and Betanal Carrera caused chlorosis followed by stunting. Betanal Carrera caused the most necrosis, Goltix caused vigour loss and thinning of the crop. Defy caused slight damage in the form of necrosis, leaves had reduced wax and some stuck together. Weed control from these treatments was poor.

Weed control parsnip and carrot sites 2005

Species that will be difficult to control after the loss of herbicides at the end of 2007, were target weeds in the trials: mayweeds, fumitory, fool's parsley and groundsel, but only groundsel was found at these trial sites. The main weed species at the parsnip site were field pansy (194/m^2), annual meadow-grass (51/m^2) and groundsel (6/m^2). The main weed species at the carrot sites were annual meadow-grass (32/m^2), redshank (11/m^2), black-bindweed and groundsel (Site 2), and fat-hen (49/m^2) and some small nettle, field pansy and black and green nightshade (Site 3).

Volunteer potatoes were present in low numbers and unevenly distributed at one site but none of the treatments tested gave any control.

Some treatments were extremely effective on the weed spectra at two carrot sites and no further applications would have been needed i.e. pre-emergence 3-way tank-mixes, post-emergence DFF + linuron and post-emergence Sencorex.

- Pre-emergence tank-mixes Stomp + aclonifen + Centium, Stomp + linuron + Sencorex, Stomp + aclonifen + Sencorex, Stomp + aclonifen + Goltix gave excellent season-long weed control at carrot sites 2 and 3, only a few redshank remained on plots treated with Stomp + linuron (treatment 1) and Stomp + linuron + Sencorex (7).

- Efficacy of Stomp + aclonifen on groundsel was poor, but the addition of Goltix, or Sencorex, or Centium improved control.

- At the parsnip site 1 the doses of Stomp at 2.0 or 2.5 L/ha were too low to achieve good control of a very high population of field pansy, and neither aclonifen (treatment 2) nor linuron (1) tank-mixes were effective. Field pansy is resistant to Centium, and its addition to the Stomp + aclonifen tank-mix did not improve control. The numbers of pansy were only well controlled pre-emergence where Sencorex doses of 0.25 x 2 were included. All pre-emergence treatments gave good control of the high population of annual meadow-grass.

- The low doses of Goltix, Betanal, Betanal Carrera were applied in carrots at one true-leaf stage, the weeds were beyond cotyledon stage and very advanced (up to 8 true leaves). Thus weed control was poor and unacceptable overall. When these post-emergence treatments were applied in parsnips at one true-leaf stage, the weeds were large, groundsel was 5-10cm tall and pansy 2-3cm tall. Control of all weeds was poor and higher dose rates could increase crop damage.

- Post-emergence Alpha DFF + linuron (0.3 + 0.4) L/ha applied when carrots were at 2 true leaf stage, controlled all weeds including black-bindweed and redshank up to10 and 8 true leaves respectively, groundsel at rosette stage at site 2, and fat-hen, nightshade and field pansy up to 6, 3 and 7 true leaves respectively at site 3. Only larger (5 tillers) annual meadow-grass remained and a higher dose of linuron would have improved control. At the parsnip site 1, DFF + linuron (0.1 + 0.2) L/ha, killed large groundsel, field pansy and all species except annual meadow-grass.

- Defy 4.0 L/ha post-emergence controlled some species when small (fat-hen and nettle) but weed control was inadequate, particularly for groundsel and field pansy.

- Weed control with Sencorex was excellent at sites 2 and 3, with the higher dose rate 0.5 L/ha applied later than the 3 true-leaf stage of carrots, performing better than the 0.3 L/ha dose. However it did not control the green and black nightshades.

- The dose of 0.25 L/ha Sencorex applied when parsnips were at 4 true leaves, was too low for good weed control.

The treatments were reviewed after 2005, the first year

Parsnip:

- Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha and at double this dose rate were safe to the parsnip crop on the light soil (SL sandy loam), but needed to be tested on a very light soil type.
- In 2005 the damage to parsnips caused by Centium CS pre-emergence and by Sencorex pre- and post-emergence was demonstrated and these treatments were omitted in 2006.
- Defy (prosulfocarb) was included at one site (parsnips) in 2006 to see whether it controlled fumitory.

Carrots

- Sencorex has a SOLA for carrots, and at 0.3 kg/ha at 2 true leaves or 0.5 kg/ha later than 3 true leaves it was very effective on most species and in these trials was safe to carrots only. It was not considered necessary to repeat these post-emergence treatments in 2006.

Carrots and parsnips

- Post-emergence treatments applied in 2005 at 1 true-leaf stage: Goltix, Betanal, Betanal Carrera and Defy caused damage, and the weed control from these treatments was poor.
- New post-emergence treatments included were aclonifen, aclonifen + linuron.
- Following good results with at the peat soil site in 2005, post-emergence Stomp + linuron was tested further at two timings.
- Alpha DFF + a higher dose of linuron to improve control of annual meadow-grass, was to be evaluated in 2006.

MATERIALS AND METHODS 2006

Herbicide Treatments 2006

No programmes were evaluated in these trials – all treatments were single applications. A '+' denotes a tank-mix; TL= true leaf; x 2 'overlap' dose. Product approval status, product active ingredients, formulations and company names are given in Table 1.

Table 1. Herbicide Current Approval Status (November 2006)

a.i.	*EC review*	*Product*	*Company*	*Formulation*	*UK Approval Status*
pendimethalin	Annex 1	Stomp 400 SC	BASF	400 g/L SC	UK approval carrots, parsnips
aclonifen	List 3	(Challenge)	Bayer CropScience	600 g/L SC	no UK approval for any crop, unlikely UK until 2008; registered Denmark carrots; registration sought France
metribuzin	List 2	Sencorex WG	Bayer	70% w/w WDG	SOLA for carrots; parsnips
diflufenican	Lst 3	Alpha DFF 500	Makhteshim	500 g/L SC	UK approval for cereals
linuron	Annex 1	Alpha linuron	Makhteshim	500 g/L SC	UK approval carrots and parsnips
clomazone	List 3	Centium 360 CS, Gamit #	Belchim	36 g/L CS	UK approval carrots
metamitron	List 3	Goltix WG	Makhteshim	700 g/L DG	UK SOLA parsnips new
prosulfocarb	List 3	Defy	Syngenta	800 g/L SC	UK approval for cereals

(Product) name in other EU member state no UK registration; SOLA Specific Off-Label Approval; # do not use on sands, very light soils

Parsnips 2006

	Parsnips Site 1	
Herbicide a.i	**g a.i/ha**	**L or kg product/ha**
1. untreated	-	-
Pre-emergence		
2. Stomp + linuron (standard)	1000 + 500	2.5 + 1.0
3. Stomp + aclonifen	800 + 1200	2.0 + 2.0
4. Stomp + aclonifen + Goltix WG	800 + 1200 + 1050	2.0 + 2.0 + 1.5
5. Stomp + aclonifen + Goltix WG	(800+1200+1050) x 2	(2.0+2.0+1.5) x 2
Post-emergence 2 TL		
6. aclonifen	600	1.0
7. aclonifen + linuron	300 + 200	0.5 + 0.4
8. Stomp + linuron	200+ 200	0.5 + 0.4
9. Stomp + linuron	(200+ 200) x 2	(0.5 + 0.4) x 2
10. Alpha DFF + linuron	50 + 100	0.1 + 0.2
11. Alpha DFF + linuron	150 + 200	0.2 + 0.4
12. Defy	3200	4.0

Carrots 2006

Herbicide a.i	Carrots Sites 2 and 3 g a.i/ha	L or kg product/ha
1. untreated	-	-
Pre-emergence		
2. Stomp	2000	5.0
3. Stomp + aclonifen	800 + 1200	2.0 + 2.0
4. Stomp + aclonifen + Sencorex	800 + 1200 + 175	2.0 + 2.0 + 0.25
5. Stomp + linuron + Sencorex	800 + 500 + 175	2.0 + 1.0 + 0.25
6. Stomp + aclonifen + Centium	600 + 1200 + 72	1.5 + 1.5+0.2
7. Stomp + aclonifen + Centium	(600+1200+72) x 2	(1.5+1.5+0.2) x 2
Post-emergence carrots 2 TL		
8. aclonifen	600	1.0
9. aclonifen + linuron	300 + 200	0.5 + 0.4
10. Stomp + linuron	200+ 200	0.5 + 0.4
11. Stomp + linuron	(200+ 200) x 2	(0.5 + 0.4) x 2
12. Alpha DFF + linuron	150 + 200	0.3 + 0.4
13. Alpha DFF + linuron	150 + 200	0.3 + 1.0

Herbicide a.i	Carrots Site 4 peat g a.i/ha	L or kg product/ha
1. untreated	-	-
Post-emergence carrots 1 TL		
2. linuron (standard)	200	0.4
3. Stomp + linuron	200+ 200	0.5 + 0.4
Post-emergence carrots 2 TL		
4. aclonifen	600	1.0
5. aclonifen + linuron	300 + 200	0.5 + 0.4
6. Stomp + linuron	200+ 200	0.5 + 0.4
7. Stomp + linuron	(200+ 200) x 2	(0.5 + 0.4) x 2
8. Alpha DFF + linuron	150 + 200	0.3 + 0.4
9. Alpha DFF + linuron	150 + 200	0.3 + 1.0

2006 Crop; Site Location; Soil type

Crop	Site	OS Reference	Soil Type (ADAS scale)
Parsnip	1. Tuddenham, Suffolk	TL 737 697	Very Light LS Loamy sand
Carrot	2. Swinderby, Lincs.	SK 877 641	Very Light LFS loamy fine sand
Carrot	3. Higham, Suffolk	TL 672 752	Very Light LS Loamy sand
Carrot	4. Holme Fen, Peterborough, Cambs.	TL 890 225	Peat

Crop variety, sowing and emergence date

Site 1. Parsnips cv. Javelin, sown 24 April, 4 double rows/bed
Site 2. Carrots cv. Nairobi, sown 6 May
Site 3. Carrots cv. Nairobi, sown 6 June
Site 4. Carrots cv. Narbonne, sown 13 April

Trial Design

Each plot was 6 m long x 2 m with 3 replicates of each treatment. There were two blocks: pre- and post-emergence treatments with untreated plots for each timing.

Records/Assessments

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

- Weather during application.

- Observations on any phytotoxicity symptoms, crop scores for damage (0=complete kill; 7= acceptable damage; 10=untreated no damage)

Crop tolerance score		crop damage (% photoxicity)
0	=	complete crop kill 100%
1	=	80 - 95% damage
2	=	70 - 80%
3	=	60 - 70%
4	=	50 - 60%
5	=	40 - 50%
6	=	25 - 40%
7#	=	20 - 25% #
8	=	10 - 20%
9	=	5 - 10%
10	=	no damage (or same as untreated)

damage unlikely to reduce yield and acceptable to the farmer, or no more severe than standard herbicide applied at twice N dose rate.

- Assessments of % crop cover

- Observations on weed control, scores (0=untreated no control, 7= acceptable control, 10= complete control); number of weed species /m^2 in three 0.33 m^2 quadrats per plot. Weed control was also assessed either as the visual % control relative to the ground cover and vigour of individual weed species on the untreated plots.

Application Details

Sprays were applied using an AUK plot precision sprayer with a 2 m boom and four 110° flat fan nozzles (code ISO LD015-F110) delivering 200 L/ha volume of water at 3 bar pressure to give medium spray quality (BCPC). TL true leaves.

Date applied	Weather	GS crop	GS weed
Site 1Tuddenham, parsnips sown 24 April			
27 April Treatments 2 - 5	17°C; RH81%; cloud cover 20%; soil surface damp,	No germination	No germination
2 June Treatments 6 - 11	16°C; 76% RH; cloud cover 5%; soil surface dry	1 - 2 TL (45 – 55%)	groundsel (large plant) fumitory 1 - 2 – 3TL (35 – 35 – 30%) fat-hen 2- 4 – 6TL small nettle 2 – 6 – 8 TL (20 – 60 – 20%)
Date applied	**Weather**	**GS crop**	**GS weed (% plot ground cover)**
Site 2 Swinderby carrots sown 19 April			
11 May Treatments 2 - 7	17°C; RH 65%; 5% cloud cover; soil surface damp,	No germination	No germination
7 June Treatments 8 - 13	19°C; RH% 75; 30% cloud cover; soil surface damp	1TL (25%) – 2 TL (75%)	fat-hen 100% cotyledon, black nightshade cotyledon; small nettle 20% cotyledon - 75% at 2 TL
Site 3 Higham carrots sown 6 June			
6 June Treatments 2 - 7	17°C; RH% 65; 5% cloud cover; soil surface dry	No germination	No germination
11 July Treatments 8 - 13	24°C; RH% 66; 15% cloud cover; soil surface dry	5% 1TL; 50% at 2TL; 40% at 3 TL; 5% 4 TL	fat-hen 2-10cm high; 2-6 TL mainly 4 TL (20% ground cover) nightshades 8 -10cm high, 6 - 9 TL (2) small nettle 0.5 - 7cm high, 2 - 75% at 8 TL (10% ground cover) black-bindweed 10 cm diameter; 4-5 TL (0.7% ground cover) a few potato shoots 10cm tall (2 – 3 plants per plot)
Site 4 Holme Fen, carrots sown 13 April			
10 May Treatments 2, 3	13°C; 79% RH; cloud cover 15%; soil surface damp	Cotyledon to 1 TL (70%) - 2 TL (15%)	fat-hen cotyledon – 2 TL (40 - 60%); 1 - 3cm high black-bindweed cotyledon – 1 TL (35 – 65%) 4cm diameter small nettle cotyledon – 2 TL (35 – 65%); 1 – 4cm height flixweed, chickweed and mugwort small plant
23 May Treatments 4 - 9	14°C; 79% RH; cloud cover 35%; soil surface damp	2 (75% - 3 (25%) TL	fat-hen cotyledon – 4 - 6 TL (10 – 65 - 25%) 1 - 5cm high black-bindweed cotyledon – 2 - 3 TL (20 – 60 - 20%) 5.5cm diameter small nettle 2 – 6 – 8 TL (30 – 45 - 25%); 2 - 12 cm high flixweed, chickweed and mugwort small plant

RESULTS 2006

Observations were made on ease of mixing the formulations and for problems with application (nozzle blockage etc.) or uneven spray patterns. No problems were encountered.

Crop Safety 2006

Parsnips Site 1

Scores for crop vigour and phytotoxicity symptoms are shown in Table 2.

Table 2. Tuddenham parsnips Site 1 (sown 24 April): Crop tolerance score (10 = untreated, 7 = acceptable damage, 0 = crop death). Assessment date and crop growth stage TL=true leaves; % crop cover in parentheses; DA days after application

Herbicide	L or kg product/ha	19 May cotyledon (10% 1TL)	31 May 1-2 TL	13 June 3-4 TL	30 June 6-7 TL
1. untreated	-	10	10	10 (40%)	10 (80%)
Pre-emergence on 27 April					
2. Stomp + linuron (standard)	2.5 + 1.0	10	10	10	10
3. Stomp + aclonifen	2.0 + 2.0	10	10	10	10
4. Stomp + aclonifen + Goltix WG	2.0 + 2.0 + 1.5	10	10	10	10
5. Stomp + aclonifen + Goltix WG	(2.0+2.0+1.5) x 2	9.7 cl	9 st	7 st	9 slight st
Post-emergence 2 TL on 2 June				***11 DA***	***28 DA***
6. aclonifen	1.0			5.3 lf loss	9 lf loss
7. aclonifen + linuron	0.5 + 0.4			3 st lf loss	6.3 lf loss
8. Stomp + linuron	0.5 + 0.4			6 a few lf loss	10
9. Stomp + linuron	(0.5 + 0.4) x 2			5 sc lf loss	9 lf loss
10. Alpha DFF + linuron	0.1 + 0.2			8.3 bl	10
11. Alpha DFF + linuron	0.2 + 0.4			6 bl lf loss	10
12. Defy	4.0			7 sc lf loss	10
13 untreated	-			10	10

st stunting; sc scorch; cl chlorosis; lf loss leaf loss; bl bleaching

From the 6 May rainfall was frequent and sometimes very heavy (6/7 May), increasing the risk of crop damage from herbicide leaching on the loamy sand soil.

Pre-emergence treatments

Pre-emergence Stomp + linuron (2.5 + 1.0) L/ha (treatment 2), Stomp + aclonifen (2.0 + 2.0) L/ha (tr 3) and Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha (tr 4) caused no damage to parsnips at any stage. On 19 May the parsnips treated with the overlap dose of Stomp + aclonifen + Goltix WG ((2.0 L +2.0 L+1.5 kg)/ha x 2 (treatment 5) showed slight chlorosis but there was no reduction in plant stand. A more severe growth check occurred by 13 June, but the parsnips recovered later.

Post-emergence treatments

On 13 June, 11 days after treatment (DAT) at 2 true leaves, parsnips had suffered damage from all post-emergence herbicides.

Aclonifen 1.0 L/ha (tr 6) caused yellow mottling of the parsnip leaves, plants were slightly stunted and and c. 50% of plants lost the first true leaf.

Aclonifen + linuron (0.5 + 0.4) L/ha (tr 7) was more damaging: all plants lost the first true leaf and plants were stunted.
Stomp + linuron (0.5 + 0.4) L/ha (tr 8) caused scorch and some leaf loss, and at the double dose (tr 9) all parsnips lost the first true-leaf and were stunted.
Alpha DFF (tr 10, 11) caused bleached spots on the second true leaves and scorch on the first leaf, but there was no leaf loss from Alpha DFF + linuron (0.1 + 0.2) L/ha (tr 10). A few first leaves were lost from the higher dose of linuron (tr 11) and parsnips were stunted.
Defy caused mottled yellowing and leaf crinkling on the second true leaf and a few leaves were scorched or lost.

The growth of the irrigated crop was vigorous during a very warm June. On 30 June ground cover was 80%, parsnips were at 7 expanded true-leaf stage and root crown diameter was c. 1cm. Parsnips recovered from earlier damage with the exception of those treated with aclonifen + linuron (0.5 + 0.4) L/ha (tr 7), where they were severely stunted. The parsnips were still stunted at later assessments on 17 July, although plots were weed-free.

Carrots Site 2

Scores for crop vigour and phytotoxicity symptoms are shown in Table 3.

Table 3. Swinderby carrots Site 2 (sown 6 May): Crop vigour score (0 = crop death, 7 = acceptable damage, 10 = untreated); assessment date and crop growth stage TL=true leaves; % crop cover in parentheses; DA days after application

Herbicide	L or kg product/ha	4 June 1 TL	18 June 3 ½ TL	2 July 5 ½ - 6 ½ TL	23 July 8 ½ TL
1. untreated	-	10	10	10 (80)	10(100)
Pre-emergence 11 May					
2. Stomp	5.0	10	10	10 (80)	10(100)
3. Stomp + aclonifen	2.0 + 2.0	10	9.7 st slight cl	10 (80)	10(100)
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	9st	6 st vig	6 st vig (70)	10(100)
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	9st	5.3 st vig	5.3 st vig (65)	10(100)
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	10	10	10 (80)	10(100)
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	9	9.7	10 (80)	10(100)
Post-emergence carrots 2 TL 7 June			***11 DA***	***25 DA***	***46 DA***
8. aclonifen	1.0		8 cl sc	7st vig cl (75)	10(100)
9. aclonifen + linuron	0.5 + 0.4		6.3 sc leaf loss	5.3 sc cl st vig (65)	10(100)
10. Stomp + linuron	0.5 + 0.4		10	10 (80)	10(100)
11. Stomp + linuron	(0.5 + 0.4) x 2		8.7st sc	7.7st vig cl sc (70)	10(100)
12. Alpha DFF + linuron	0.3 + 0.4		9.5 bl cl	10 (80) bl	10(100)
13. Alpha DFF + linuron	0.3 + 1.0		7.7 bl	7st vig sc bl (70)	10(100)

bl bleaching; cl chlorosis; sc scorch; st stunting; vig vigour loss

Pre-emergence treatments

There were no delays in emergence from any pre-emergence herbicide.
There were no crop effects from Stomp, and Stomp + aclonifen (2.0 + 2.0) L/ha (tr 3) caused only transient yellowing and stunting. Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha (tr 6) also appeared a very safe treatment, so was the double dose rate where only a temporary growth check was observed. No bleaching (from Centium) was observed at this site.

Pre-emergence tank-mixes of Stomp + aclonifen or Stomp + linuron with a very low dose of Sencorex (0.25 kg/ha) (tr 4 and 5) were less safe to the crop. Both caused severe vigour loss and reduction in crop cover compared with the untreated on 18 June and 2 July (Table 3) and growth

stage was less advanced but there was no plant loss. In addition, on the linuron treatment (tr 5) stunting was more severe and lower leaves also suffered chlorosis and necrosis. The damage was unacceptable and was probably more severe as a result of herbicide leaching in a very wet May. On 2 July carrot roots appeared slightly smaller in size than untreated roots as a result of growth check. However, the crop appeared to recover later.

Post-emergence treatments

Post-emergence herbicides were applied when 75% of carrots were at 2 true-leaf stage, 25% at 1 TL, on a warm sunny day and temperatures during the following days were high. These conditions may have increased herbicide damage.

On 18 June, damage from post-emergence aclonifen (1.0) L/ha (tr 8) was in the form of chlorosis and scorch.

Damage from aclonifen + linuron (0.5 + 0.4) L/ha was more severe and unacceptable - the linuron increased scorch. On the 18 June, scorch (5% of the leaf area on 10% of the plants) and death of the 1st true leaf on *c.* 10% of plants was recorded.

There was no plant loss from these treatments (8 & 9) but on 2 July carrots suffered stunting and vigour loss.

Stomp + linuron (0.5 + 0.4) L/ha (tr 10) was very safe to the crop.

The higher dose of linuron in Stomp + linuron (0.5 + 0.4) x 2 L/ha (tr 11) caused stunting, chlorosis and scorch on the first true leaf – damage was just acceptable on 2 July, but the carrots recovered later.

Alpha DFF + linuron (0.3 + 0.4) L/ha (tr 12) was also safe, causing bleaching on 5% leaf area of 5% of plants but further growth was unaffected. The higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha (tr 13) increased damage, i.e. stunting, vigour loss, scorch on 1% of plants and bleaching increased (5% of leaf area on 10% plants). Although damage was just acceptable and the carrots recovered later, the 1.0 L/ha linuron (higher than tr 11) was probably too high.

On 23 July there were no observable differences in carrot growth between any herbicide treatments and untreated. Samples of roots from plots indicated that there was a little fanging on untreated carrots, but no herbicide increased these effects.

Carrots Site 3

Scores for crop vigour and phytotoxicity symptoms are shown in Table 4.

In contrast to the earlier drilled sites the weather after sowing on 6 June was exceptionally warm, sunny and dry although the crop was irrigated at regular intervals.

Pre-emergence treatments

There was no damage to carrots from Stomp at 5.0 L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha or from Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha (tr 6) at any growth stage. There was no bleaching from Centium at the single dose rate (tr 6) but at the double dose (tr 7) on 30 June *c.* 1.7% of plants were bleached. The new growth was unaffected by bleaching but there was slight stunting on 21 July from the double rate.

The three-way tank-mixes with Sencorex: Stomp + aclonifen + Sencorex (2.0L + 2.0L + 0.25kg)/ha (tr 4) and Stomp + linuron + Sencorex (2.0L + 1.0L + 0.25kg) /ha (tr 5) caused less damage at this site probably because there was less herbicide leaching on the very light soil in drier soil conditions.

There was some slight loss of crop vigour but no plant loss and negligible difference between the two tank-mixes.

Table 4. Higham carrots Site 3 (sown 6 June). Crop vigour score (0 = crop death, 7 = acceptable damage, 10 = untreated); assessment date and crop growth stage TL=true leaves; crop cover % in parentheses; DA = Days After Application

Herbicide	L or kg product/ha	30 June cotyledon-1TL – 2TL	21 July 3-4TL	2 August 5-6 ETL	14 August
1. untreated	-	10	10 (30% cover)	10 (60% cover)	10 (100% cover)
Pre-emergence 6 June					
2. Stomp	5.0	10	10	10	10
3. Stomp + aclonifen	2.0 + 2.0	10	10	10	10
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	8.3	8.3	9.5	9.7 (90)
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	8	8.3	9.5	9.7 (90)
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	10	10	10	10
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	8.7 bl	8.7st	9st	10
Post-emergence carrots 2 TL 11 July			***10 DA***	***22 DA***	***34 DA***
8. aclonifen	1.0		6 y leaf loss	5.7 (40%) st sc	8.7 (80)
9. aclonifen + linuron	0.5 + 0.4		8 leaf loss	7 (50%) st	9.7 (90)
10. Stomp + linuron	0.5 + 0.4		9.5 slight sc	10	10
11. Stomp + linuron	(0.5 + 0.4) x 2		9 sc	9.3 slight st	10
12. Alpha DFF + linuron	0.3 + 0.4		9.8 slight bl	10 bl	10
13. Alpha DFF + linuron	0.3 + 1.0		9	9 bl sc	10
14. untreated	-		10	10 (60% cover)	10 (100% cover)

bl bleaching; cl chlorosis;sc scorch; st stunting; y yellowing;

Post-emergence treatments

Post-emergence applications were sprayed on a hot day (24°C) and the carrots were at a range of growth stages, 5% at 1TL; 50% at 2TL; 40% at 3 TL; 5% at 4 TL and were more advanced than at Site 2.

Aclonifen (tr 8) caused more damage than other treatments. On 21 July 10 DA, all carrot leaves were yellow, first leaves were scorched and 1 or 2 leaves on some plants had died (*c.* 60%). The new growth was unaffected. On 2 August, 22 DA, leaf colour was restored, but carrots were severely stunted, leaf scorch was still apparent and there was a reduction in crop cover compared with the untreated.

At this site aclonifen + linuron (0.5 + 0.4) L/ha (tr 9) caused less damage than aclonifen alone (tr 8) - there was less scorch and leaf loss. On smaller plants the first true leaf was scorched, but only 1% of plants had lost a leaf. Carrots at more advanced growth stage 3-4 true leaves were least affected.

There was negligible damage i.e. slight scorch on 1% of plants from Stomp + linuron, at (0.5 + 0.4) L/ha (tr 10), at the double dose there was more scorch followed by slight stunting but no leaf loss and complete recovery by 14 August.

Alpha DFF + linuron (0.3 + 0.4) L/ha (tr 12) was also safe to the crop, with only slight bleaching on leaves 4 and 5 for 1% of plants. Alpha DFF + linuron (0.3 + 1.0) L/ha (tr 13) with the higher dose of linuron there was scorch on 10% of plants in addition, but no leaf loss occurred and there was complete recovery by 14 August.

Samples of roots from plots on 14 August indicated that no herbicide had caused fanging and there appeared to be no differences in root size between treatments and untreated carrots.

Carrots Site 4

Scores for crop vigour and phytotoxicity symptoms are shown in Table 5. Only post-emergence treatments were applied on this organic soil site. Herbicides were sprayed in cool conditions, growth was vigorous during May when there was frequent rainfall and there was little herbicide damage at this site.

Table 5. Holme Fen organic soil type, carrots Site 4 (sown 12/13 April). Crop tolerance score (10 = untreated, 7 = acceptable damage, 0 = crop death); assessment date and crop growth stage TL true leaves; DA days after application

Herbicide	L or kg product/ha	15 May 1-2 TL	24 May 2 – 3 TL	4 June 4 TL	10 June 5TL	21 June 6 ½ TL	11 July
1. untreated	-	10	10	10	10	10	10
Post-emergence carrots 1 TL 10 May		***5 DA***	***14 DA***	***25 DA***	***31 DA***	***41 DA***	***62 DA***
2. linuron (standard)	0.4	10	10	10	10	10	10
3. Stomp + linuron	0.5 + 0.4	10	10	10	10	10	10
Post-emergence carrots 2 TL 23 May				***12 DA***	***18 DA***	***29 DA***	***49 DA***
4. aclonifen	1.0			9 st	10	10	10
5. aclonifen + linuron	0.5 + 0.4			10	8st	9.7	10
6. Stomp + linuron	0.5 + 0.4			10	10	10	10
7. Stomp + linuron	(0.5 + 0.4) x 2			10	10	10	10
8. Alpha DFF + linuron	0.3 + 0.4			9.5 bl	9.5 bl	10	10
9. Alpha DFF + linuron	0.3 + 1.0			9.5 bl	9.5 bl	10	10

bl bleaching

There was no damage at any growth stage from early post-emergence linuron (tr 2) or Stomp + linuron (tr 3) applied when 70% of carrots were at one true-leaf stage.

Post-emergence applications to carrots at 2 TL (75%) to 3 TL (25%) on 23 May caused less damage at Holme Fen than at other sites. No herbicide treatment caused carrot leaf or plant loss.
Aclonifen (tr 4) caused yellowing and slight temporary stunting of the crop, aclonifen + linuron (0.5 + 0.4) L/ha (tr 5) caused more stunting.
There were no effects from Stomp + linuron at single or double dose rates (trs 6 or 7).
There was some slight bleaching from the diflufenican where Alpha DFF + linuron was applied (trs 8 and 9) but the new growth was unaffected.
On 11 July crop cover was 100% on all plots. No fanging was found on roots from any treatment.

Weed Control 2006 (Latin and common weed names are given in Appendix 2)

Parsnips site 1

The predominant weed species at this site were groundsel, small nettle and fat-hen and on the post-emergence areas, fumitory as well (Table 6).

Pre-emergence treatments

The residual soil-acting herbicides worked well as a result of high rainfall in May.
The standard Stomp + linuron (2.5 + 1.0) L/ha (tr 2) and Stomp + aclonifen (2.0 + 2.0) L/ha (tr 3) gave almost complete control of high populations of small nettle and fat-hen but activity on groundsel was very poor.
The efficacy of Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha (tr 4) and the double dose (tr 5) was excellent. The addition of Goltix achieved control of groundsel and the plots remained virtually weed-free throughout the season.

All pre-emergence herbicide treatments appeared to control the very low number of annual meadow-grass and shepherd's purse. Those containing aclonifen may have controlled fumitory but numbers were low on the pre-emergence area.

Post-emergence treatments

When the post-emergence treatments (6 - 12) were applied to parsnips at two true-leaf (TL) stage, the weeds were large - groundsel at large plant stage, fumitory at 1 to 3TL, fat-hen 2 to 6TL, small nettle mainly at 6 TL but some at 8 TL.

None of the post-emergence treatments killed groundsel although aclonifen (tr 6) caused scorch, aclonifen + linuron (0.5 + 0.4) L/ha (tr 7) caused severe stunting and all other treatments (except Defy) also caused some stunting. The best treatments only achieved 43% control of groundsel numbers (tr 7, 10 and 11)

All post-emergence treatments controlled fat-hen and small nettle. Defy (tr 12) was not quite as effective as the otherherbicides.

Aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and DFF + linuron at (0.2 + 0.4) L/ha (tr 11) gave excellent control of fumitory. DFF + linuron at (0.1 + 0.2) L/ha (tr 10) gave 73% control of fumitory numbers and those remaining were stunted.

Fumitory was not controlled by Stomp + linuron (0.5 + 0.4) L/ha at single or double dose rates (tr 10, 11) or Defy (tr 12).

There was an uneven distribution of low numbers of annual meadow-grass. The higher dose rate of DFF + linuron (0.2 + 0.4) L/ha (tr 11) was more effective than the single dose.

There were also low numbers of mignonette on the post-emergence trial area. All treatments except Stomp + linuron at (0.5 + 0.4) L/ha or Defy may have been effective.

All post-emergence treatments appeared to control the low population of shepherd's purse.

Table 6. Tuddenham parsnips Site 1: Number of weed species /m^2 (mean of three 0.33 m^2 quadrats per plot) after each application timing, on 31 May (tr 1 – 5), 13 June (tr 6 –13)

Herbicide	L or kg product/ha	Groundsel	Small nettle	Fat-hen	Shepherd's purse	Fumitory	Annual meadow-grass	Wild mignionette	TOTAL
1. untreated	-	35.3	37	25.7	3	2	2	0	**105**
Pre-emergence 27 April									
2. Stomp + linuron (standard)	2.5 + 1.0	23.7	1.3	0	0	1	0	0	**32**
3. Stomp + aclonifen	2.0 + 2.0	20	0	0	0	0	0	0	**20**
4. Stomp + aclonifen + Goltix	2.0 + 2.0 + 1.5	0.7	0	0	0	0	0	0	**0.7**
5. Stomp + aclonifen + Goltix	(2.0+2.0+1.5) x 2	0	0	0	0	0	0	0	**0**
Post-emergence 2 TL 2 June									
13. untreated	-	22.7	25	18.3	0	19	1	3	**89**
6. aclonifen	1.0	19	0	0	0	0	0	0	**19**
7. aclonifen + linuron	0.5 + 0.4	13	0	0	0	0.3	0.3	0	**13.6**
8. Stomp + linuron	0.5 + 0.4	14.3	0	0	0	20	0	2	**36.3**
9. Stomp + linuron	(0.5 + 0.4) x 2	20	0	0	0	19st	0	0	**39**
10. Alpha DFF + linuron	0.1 + 0.2	12.3	2	0	0	5 st	3.7sc	0	**18.7**
11. Alpha DFF + linuron	0.2 + 0.4	13	1.3	0	0	3 #	0	0	**19**
12. Defy	4.0	19.3	4	0.3	0	24.3	1.3	0.3	**49.6**

st stunted; sc scorched; # stunted, scorched and died later 30 June.

Scores for **weed control overall** are shown in Table 7, and are a reflection of groundsel control – efficacy was poor for all treatments except for pre-emergence Stomp + aclonifen + Goltix WG (2.0L + 2.0 L + 1.5 kg)/ha (tr 4) which gave excellent control of all species including groundsel, as did the double dose (tr 5).
Where control of groundsel was excluded from scores the following were very effective on the other species: all pre-emergence treatments; aclonifen alone, aclonifen + linuron; Alpha DFF + linuron (0.2 + 0.4) L/ha.
Alpha DFF + linuron (0.1 + 0.2) L/ha control was acceptable although some fumitory remained. Weed control was unacceptable from Defy and both dose rates of Stomp + linuron because fumitory (present on the post-emergence area) remained.

Table 7. Tuddenham parsnips Site 1. Overall weed control score (0=untreated no control, 7=acceptable control, 10= complete control). Scores overall and excluding groundsel on 30 June

Herbicide	L or kg product/ha	31 May 1-2 TL	13 June 3-4TL	30 June 6-7 TL overall	30 June 6-7 TL excludes groundsel
1. untreated	-	0	0	0	0
Pre-emergence on 27 April					
2. Stomp + linuron (standard)	2.5 + 1.0	6.7	4	3	9.3
3. Stomp + aclonifen	2.0 + 2.0	7	5.3	4	10
4. Stomp + aclonifen + Goltix WG	2.0 + 2.0 + 1.5	10	9.5	9.2	10
5. Stomp + aclonifen + Goltix WG	(2.0+2.0+1.5) x 2	10	10	10	10
Post-emergence 2 TL on 2 June					
13. untreated			0	0	0
6. aclonifen	1.0		6.7	4.3	10
7. aclonifen + linuron	0.5 + 0.4		8	5.7	9.7
8. Stomp + linuron	0.5 + 0.4		5	2	5
9. Stomp + linuron	(0.5 + 0.4) x 2		5	3.3	5
10. Alpha DFF + linuron	0.1 + 0.2		4.3	3.7	8
11. Alpha DFF + linuron	0.2 + 0.4		6.3	5.7	9.5
12. Defy	4.0		2	1.3	2

Percent plot cover for the main weed species at Site 1 are shown in Table 8.
Crop cover was 80% on untreated plots on 30 June. Of the estimated weed cover on untreated plots on the pre-emergence area 70% was due to groundsel and there would have been considerable seed return to the field before the parsnips were harvested. Groundsel cover was high on the Stomp + linuron and Stomp + aclonifen plots but cover from other weed species was negligible. Fumitory populations were low on the pre-emergence area. Treatments that included Goltix (tr 4 and 5) were the only ones pre- or post-emergence to control groundsel and weed cover was negligible.

On the post-emergence area, cover with groundsel on untreated plots was 40%, only aclonifen + linuron (0.5 + 0.4) L/ha (tr 7) and Alpha DFF + linuron (0.2 + 0.4) L/ha (tr 11) gave some suppression.
Fumitory was an additional problem on the post-emergence area - 33% cover on untreated plots. Several treatments performed well and cover was negligible on plots treated with aclonifen (tr 6), aclonifen + linuron (0.5 + 0.4) L/ha (tr 7) and Alpha DFF + linuron (0.2 + 0.4) L/ha (tr 11). Some fumitory remained on plots treated with a lower dose of Alpha DFF + linuron (0.1 + 0.2) L/ha (tr 10) but they were very stunted. Cover with fumitory on Stomp + linuron and Defy plots was similar to the untreated.

Table 8. Tuddenham parsnips Site 1. Weed % plot cover for main species, 30 June

Herbicide	L or kg product/ha	Groundsel	Small nettle	Fat-hen	Fumitory
1. untreated	-	70	20	10	2
Pre-emergence 27 April					
2. Stomp + linuron (standard)	2.5 + 1.0	76	0	0	0
3. Stomp + aclonifen	2.0 + 2.0	70	0	0	0
4. Stomp + aclonifen + Goltix WG	2.0 + 2.0 + 1.5	0.8	0	0	0
5. Stomp + aclonifen + Goltix WG	(2.0+2.0+1.5) x 2	0.1	0	0	0
Post-emergence 2 TL 2 June					
13. untreated	-	40	20	10	33
6. aclonifen	1.0	30	0	0	0
7. aclonifen + linuron	0.5 + 0.4	17	0	0	0
8. Stomp + linuron	0.5 + 0.4	40	0	0	40
9. Stomp + linuron	(0.5 + 0.4) x 2	40	0	0	30
10. Alpha DFF + linuron	0.1 + 0.2	30	0	0	9
11. Alpha DFF + linuron	0.2 + 0.4	15	0	0	0
12. Defy	4.0	47	0	0	40

Carrots site 2

Table 9. Swinderby carrots Site 2 (sown 6 May). Number of weed species /m^2 in three 0.33 m^2 quadrats per plot on 18 June

Herbicide	L or kg product/ha	Small nettle	Annual meadow-grass	Black nightshade	Fat-hen	Shepherd's purse	Groundsel	Creeping thistle seedling	Sowthistle	Black-bindweed	Pale persicaria	TOTAL
1. untreated	-	83	162	12.3	143	8.7	0.7	1	1	1	0	**412.7**
Pre-emergence 11 May												
2. Stomp	5.0	0	9	2	13.7	0	0	2	0	0.3	0	**25**
3. Stomp + aclonifen	2.0 + 2.0	0	2	5	9	0	0.3	0.3	0	0.7	0	**17.3**
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	0	0	3	4	0	0	0	0	0.3	0	**8.3**
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	0	0	1.3	5.3	0	0	0	0	0.3	0	7
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	0	0	2.7	7	0	0	0	0	0	0	**9.7**
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	0	0	2.3	2.3	0	0	0	0	0	0	**4.6**
Post-emergence carrots 2 TL 7 June												
14. untreated	-	57	30	13	294	12	1	7	0	0.3	2	**414.3**
8. aclonifen	1.0	0	0	3	0	0	0	0	0	0	0	**3**
9. aclonifen + linuron	0.5 + 0.4	0	0	0	0	0	0	0	0	0	0	**0**
10. Stomp + linuron	0.5 + 0.4	0	1.7	0	0	0	0	0	0	0	2	**4.4**
11. Stomp + linuron	(0.5 + 0.4) x 2	0	0.3	0	0	0	0	0	0	0	1	**1.3**
12. Alpha DFF + linuron	0.3 + 0.4	0	3	0	0	0	0	0	0	0	0.3	**3.3**
13. Alpha DFF + linuron	0.3 + 1.0	0	0.7	0	0	0	0	0	0	0	0	**0.7**

There was a very high weed population 413/m^2 (Table 9) on untreated plots at this site – predominantly annual meadow-grass on the pre-emergence area, and mainly fat-hen on the post-emergence area. There was also a high population of small nettle, and some black nightshade and shepherd's purse.

Pre-emergence treatments
On 4 June several species emerged on plots treated with Stomp but died later. On 18 June weed cover on untreated plots was 80% and the carrots were at 3 ½ true leaves.

All treatments gave excellent control of the large numbers of small nettle and annual meadow-grass and lower populations of shepherd's purse (Table 9).
Control of the high numbers of fat-hen with pre-emergence treatments was incomplete and Stomp or Stomp + aclonifen were the least effective, even so, control was 90% and 94% respectively. Another flush of fat-hen was noted later, on 23 June.
No pre-emergence treatment gave complete control of black nightshade and the low dose of Stomp + aclonifen (2.0 + 2.0) L/ha was the least effective.

Post-emergence treatments
At the time of application weeds were small: fat-hen and black nightshade were at cotyledon stage, small nettle (20% cotyledon - 75% at 2 true-leaf stage).

The post-emergence treatments all gave excellent weed control.
All controlled black nightshade except for aclonifen (tr 8), which was the least effective but gave 77% control of nightshade numbers.
Alpha DFF + the lower dose of linuron (0.3 + 0.4) L/ha (tr 12) did not control the larger annual meadow-grass, but the higher dose of linuron (tr 13) improved control.
Pale persicaria was present in low numbers but was not controlled by Stomp + linuron (0.5 + 0.4) L/ha (tr 10).
Aclonifen 1.0 L/ha, aclonifen + linuron (0.5 + 0.4) L/ha and Alpha DFF + linuron (0.3 + 1.0) L/ha killed a patch of established creeping thistle shoots.

Percent weed species cover per plot on 2 July is given in Table 10.

Fat-hen, small nettle, black nightshade, shepherd's purse and annual meadow-grass were present in sufficient numbers to assess plot cover. The annual meadow-grass was suppressed by the crop and by tall weeds. Crop cover on untreated was 80% on 2 July.

The weed cover shown in Table 10 was mainly fat-hen for pre-emergence treatments, and for post-emergence aclonifen (tr 8) weed cover was due to nightshade.

Weed control scores overall are given in Table 11.

On 23 July a late flush of fat-hen was observed, mainly on the post-emergence area on all except aclonifen treatment (tr 8) but the weeds were suppressed by the vigorous carrots (crop cover 100%, root crown diameter 2cm).

The most effective pre-emergence weed control was with the three-way tank-mixes treatments 4, 5, 6, & 7 although the late-emerging fat-hen escaped control.
All post-emergence treatments gave excellent control.

Table 10. Swinderby carrots Site 2 (sown 6 May). Weed control, visual % plot cover for main species on 2 July

Herbicide	L or kg product/ha	Fat-hen	Small nettle	Black nightshade	Shepherds purse	Annual meadow-grass	Pale persicaria	TOTAL
1. untreated	-	58	21	2	0.1	1	0.1	83.1
Pre-emergence								
2. Stomp	5.0	1.3	0	0	0	0.3	0	1.6
3. Stomp + aclonifen	2.0 + 2.0	2	0	0.1	0	0	0	2.1
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	0.2	0	0.1	0	0	0	0.3
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	0.7	0	0.01	0	0	0	0.71
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	1.7	0	0.1	0	0	0	1.8
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	0.3	0	0.3	0	0	0	0.6
Post-emergence carrots 2 TL								
14. untreated	-	70	15	3	2	0.5	0	90.5
8. aclonifen	1.0	0	0	0.5	0	0	0	0.5
9. aclonifen + linuron	0.5 + 0.4	0	0	0	0	0	0	0
10. Stomp + linuron	0.5 + 0.4	0	0	0	0	0	0.1	0.1
11. Stomp + linuron	(0.5 + 0.4) x 2	0	0	0	0	0	0.1	0.1
12. Alpha DFF + linuron	0.3 + 0.4	0	0	0	0	0.01	0	0.01
13. Alpha DFF + linuron	0.3 + 1.0	0	0	0	0	0	0	0

Table 11. Swinderby carrots Site 2 (sown 6 May). Weed control score (0=untreated no control, 7= acceptable control, 10= complete control) (%weed cover on 23 July)

Herbicide	L or kg product/ha	4 June 1-2 TL	18 June 3 ½ TL	2 July	23 July
1. untreated	-	0	0	0	0 (100)
Pre-emergence					
2. Stomp	5.0	(6)*	7	6.3	5.7 (20)
3. Stomp + aclonifen	2.0 + 2.0	9	7.3	6.3	5.7 (30)
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	10	9.5	9.7	7.3 (3.3)
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	10	9.5	9.7	7.3 (5)
6. Stomp + aclonifen + Centium	1.5 + 1.5 + 0.2	10	9	9.3	7 (7)
7. Stomp + aclonifen + Centium	(1.5 + 1.5 + 0.2) x 2	10	9.7	9.7	8 (2)
Post-emergence carrots 2 TL					
14. untreated			0	0	0 (100)
8. aclonifen	1.0		9.9	9.8	9.3 (0.7)
9. aclonifen + linuron	0.5 + 0.4		10	9.8	8.7 (1.3)
10. Stomp + linuron	0.5 + 0.4		9.6	10	9 (1)
11. Stomp + linuron	(0.5 + 0.4) x 2		9.9	9.5	9 (1)
12. Alpha DFF + linuron	0.3 + 0.4		9.9	9.5	9.5 (0.5)
13. Alpha DFF + linuron	0.3 + 1.0		10	9.9	9.7 (0.2)

* weeds emerged but died by 18 June

Carrots site 3

The weed population was lower at this site, and consisted of predominantly fat-hen and small nettle, with low numbers of nightshades (mainly green nightshade) (Table 12).

Table 12. Higham carrots Site 3 (sown 6 June). Number of weed species /m^2 in three 0.33 m^2 quadrats per plot after each application timing, on 30 June (untreated, treatments 2 – 7), and 21 July (tr 8 – 14)

Herbicide	L or kg product/ha	Fat-hen	Small nettle	Nightshades *	Groundsel	Black-bindweed	TOTAL
1. untreated	-	55.3	17	2.6	1	0.3	77
Pre-emergence 6 June							
2. Stomp	5.0	2	0	0	2	0	**4**
3. Stomp + aclonifen	2.0 + 2.0	0	0	0.7	0.3	0	**1**
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	0	0	0	0	0	**0**
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	0	0	0	0	0	**0**
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	0	0	0	0	0	**0**
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	0	0	0	0	0	**0**
Post-emergence carrots 2 TL 11 July							
8. aclonifen	1.0	0	0	0.7	0.3	0	**1**
9. aclonifen + linuron	0.5 + 0.4	0	0	0.3	0.3	0	**0.6**
10. Stomp + linuron	0.5 + 0.4	0	0	0.3	0.3	0	**0.6**
11. Stomp + linuron	(0.5 + 0.4) x 2	0	0	0	0	0	**0**
12. Alpha DFF + linuron	0.3 + 0.4	0	0	1.3	0.7	0	**2**
13. Alpha DFF + linuron	0.3 + 1.0	0	0	0	0	0	**0**
14. untreated	-	32.3	19.3	2.6	0	0.7	**55**

* mainly green nightshade, a few black nightshade

Pre-emergence treatments

June was exceptionally dry but some irrigation was applied and the residual herbicides all gave excellent control of fat-hen and nettle present in large numbers. However, another flush of fat-hen emerged on the Stomp and Stomp + aclonifen plots later.

Stomp at 5.0 L/ha (tr 2) had a weakness on groundsel but controlled nightshades; Stomp + aclonifen (2.0 + 2.0) L/ha (tr 3) had poor efficacy on both. The addition of a low dose of Sencorex or of Centium appeared to improve efficacy on groundsel.

Post-emergence treatments

Crop growth stages were variable at this site, ranging from 1 – 4 TL at the time of post-emergence application on 11 July. Weeds were large (see application data): fat-hen was 2-10cm high, small nettle 0.5 - 7cm high, nightshades 8 -10cm high, black-bindweed 10 cm across. The temperature was 24°C.

Aclonifen + linuron (0.5 + 0.4) L/ha was very fast-acting, killing very large weeds in less than 6 days. All treatments gave excellent control of fat-hen, nettle and the few black-bindweed, but large nightshades remained on all except treatments where high doses of linuron were included: Stomp + linuron (0.5 + 0.4) L/ha x 2 (tr 11) and Alpha DFF + linuron (0.3 + 1.0) L/ha (tr 13).

There were a few volunteer potatoes on the trial area but distribution was uneven. Pre-emergence treatments had no effect. There were a few potato shoots 10cm tall (0 to 3 per plot) at the post-emergence application timing. Aclonifen had little effect; aclonifen + linuron caused severe scorch

and killed shoots but there was regrowth by 16 August; the other treatments (10 – 13) caused severe scorch or death of potato shoots. The greatest effect was from Stomp + linuron (0.5 + 0.4) L/ha x 2 (tr 11) and Alpha DFF + linuron (0.3 + 1.0) L/ha (tr 13).

There was a small area of common amaranth on discard plots but none on the trial area. Aclonifen + linuron was applied to large plants on 21 July when the carrots were at 3-4 TL stage. Common amaranth leaves were severely scorched but the growing points were unaffected and plants survived, whereas the very large fat-hen did not.

Percentage plot cover for the main weed species on 16 August is given in Table 13.
On untreated plots on 17 July when crop cover was 30%, total weed cover was already 80%; on 2 August crop cover was 60%, weed cover 100% and fat-hen, small nettle and nightshades were taller than the crop. Although there was *c.*one nightshade plant per plot on all except treatments with higher doses of Stomp + linuron and Alpha DFF + linuron (tr 11 and 13), plot cover was negligible. Groundsel cover was also negligible where it occurred.

Table 13. Higham carrots Site 3 (sown 6 June). Percentage plot cover for the main weed species on 16 August

Herbicide	L or kg product/ha	Fat-hen	Small nettle	Nightshades *
1. untreated	-	93	0.5	2
Pre-emergence 6 June				
2. Stomp	5.0	0.2	0	0
3. Stomp + aclonifen	2.0 + 2.0	0.1	0	0
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	0	0	0
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	0	0	0
6. Stomp + aclonifen + Centium	1.5 + 1.5 + 0.2	0	0	0
7. Stomp + aclonifen + Centium	(1.5 + 1.5 + 0.2) x 2	0	0	0
Post-emergence carrots 2 TL 11 July				
8. aclonifen	1.0	0	0	0.1
9. aclonifen + linuron	0.5 + 0.4	0	0	0.1
10. Stomp + linuron	0.5 + 0.4	0	0	0.2
11. Stomp + linuron	(0.5 + 0.4) x 2	0	0	0
12. Alpha DFF + linuron	0.3 + 0.4	0	0	0.1
13. Alpha DFF + linuron	0.3 + 1.0	0	0	0
14. untreated		90	0.2	1

* mainly green nightshade, a few black nightshade

Weed control scores at site 3 are shown in Table 14.
Weed control overall was excellent for all treatments except Stomp pre-emergence where a few fat-hen escaped control and Stomp + aclonifen where there were late emerging fat-hen.

Table 14. Higham carrots Site 3 (sown 6 June). Weed control score (0=untreated no control, 7= acceptable control, 10= complete control)

Herbicide	L or kg product/ha	30 June cotyledon -1TL-2TL	21 July 3 TL	2 Aug 5-6 TL	14 Aug
1. untreated	-	0	0	0	0
Pre-emergence					
2. Stomp	5.0	9.3	9	7	8
3. Stomp + aclonifen	2.0 + 2.0	10	10	8	9
4. Stomp + aclonifen + Sencorex	2.0 + 2.0 + 0.25	10	10	10	9.9
5. Stomp + linuron + Sencorex	2.0 + 1.0 + 0.25	10	10	10	9.9
6. Stomp + aclonifen + Centium	1.5 + 1.5+0.2	10	10	10	9.9
7. Stomp + aclonifen + Centium	(1.5+1.5+0.2) x 2	10	10	10	10
Post-emergence carrots 2 TL 11 July					
8. aclonifen	1.0	-	9.5	9.9	9.9
9. aclonifen + linuron	0.5 + 0.4	-	9.9	10	9.9
10. Stomp + linuron	0.5 + 0.4	-	9.7	9.9	9.8
11. Stomp + linuron	(0.5 + 0.4) x 2	-	10	10	10
12. Alpha DFF + linuron	0.3 + 0.4	-	9.3	9.9	9.8
13. Alpha DFF + linuron	0.3 + 1.0	-	10	10	10
14. untreated	-	-	0	0	0

Carrots site 4

Weed pressure was extremely high at this site and there was a wide weed spectrum with 16 species recorded. The main weed species was fat-hen, and there were also several small nettles, black-bindweed and lower numbers of mugwort, flixweed and fool's parsley (Table 15).

Table 15. Holme Fen carrots Site 4 (sown 13 April). Number of weed species /m^2 (mean of three 0.33 m^2 quadrats per plot) after each application timing, on 23 May (untreated, treatments 2 and 3), and 4 June (tr 4 – 9).

Herbicide	L or kg product/ha	Fat-hen	Small nettle	Black-bindweed	Wild radish	Flixweed	Fools' parsley	Mugwort seedling	Chickweed	Redshank	Cleavers #	Weed beet	Hairy nightshade	Field speedwell	Groundsel	TOTAL
1. untreated	-	297	25	11	4	6	5	7	2	2	0.7	2	4	0	3	**366**
Post-emergence carrots 1 TL 10 May																
2. linuron (standard)	0.4	0	0	3.3	0	4	4.3	2	0	0	2	0	0	0.3	1	**17**
3. Stomp + linuron	0.5 + 0.4	0	0	0	0	3 st	2	3 st	0	0	0.3	0	0	0.3	0.7	**9.3**
Post-emergence carrots 2 TL 23 May																
4. aclonifen	1.0	42 sc st	0	6	0.3	6	7	5.7	0	0	0.3	0	4	1.7	2	**75**
5. aclonifen + linuron	0.5 + 0.4	0	0	0.7	0	0	6	0.3	0	0	0	0	0	0	1	**8**
6. Stomp + linuron	0.5 + 0.4	0	0	9	0	3	6.3	4.7	0	0	3	0	0	1.3	2	**29.3**
7. Stomp + linuron	(0.5 + 0.4) x 2	0	0	5.7	0	0	6	2.3	0	0	2.7	0	0	0	0.7	**15.4**
8. Alpha DFF + linuron	0.3 + 0.4	0	0	8.3	0	2	9	1.7	0	0	0.3	0	0	0.3	0.3	**22**
9. Alpha DFF + linuron	0.3 + 1.0	0	0	1.7	0	0	8	0.3	0	0	0.3 st	0	0	0	0.7	**11**

sc scorched; st stunted; # uneven distribution

The trial was on a peat soil therefore only the post-emergence treatments were evaluated here. All herbicides were applied as single treatments as at all sites, no programmes were evaluated.

Early post-emergence treatments
On 10 May, at the first post-emergence timing, fat-hen and small nettle were at cotyledon–2 TL stage, black-bindweed cotyledon–1 TL, late germinating hairy nightshade was emerging and at cotyledon stage; flixweed, chickweed and mugwort at small plant stage.

The standard linuron at 0.4 L/ha (tr 2) controlled the very high numbers of fat-hen and small nettle, a low population of wild radish, chickweed and hairy nightshade. It did not control fool's parsley or groundsel, and was inadequate for control of black-bindweed, mugwort and flixweed. These species smothered the crop by 11 July.
The addition of Stomp as Stomp + linuron (0.5 + 0.4) L/ha (tr 3) applied early to small weeds improved control of black-bindweed. It was more effective at this earlier timing than the late application (tr 6).

Post-emergence treatments
On 23 May, at the second timing, weeds were large: fat-hen up to 6 TL, 5cm high; small nettle up to 8 TL, 12 cm high; black-bindweed up to 3 TL, 5cm diameter and most hairy nightshade was still at cotyledon stage. Mugwort, chickweed and flixweed were still at small plant stage. The carrots were at 2-3 TL stage.

With the exception of aclonifen all treatments gave excellent control of fat-hen and small nettle at advanced growth stages.

Aclonifen gave 86% control of numbers of fat-hen (although more died after assessment on 4 June) but it only scorched and stunted the larger plants, which grew away later. Aclonifen 1.0 L/ha (tr 4) was effective on nettle, chickweed and possibly low numbers of redshank, but did not control fool's parsley, hairy nightshade, groundsel and field speedwell. Flixweed and mugwort only suffered scorch and black-bindweed were stunted but not killed.
Aclonifen + linuron (0.5 + 0.4) L/ha (tr 5) was the best treatment in the trial. Weaknesses were on fool's parsley (and groundsel), and larger mugwort. Flixweed and hairy nightshade were killed (but at the Higham site other nightshades were not). Black-bindweed and mugwort were also controlled. It also appeared to be effective on cleavers although numbers were low and the distribution uneven.

All the other treatments (tr 6 – 9) failed to control fool's parsley or groundsel.

Efficacy of the later treatment with Stomp + linuron (tr 6) was poor. It did not control black-bindweed at this timing. The overlap dose (tr 7) was more effective particularly on flixweed and mugwort, and it stunted black-bindweed, but there was no control of fool's parsley.
Diflufenican + linuron (0.3 + 0.4) L/ha (tr 8) only stunted black-bindweed, did not control fool's parsley and some flixweed and mugwort remained. Treatment containing a higher dose of linuron, Alpha DFF + linuron (0.3 + 1.0) L/ha (tr 9) performed much better, particularly on black-bindweed, flixweed and mugwort, and cleavers were severely stunted.
The best control of flixweed was with aclonifen + linuron (0.5 + 0.4) L/ha, Stomp + linuron (0.5 + 0.4) L/ha x 2 or Alpha DFF + linuron (0.3 + 1.0) L/ha.
Sugar beet is frequently grown in the same rotation as carrots – all treatments controlled the low number of weed beet.
There were a few volunteer potatoes but distribution was uneven. Aclonifen + linuron (0.5 + 0.4) L/ha and Alpha DFF + linuron (0.3 + 1.0) L/ha caused severe damage although there was some recovery from the former.

Scores for weed control and % weed cover of weed species are given in Table 16.
On 10 June the untreated crop was completely covered by weeds well above crop height. Crop ground cover on 10 June was 50%; fool's parsley, groundsel and nightshade were below a canopy of fat-hen and small nettle on untreated plots.

Table 16. Holme Fen carrots Site 4 (sown 13 April). Scores for control of weed species on 10 June (0=untreated no control, 7= acceptable control, 10= complete control); % weed cover of weed species in parentheses; only scores given where cover is low

Herbicide	L or kg product/ha	Fat-hen	Small nettle	Flixweed	Black-bindweed	Mugwort	Cleavers	Fools' parsley	Groundsel	Hairy nightshade
1. untreated	-	(57)	(32)	(5)	(6)	(1)	(1)	(1)	(0.5)	(0.5)
Post-emergence carrots 1 TL 10 May										
2. linuron (standard)	0.4	10 (0)	10 (0)	5st(0.1)	0	0	0	0	0	10
3. Stomp + linuron	0.5 + 0.4	10 (0)	10 (0)	6st(0.1)	9st(0.1)	2	0	0	0	10
Post-emergence carrots 2 TL 23 May										
4. aclonifen	1.0	8 (10)	10 (0)	3 (0.3)	2st(1)	3sc	5	0	0	0
5. aclonifen + linuron	0.5 + 0.4	10 (0)	10 (0)	10(0)	9st(0.1)	9.7	10	0	0	10
6. Stomp + linuron	0.5 + 0.4	10 (0)	10 (0)	5st(0.1)	2st(1)	0	0	0	0	10
7. Stomp + linuron	(0.5 + 0.4) x 2	10 (0)	10 (0)	9.3(0.1)	3st(0.5)	6st	0	0	0	10
8. Alpha DFF + linuron	0.3 + 0.4	10 (0)	10 (0)	5.3(0.3)	2st(1)	4	0	0.7	0	10
9. Alpha DFF + linuron	0.3 + 1.0	10 (0)	10 (0)	10 (0)	5st(0.3)	9	4st	0.7	9.7	10

st stunted; sc scorched

Weed control scores overall are shown for site 4 in Table 17.
Although weed control was not acceptable, Alpha DFF + linuron (0.3 + 1.0) L/ha performed nearly as well as aclonifen + linuron.
Weeds remaing grew vigorously under the warm conditions, by 21 June weed control with the most effective treatment aclonifen + linuron was only just acceptable, and it was unacceptable by 11 July.
A post-emergence programme is essential on this soil type.

Table 17. Holme Fen carrots Site 4 (sown 13 April). Weed control score (0=untreated no control, 7= acceptable control, 10= complete control); (% weed cover) on 4 June

Herbicide	L or kg product/ha	23 May 2 – 3 TL	4 June 4 TL	21 June 6 ½ TL	11 July
1. untreated	-	0	0 (95%)	0	0
Post-emergence carrots 1 TL 10 May					
2. linuron (standard)	0.4	7.7	8.3 (2.3%)	3	2
3. Stomp + linuron	0.5 + 0.4	8.7	9.3 (0.5%)	4.7	4
Post-emergence carrots 2 TL 23 May					
4. aclonifen	1.0		5 (50%)	3	3
5. aclonifen + linuron	0.5 + 0.4		9.5 (0.2%)	7.7	6.7
6. Stomp + linuron	0.5 + 0.4		6 (20%)	3.7	3.3
7. Stomp + linuron	(0.5 + 0.4) x 2		9 (0.5%)	5.7	5
8. Alpha DFF + linuron	0.3 + 0.4		6 (20%)	4.3	4
9. Alpha DFF + linuron	0.3 + 1.0		8.3 (2%)	6.3	6

CONCLUSIONS 2006

Parsnips

Crop Safety

- The safest treatments were: pre-emergence Stomp + linuron (2.5 + 1.0) L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha, Stomp + aclonifen + Goltix WG. The double dose of Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha x 2 was safe on a sandy loam soil in the 2005 trial, but caused stunting that was only just acceptable on the very light soil after high rainfall in 2006, although the parsnips recovered and were weed-free.

- Post-emergence DFF + linuron (0.1 + 0.2) L/ha applied at 2 true-leaves caused slight bleaching (from DFF) initially but appeared very safe to parsnips. It did not control groundsel or large annual meadow-grass

- In 2006 all other post-emergence herbicides applied at 2 true-leaves caused scorch and leaf loss although the parsnips recovered a month after application. Aclonifen 1.0 L/ha, Stomp + linuron (0.5 + 0.4) L/ha could perhaps be used at a later parsnip growth stage as a 'fire engine' treatment where there was a specific weed problem. Aclonifen + linuron (0.5 + 0.4) L/ha caused the most severe damage, and the crop did not recover.

Weed Control

- The predominant weed species at the 2006 site were groundsel 35 plants/m^2, small nettle and fat-hen and on the post-emergence areas, fumitory as well. Pre-emergence the standard Stomp + linuron (2.5 + 1.0) L/ha and Stomp + aclonifen (2.0 + 2.0) L/ha gave almost complete control of high populations of small nettle and fat-hen but activity on groundsel was very poor.

- The efficacy of pre-emergence Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha was excellent. The addition of Goltix achieved control of groundsel and the plots remained virtually weed-free throughout the season.

- All post-emergence treatments controlled fat-hen and small nettle but none (including Defy) killed groundsel although aclonifen + linuron (0.5 + 0.4) L/ha caused severe stunting

- Post-emergence aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and DFF + linuron at (0.2 + 0.4) L/ha gave excellent control of fumitory. DFF + linuron at (0.1 + 0.2) L/ha gave 73% control of fumitory numbers and those remaining were stunted. It was not controlled by Defy 4.0 L/ha or Stomp + linuron (0.5 + 0.4) L/ha at single or double doses.

Carrots

Crop Safety

- The safest pre-emergence treatments were Stomp 5 L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha and Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha. The latter 3-way tank-mix gave excellent weed control.

- The three-way pre-emergence tank-mixes Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha and Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha were not as safe as the Stomp + aclonifen + Centium tank-mix - causing stunting but no plant loss.

- Post-emergence at 2 true leaves Stomp + linuron (0.5 + 0.4) L/ha was very safe to carrots at all sites, and on organic soil where it was applied at one true leaf as well. Alpha DFF +

linuron (0.3 + 0.4) L/ha was also safe at all sites. A higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha and in the double dose rate of Stomp + linuron (0.5 + 0.4) L/ha increased damage at site 2, where carrots were at an earlier growth stage (25% at one true-leaves). Although the carrots recovered later, the 1.0 L/ha linuron was too high.

- Post-emergence at 2 true leaves, aclonifen (1.0) L/ha caused scorch and stunting, damage from aclonifen + linuron (0.5 + 0.4) L/ha was usually more severe and unacceptable causing leaf loss at two sites. The linuron increased scorch. Damage from both was increased when applied at high temperatures 24°C at Higham. Post-emergence aclonifen (1.0) L/ha or aclonifen + linuron (0.5 + 0.4) L/ha are likely to have a wider margin of crop safety if applied at a later carrot growth stage and further work is needed.

- All post-emergence treatments were safe at Holme Fen. Herbicides were sprayed in cooler weather to carrots at 2 TL (75%) to 3 TL (25%) caused less damage than at other sites. These treatments, particularly aclonifen + linuron (0.5 + 0.4) L/ha, gave the best weed control and could be useful on organic soil, where pre-emergence herbicides are ineffective.

Weed Control

- Pre-emergence Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha gave the best weed control. The level of weed control with pre-emergence tank-mixes Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha and Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha was similar to the Stomp + aclonifen + Centium tank-mix but were not as safe to the crop.

- Pre-emergence Stomp or Stomp + aclonifen were less effective on high numbers of fat-hen.

- The post-emergence treatments all gave excellent weed control at the two sites Swinderby and Higham. There was a very high weed population total 413/m^2 on untreated plots at Swinderby of mainly annual meadow-grass on the pre-emergence area, and fat-hen on the post-emergence area and a high population of small nettle.

- No pre-emergence treatment gave complete control of black nightshade and the low dose of Stomp + aclonifen (2.0 + 2.0) L/ha was the least effective. Aclonifen 1.0 L/ha post-emergence had a weakness on black and green nightshades.

- Alpha DFF + the lower dose of linuron (0.3 + 0.4) L/ha (tr 12) did not control the larger annual meadow-grass, but the higher dose of linuron as Alpha DFF + linuron (0.3 + 1.0) L/ha improved control.

- Weed pressure was also high 366 weeds/m^2 at the organic soil site and 16 weed species were recorded mainly fat-hen, also small nettle, black-bindweed and lower numbers of mugwort, flixweed and fool's parsley. A post-emergence programme is essential on this soil type. Aclonifen + linuron (0.5 + 0.4) L/ha, gave the best weed control including black-bindweed, mugwort, flixweed and possibly cleavers. Alpha DFF + linuron (0.3 + 0.4) L/ha was not as effective, the higher dose of linuron 1.0 L/ha improved control.

- There were a few volunteer potatoes but distribution was uneven. Aclonifen + linuron (0.5 + 0.4) L/ha caused severe damage although there was some recovery. The greatest effect was from Alpha DFF + linuron (0.3 + 1.0) L/ha but it was not as effective as Dosaflo used on the commercial crop.

CONCLUSIONS 2005 and 2006 trials

Linuron forms the basis for weed control in parsnips and carrots. It is on Annex 1 of the EC positive list but when it is re-registered the dose rate will be restricted to 950 g a.i./ha per year.
It is worth considering a different approach - using other residual herbicides (aclonifen and Centium) pre-emergence and saving the option of linuron for post-emergence use. However, aclonifen may not be available until after 2008.
No programmes were evaluated in these trials – all treatments were single applications.

Crop Safety
Parsnips
Safe effective treatments:

- Pre-emergence Stomp + linuron (2.5 + 1.0) L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha and Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha caused no damage to parsnips at any stage on a light (sandy loam) soil in 2005 or on a very light soil (loamy sand) in 2006. Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha x 2 at double this dose rate were both safe to the parsnip crop on the light soil, but caused stunting on the loamy sand.

- Post-emergence DFF + linuron (0.1 + 0.2) L/ha applied at 2 true-leaf stage caused slight bleaching (from DFF) initially but appeared very safe to parsnips in both years. It was effective on most species except groundsel and large annual meadow-grass.

- In 2006 all other post-emergence herbicides applied at 2 true-leaves caused scorch and leaf loss although the parsnips recovered a month after application. Aclonifen 1.0 L/ha, Stomp + linuron (0.5 + 0.4) L/ha.could perhaps be used as a 'fire engine' treatment where there was a severe weed problem. Aclonifen + linuron (0.5 + 0.4) L/ha caused the most severe damage, and the crop did not recover.

In 2005 the following lacked efficacy or were too phytotoxic to parsnips and, except for Defy, were not tested further:

- In 2005 Sencorex was too damaging to parsnips – even a very low dose rate of 0.25 kg/ha in pre-emergence tank-mixes caused severe damage and reduced plant stand. The low dose of Sencorex 0.25 kg/ha applied to parsnips after the 3 true-leaf stage, caused severe necrosis, leaf loss and plant death and also lacked efficacy on weeds.

- In 2005 Centium 0.2 L/ha in tank-mixes caused vigour reduction and there was plant loss and unacceptable stunting from the double dose.

- Post-emergence treatments applied at 1 true-leaf stage: Betanal, Betanal Carrera, Goltix were ineffective on the weed spectrum at this site. Defy applied at 2 true-leaf stage caused more damage to parsnips in the form of leaf crinkling, necrosis and slight, but more persistent, stunting. Defy 4.0 L/ha post-emergence gave poor control of field pansy, annual meadow-grass and groundsel

Carrots
Safe effective treatments:

- In both years pre-emergence tank-mixes Stomp + linuron (2.5 + 1.0) L/ha, Stomp + aclonifen (2.0 + 2.0) L/ha and Stomp + aclonifen + Centium at (1.5 + 1.5 + 0.2) L/ha were very safe to carrots. Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha gave the best weed control.

- Post-emergence at 2 true-leaf stage: In 2006, Stomp + linuron (0.5 + 0.4) L/ha was very safe to carrots at all sites, and on organic soil where it was applied at one true-leaf as well. In both years Alpha DFF + linuron (0.3 + 0.4) L/ha was also safe at all sites. A higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha and in the double dose rate of Stomp + linuron (0.5 + 0.4) L/ha increased damage at Swinderby, where carrots were at an earlier growth stage (25% at one true-leaves). Although damage was just acceptable and the carrots recovered later, the 1.0 L/ha linuron was too high.

- In 2005 Sencorex was applied at 0.3 kg/ha post-emergence to carrots at 2 true-leaves or at 0.5 kg/ha later than 3 true-leaves. Weed control was excellent except for black and green nightshade.

The following were less safe, but none caused plant loss:

- Pre-emergence: In 2006 Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha caused slightly less phytotoxicity than Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha (the reverse was true in 2005), but the reason is not clear. Both treatments caused stunting but no plant loss (but the overlap dose reduced emergence). The level of weed control was excellent - similar to the Stomp + aclonifen + Centium tank-mix.

- Post-emergence at 2 true leaves: aclonifen (1.0) L/ha caused scorch and stunting; damage from aclonifen + linuron (0.5 + 0.4) L/ha was generally more severe and unacceptable causing leaf loss at two sites. The linuron increased scorch. Damage was more severe when applied at high temperatures 24°C at Higham. However there was less damage at Holme Fen and aclonifen + linuron (0.5 + 0.4) L/ha, gave the best weed control including black-bindweed, mugwort, flixweed and possibly cleavers and could prove useful on an organic soil, where pre-emergence herbicides are ineffective. They are likely to have a wider margin of crop safety if applied at a later carrot growth stage.

In 2005, the following lacked efficacy or were too phytotoxic and were not evaluated further:

- In 2005, the most damaging pre-emergence treatment for carrots, Stomp + aclonifen + Goltix WG: (2.0 L + 2.0 L + 1.5 kg) /ha, caused vigour loss, and at double this dose rate there was a reduction in plant stand at sites 2 and 3. Damage was very severe at N Elmham.

- In 2005, Sencorex at 0.5 kg/ha in pre-emergence 'overlap'tank-mixes caused damage and plant loss: Stomp + aclonifen + Sencorex at 2 x (2.0 L + 2.0 L + 0.25 kg) /ha caused severe phytotoxicity - plant loss was greater than from Stomp + linuron + Sencorex 2 x (2.0 L + 1.0 L + 0.25 kg) /ha. Damage was more severe at N Elmham (about 70% loss) from Stomp + aclonifen + Sencorex at 2 x (2.0 L + 2.0 L + 0.25 kg) /ha, than at Blyton.

- In 2005, post-emergence treatments applied at 1 true-leaf stage: Goltix, Betanal and Betanal Carrera caused chlorosis followed by stunting. Betanal Carrera caused the most necrosis, Goltix caused vigour loss and thinning of the crop. Defy caused slight damage in the form of necrosis, and leaves had reduced wax and some stuck together. The weed control from these treatments was poor overall.

Weed control parsnip and carrot sites 2005 and 2006

Species that will be difficult to control after the loss of herbicides at the end of 2007, unless there are alternatives are: mayweeds, fumitory, fool's parsley and groundsel. There are possible solutions for all except volunteer potatoes.

All herbicide applications were single treatments. For a programme where pre-emergence herbicides are applied, the growth of weeds escaping control may be checked and it would be possible to delay post-emergence treatments until a later (and safer) growth stage than 2 true leaves. On the organic soil a programme with more than one post-emergence application would be needed.

The best weed control overall

Parsnips

- Pre-emergence 3-way tank-mix Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha gave complete control including groundsel.

- Post-emergence Alpha DFF + linuron (0.1 + 0.2) L/ha.

- Post-emergence aclonifen 1.0 L/ha, Stomp + linuron (0.5 + 0.4) L/ha could perhaps be useful as a 'fire engine' treatment later than 2 true leaves where there was a specific weed problem but further work on crop safety is needed.

Carrots

- Pre-emergence 3-way tank-mixes Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha (and the less safe Stomp + linuron + Sencorex, Stomp + aclonifen + Sencorex) gave excellent season-long weed control.

- Post-emergence at 2 true leaves Alpha DFF + linuron (0.3 + 0.4) L/ha; Stomp + linuron (0.5 + 0.4) L/ha.

- Post-emergence weed control with Sencorex was excellent at two sites in 2005, with the higher dose rate 0.5 L/ha applied later than the 3 true-leaf stage of carrots, performing better than the 0.3 L/ha dose at 2 true leaves.

- Post-emergence at 2 true leaves aclonifen + linuron (0.5 + 0.4) L/ha controlled most species except groundsel, but caused damage. It may be safer at a later growth stage.

Weed species controlled in carrots and parsnips (check crop safety)

The following information is from only a few trials, and should be treated with caution.

- There was a high population of **groundsel** 35 plants/m^2 at the parsnip site in 2006. Aclonifen and Stomp have poor activity on groundsel pre- and post-emergence. The addition of Goltix i. e. as Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg)/ha applied pre-emergence gave complete control. At the dose rates tested in parsnips all other pre- and post-emergence treatments were ineffective, however, groundsel was at large plant stage when applications were made.

- **Nightshades** (black, green and hairy) emerge in warm weather in June. Stomp at 5.0 L/ha controls nightshade but lower doses pre-emergence were ineffective. Aclonifen pre-emergence did not control nightshades, and neither did Sencorex pre- or post-emergence in 2005. In 2006 aclonifen post-emergence achieved better control. In 2006 all other post-emergence treatments gave complete control of 13 plants/m^2 at Swinderby.

- The only trial where **fumitory** occurred 19 plants/m^2 was in the post-emergence area at the parsnip site in 2006. Post-emergence aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and DFF + linuron at (0.2 + 0.4) L/ha gave excellent control of fumitory but were not safe to the crop. DFF + linuron at (0.1 + 0.2) L/ha gave 73% control of fumitory numbers

and those remaining were stunted. Fumitory was not controlled by Stomp + linuron (0.5 + 0.4) L/ha at single or double dose rates or by Defy 4.0 L/ha.

- In 2005, at the parsnip site there was a very high population 194 plants/m^2 of **field pansy**. The dose of Stomp at 2.0 or 2.5 L/ha was too low to achieve good control and tank-mixes with aclonifen or linuron were ineffective. Field pansy is resistant to Centium and it did not improve control in the Stomp + aclonifen tank-mix. Post-emergence Alpha DFF + linuron (0.1 + 0.2) L/ha gave complete control in parsnips.

- All pre-emergence treatments gave good control of **annual meadow-grass** in 2005 and in 2006 at carrot site 2, where the population was 162 plants/m^2. Post-emergence Alpha DFF + the lower dose of linuron (0.3 + 0.4) L/ha did not control large annual meadow-grass in 2005 and 2006, but the higher dose of linuron in Alpha DFF + linuron (0.3 + 1.0) L/ha, tested in 2006, improved control. In 2006 post-emergence aclonifen 1.0 L/ha and aclonifen + linuron (0.5 + 0.4) L/ha and Stomp + linuron (0.5 + 0.4) L/ha were very effective.

- **Small nettle** (up to 8 true-leaves) and was controlled by all pre-emergence treatments in both years, with post-emergence treatments in 2006 and with Sencorex and Defy in 2005.

- **Shepherd's purse** at carrot site 2 was controlled by all pre- and post-emergence treatments.

- All treatments pre- and post-emergence controlled **fat-hen** (up to 6 true leaves) in 2006, although a few escaped control with Stomp alone at site 2, and aclonifen post-emergence at site 4.

- At the organic soil site in 2006 there were a few **cleavers,** but the distribution was uneven. Aclonifen + linuron (0.5 + 0.4) L/ha may be effective.

- Aclonifen + linuron (0.5 + 0.4) L/ha or Alpha DFF + linuron (0.3 + 1.0) L/ha controlled **black-bindweed** at cotyledon to 3 true-leaves in carrots on the organic soilsite in 2006. Populations were too low at other sites to assess control with pre-emergence herbicides.

- Surprisingly there were no **mayweeds** at any of the sites, but pre-emergence Stomp + aclonifen is known to be effective (French data). Pre-emergence Centium controls **fool's parsley** but this weed only occurred in 2006 on the organic soil site and was not controlled by any of the post-emergence treatments.

- There were a few **volunteer potatoes** at Higham and Holme Fen but their distribution was uneven. Post-emergence aclonifen had little effect; aclonifen + linuron caused severe scorch and killed shoots but there was regrowth. The greatest effect was from Alpha DFF + linuron (0.3 + 1.0) L/ha or possibly Stomp + linuron (0.5 + 0.4) L/ha x 2 but control was inferior to Dosaflo applied to the commercial crop.

Weed control and herbicide activity

Appendix 1 of this report shows product label claims and other information on weed species controlled. Appendix 2 gives Latin weed names.

Residues data and approvals

Aclonifen is registered for use in carrots in other N EU Member States (Denmark for use pre- and post-emergence) but it may not be available for the UK until after 2008. There are residues data for aclonifen.
Further work is needed for metabolism and residues studies before SOLAs can be requested for DFF (Crop Protection Company and HDC).
Stomp + linuron post-emergence in carrots was also promising, but at this timing further residues data would be needed for Stomp.

HDC obtained a SOLA in 2006 for Goltix WG in parsnips No.1637/06, after good results in the 2005 trial.

RECOMMENDATIONS

This project has allowed the industry to demonstrate to the European Commission that action has been taken to find alternatives to replace the temporary 'Essential Uses' so that these uses can continue until 31 December 2007. Dosaflo (metoxuron), products containing pentanochlor or prometryne must not be used after then and an extension of use is not possible.

Growers will need to review their weed control strategy for carrots and parsnips.

The trials in 2005 and 2006 identified some promising pre-emergence tank-mixes based on Stomp + aclonifen for parsnips and carrots. In 2006, aclonifen or aclonifen + linuron post-emergence were also interesting. However aclonifen may not be available in the UK until after 2008.

In both years post-emergence Alpha DFF + linuron appears safe and effective in both parsnips and carrots. However, further work is needed for metabolism and residues studies before SOLAs are requested (Crop Protection Company and HDC) and these studies are costly.

More residues data would also be needed for Stomp applied post-emergence.

The FV 236b screening trials in two years indicated possible alternatives but dose rates, timings and programmes will need to be developed further by agronomists/growers with expert knowledge of herbicides/local weed spectra/soil types etc. The following are at growers risk:

- Linuron forms the basis for weed control in parsnips and carrots. It is on Annex 1 of the EC positive list but when it is re-registered the dose rate will be restricted to 950 g a.i./ha per year (equivalent to 1.9 L of a 500g/L product). It is worth considering a different approach in future - using other residual herbicides pre-emergence and saving linuron for post-emergence use. However, aclonifen may not be available until after 2008.

- In carrots pre-emergence Stomp + aclonifen + Centium (1.5 + 1.5 + 0.2) L/ha is safe and effective. A higher dose rate for Stomp, and up to 2.0 L/ha aclonifen could be included. Centium dose must not exceed 0.25 L/ha.

- In parsnips an effective pre-emergence tank-mix is essential because linuron will be the only post-emergence option (unless DFF becomes available). Pre-emergence Stomp + aclonifen + Goltix WG (2.0 L + 2.0 L + 1.5 kg) /ha. A higher dose rate for Stomp, Goltix WG (maximum 2.0 kg/ha on sands) and up to 2.0 L/ha aclonifen could be included.

- Before aclonifen becomes available - for carrots pre-emergence Stomp + linuron + Centium (2.0 + 1.0 +0.2) L/ha; for parsnips Stomp + linuron + Goltix WG (2.0 L + 1.0 L + 1.5 kg) /ha. This leaves linuron 0.9 L/ha for post-emergence use.

- For carrots there are post-emergence options: Sencorex (SOLA) post-emergence at 0.3 kg/ha at 2 true leaves or at 0.5 kg/ha later than 3 true leaves was very effective on most species except nightshades and in these trials was safe to carrots (but not parsnips). High rainfall/irrigation on very light soil could result in damage. The following are not available yet: Alpha DFF + linuron (0.3 + 0.4) L/ha or Alpha DFF + linuron (0.3 + 1.0) L/ha the higher linuron dose for large annual meadow-grass; Stomp + linuron (0.5 + 0.4) L/ha post-emergence at 1 or 2 true-leaves and Stomp + linuron (0.5 + 0.4) L/ha x 2 at 2 true leaves was marginally safe. The earlier timing of Stomp + linuron would be useful in carrots on organic soil.

- In parsnips post-emergence: Alpha DFF + linuron (0.1 + 0.2) L/ha was safe and effective. Stomp + linuron (0.5 + 0.4) L/ha was not as safe but worth considering.

- So far this project has not identified a replacement for Dosaflo (metoxuron) used to suppress volunteer potatoes. Populations of volunteer potatoes in the carrot trials were low and unevenly distributed but the best treatment appeared to be DFF + linuron (0.3 + 1.0) L/ha. In HDC FV 256a vegetable screening trial a confidential herbicide 212 H may have some potential but further work would be needed.

- Further work needed in carrots on post-emergence aclonifen (1.0) L/ha; aclonifen + linuron (0.5 + 0.4) L/ha (registered in Denmark). They were too phytotoxic to parsnips but could be considered as a 'fire engine' treatment. Aclonifen did not control groundsel or nightshades; aclonifen + linuron gave excellent control of a wide range of weed species (except groundsel) some were at advanced growth stages.

- In carrots the following were less safe, but none caused plant loss in 2005 or 2006: in 2006, pre-emergence Stomp + aclonifen + Sencorex (2.0 L + 2.0 L + 0.25 kg) /ha caused slightly less phytotoxicity than Stomp + linuron + Sencorex (2.0 L + 1.0 L + 0.25 kg) /ha (the reverse was true in 2005), but the reason is not clear. Both treatments can cause stunting thinning and vigour loss.

- Herbicides that were not safe to parsnips included Centium pre-emergence, Sencorex even at low dose rates pre- and post-emergence.

- Herbicides that were not safe to carrots included Goltix pre-emergence, and Sencorex pre-emergence at 0.5 kg/ha.

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Appendix 1. Weed Susceptibility to herbicides. Data from labels UK and other countries, and other information – please treat with caution. Insufficient data for post-emergence aclonifen, aclonifen + linuron. Key: S = Susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant; Dose rates L/ha or kg/ha; cot cotyledon stage

Common name	*linuron* pre 2.2L	*liinuron* post 1.1L	*Sencorex* pre 1 -1.5kg/ha	*Sencorex* post 0.5kg/ha	*Centium* pre 0.25L	*Stomp* pre 5L	*Stomp* pre 1.5 –2 L	*aclonifen* pre 2-2.5L	*Stomp + aclonifen* pre 2 + 2L	*Goltix* pre 2kg	*Alpha dff* post 0.2 L/ha	*Alpha dff* post 0.4 L	*Defy* post 4.0L
Bindweed, black	S	S	MS	S	MR	S	MS	MS	S	MR	R	MR	
Bugloss	S	MR	S	S									
Charlock	S	S	S	S	R		MS	S	S	MS	MS	MS	
Chickweed, common	S	S	S	S	S	S	S	S	S	S	MS	S	
Cleavers	MR	R	R	R	S	S	R	MS	MS	R	MS	MS	S
Corn marigold	S	R		MS		S				S			
Corn spurrey	S	S	S	S						S	MR/MS	MS	
Crane's-bill, cut-leaved											R	MR	
Dead-nettle, henbit			S	S		S							
Dead-nettle, red	S	MR	S	S	S	S	MS	MS	S	MS	MR/MS	MS	
Dock, broad-leaved										S			
Fat-hen	S	S	S	S	MS	S	S	S	S	S	MR	MR/MS	S
Fool's parsley					S		MS	R	R?	S			
Forget-me-not, field	S	S	S	S		S				S	MS/S	S	
Fumitory, common	R	R	S	S	R	MS	R	R	MS	MS	MR	MR	R
Gallant -soldier	S	S											
Groundsel	S	MR	S	S	S		R	R	R	S	MR	MR/MS	R
Hemp-nettle, common	S	S	S	S		S							
Knotgrass	MS	MR	S	MS	MR	S				S	MR	MR/MS	
Mayweed, scented	S	R	S	S	R	MS	MS	MS	S	S	MR	MR/MS	R
Mayweed, scentless	S	R	S	S	R	MS	MS	MS	S	S	MR	MR/MS	R
Nettle, small	S	S	S	S	MR				S	S			S
Nightshade, black	S	MR	S	S		S	MS	R	MS	MR			
Orache, common	S	S	S	S						S			
Pansy, field	S	S	S	MS	R	S	MS	R	MS	S	S	S	
Parsley piert						S							
Pennycress, field	S	S	S	S						S			
Persicaria, pale	S	S	S	S	MS					MS	MR	MR/MS	
Pimpernel, scarlet	S	S	S	S		S				MR	S	S	
Pineappleweed	S	R			R	MS	MS	MS	S	S	MR	MR	R
Poppy, common	S	S			R	S				S	MR	MR	
Redshank	S	S	S	S	S	S	MS	MS	S	MS			
Shepherd's-purse	S	S	S	S	S	S	S	S	S	S	MS/S	S	
Sow-thistle, smooth	S	S	S	MS	MS	S	R	MS	MS	MR			
Speedwell, common, field	S	S	S	S		S	S	MS	S	S	MS/S	S	
Speedwell, ivy-leaved			S	S	S	S				MS	MS/S	S	
Sun spurge			S							S			
Thistle, creeping	R	R			R		R	R	R	R			
Wild radish	S	S	S	S	S		MS	S	S	MR	MS/S	MS/S	
Annual meadow-grass	MS	MR	S	S	MS	S	S	MS	S		R		
Black-grass			S	MS		S				MR			
Wild-oat	R	R								R			
Vol OSR			S	S	R	MS					MS/S	S	

Appendix 2. Latin and common weed names

Common name	Latin name
Amaranth, common	*Amaranthus retroflexus*
Bindweed, black	*Fallopia convolvulus*
Bugloss	*Anchusa arvensis*
Charlock	*Sinapis arvensis*
Chickweed, common	*Stellaria media*
Cleavers	*Galium aparine*
Corn marigold	*Chrysanthemum segetum*
Corn spurrey	*Spergula arvensis*
Crane's-bill, cut-leaved	*Geranium dissectum*
Deadnettle, henbit	*Lamium amplexicaule*
Dead-nettle, red	*Lamium purpureum*
Dock, broad-leaved	*Rumex obtusifolius*
Fat-hen	*Chenopodium album*
Flixweed	*Descurainia sophia*
Fool's parsley	*Aethusa cynapium*
Forget-me-not, field	*Myosotis arvensis*
Fumitory, common	*Fumaria officinalis*
Gallant -soldier	*Galinsoga parviflora*
Groundsel	*Senecio vulgaris*
Hemp-nettle, common	*Galeopsis tetrahit*
Knotgrass	*Polygonum aviculare*
Mayweed, scented	*Matricaria recutita*
Mayweed, scentless	*Tripleurospermum inodorum*
Mugwort	*Artemisia vulgaris*
Nettle, small	*Urtica urens*
Nightshade, black	*Solanum nigrum*
Nightshade, green	*Solanum physalifolium*
Nightshade, hairy	*Solanum villosum*
Orache, common	*Atriplex patula*
Pansy, field	*Viola arvensis*
Parsley piert	*Aphanes arvensis*
Pennycress, field	*Thlaspi arvense*
Persicaria, pale	*Persicaria lapathifolia*
Pimpernel, scarlet	*Anagalis arvensis*
Pineappleweed	*Matricaria discoidea*
Poppy, common	*Papaver rhoeas*
Redshank	*Persicaria maculosa*
Shepherd's-purse	*Capsella bursa-pastoris*
Sow-thistle, smooth	*Sonchus oleraceus*
Speedwell, common, field	*Veronica persica*
Speedwell, ivy-leaved	*Veronica hederifolia*
Sun spurge	*Euphorbia helioscopia*
Thistle, creeping	*Cirsium arvense*
Wild mignonette	*Reseda lutea*
Wild radish	*Raphanus raphanistrum*
Annual meadow-grass	*Poa annua*
Blackgrass	*Alopecurus myosuroides*
Brome, barren	*Anisantha sterilis*
Wild-oat	*Avena fatua*
Volunteer OSR	*Brassica napus*