

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), met amitron (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

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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
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- Locations:** Carrots: Lincs, Norfolk, Suffolk, Cambs; Parsnips: Yorks, Suffolk.
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- Project started:** March 2005, second year completed December 2006
- 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), metamidon (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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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 Dosaflor 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). It 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 *DFP* (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. Dosafla (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)

<i>a.i.</i>	<i>EC review</i>	<i>Product</i>	<i>Company</i>	<i>Formulation</i>	<i>UK Approval Status</i>
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	List 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
prosulcarb	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/m² 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/m² at Swinderby.

- The only trial where **fumitory** occurred 19 plants/m² 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/m² 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/m². 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 Dosaflor applied to the commercial crop.