

Project Title: Annual herbs: Evaluation of herbicide tank mixes for post-emergence annual weed control in direct sown outdoor umbelliferous herbs.

Project Number: FV 199.

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Report: Final report. 1999.

Previous Reports: First Annual Report. 1997.

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Date Commenced: March 1997.

Date Completed: November 1999.

Keywords: Herbs, Culinary herbs, Weed control, Annual weed control, Weeds, Herbicides.

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GROWER SUMMARY

Scope and objectives

In the first year of this experiment, 1997, a range of eight contact herbicides was screened as single applications of individual materials and mixtures, at half normal rates or less. The herbicide selection included four materials which at the time had no form of approval for use on annual herbs. Two mixtures, Afalon + Atlas Brown and Afalon + Gesagard, showed particular promise for commercial application.

These two mixtures were further evaluated in 1999 at a range of rates together with two additional mixtures that were marginal in the 1997 screening. Sencorex which had shown total weed control was further tested at reduced rates. It was planned to carry out this follow up work in 1998 but the trial was held over for one year due to difficulties with establishing the crop.

As curled parsley had been shown to be the most sensitive to damage of the four species tested in 1997, it was selected as the test crop in 1999.

In addition to the treatments being applied to land that had not received any residual herbicide, this year treatments were repeated on crop to which a normal commercial residual had been applied.

Summary of results

Gesagard + Afalon mixtures were shown to control a wide range of weed species including large groundsel at flowering stage, and in this trial were superior to existing contact herbicide treatments.

The crop soon recovered from an initial check to growth and was able to grow away in weed free conditions.

Action points for growers

Growers are recommended to test these mixtures for themselves on their own farms. Both materials have current MAFF Approval for use on parsley, but growers must ensure that all approval conditions are met before use.

Practical and financial benefits

This work shows that it is possible to control weeds, particularly established groundsel, hitherto not controlled by existing post-emergence treatments. This should lead to easier, more efficient harvesting.

SCIENCE SECTION

Introduction

Control of annual weeds in herbs relies heavily on herbicides with a residual mode of action. Several materials are available for use, mainly under MAFF Pesticide Safety Directorate Specific Off-Label Approvals or Long Term Automatic Approval Extensions. The effectiveness of pre-emergence herbicides can be reduced by adverse field conditions, and many have a limited field life. Applications of post-emergence contact (foliar acting) materials are usually needed in order to extend weed control through to crop maturity

Currently four foliar acting herbicides may be used on annual herbs under the Off-label approval scheme. Little information is available on their crop safety to herbs when applied at different crop stages as single materials, even less when applied as mixtures.

Information on efficacy of weed control is available from commercial literature usually as standard doses, and there appears to be little data on the effect of reduced rate application to small weeds either as single or repeat doses of individual materials or mixtures.

In the first year of this experiment, 1997, a range of eight contact herbicides was screened both as single applications of individual materials, and as mixtures, at half normal rates or less on four annual Umbelliferous (recently reclassified family Apiaceae) herb species, curled parsley, flat leaf parsley, dill and coriander. The herbicide selection included four materials which at the time had no form of approval for use on annual herbs. Two mixtures, Afalon + Atlas Brown and Afalon + Gesagard, showed particular promise for commercial application.

These two mixtures were further evaluated in 1999 at a range of rates together with two additional mixtures of Sovereign with Afalon and Gesagard were safe in this first year but only marginal in terms of weed control. . Sencorex which had shown total weed control in 1997 was further tested at reduced rates. It was planned to carry out this follow up work in 1998 but the trial was held over for one year due to difficulties with establishing the crop.

The purpose of this second year of the experiment was to evaluate the safety and efficacy of the two best treatments from the screening together with two further mixtures which showed some promise. Curled parsley was selected as the test crop as it had shown to be the most sensitive to damage in the screening.

Materials and methods

Materials and rates as commercial product per hectare

1. Unsprayed control
2. Atlas Brown 3.0L + Afalon 0.6L
3. Atlas Brown 3.0L + Afalon 1.2L
4. Gesagard 50WP 1.1kg + Afalon 0.6L
5. Gesagard 50WP 1.1kg + Afalon 1.2L
6. Gesagard 50WP 0.55kg + Afalon 1.2L
7. Sovereign 1.0L + Afalon 0.6L
8. Sovereign 2.0L + Afalon 1.2L
9. Sovereign 1.0L + Gesagard 50WP 1.1kg
10. Sovereign 2.0L + Gesagard 50WP 1.1kg

X	Sencorex	0.21kg
Y	Sencorex	0.5kg
Z	Sencorex	1.0kg

All treatments were applied in a water volume equivalent to 400l/ha using a gas propelled precision knapsack sprayer

Trial design and layout

Randomised field experiment, replicated three times with treatments applied in two areas, one with and one without residual herbicide, making six replicates in all.

Plot size 1.65m x 6.1m = 10m²

Crop diary

Crop drilled 13 May following final cultivation and fertiliser application in the two days prior to this.

Following drilling the soil remained moist through until germination, with heavy thunderstorms occurring weekly for the three weeks following drilling, on May 19, 26 and June 2. This resulted in some capping of the soil surface but not enough to stop germination of the crop.

After germination of the crop on and around 4 June heavy rain again fell on several occasions causing further capping of the soil surface and some crop damage which showed as plant death and reduced crop stand. Subsequent investigation of plant samples showed infection with *Pythium spp.* though by this time the crop was too large to treat and there was no appropriate action to take.

Sowing date: 13 May 1999

Emergence date: June 4 1999

Treatments applied 30 June 1999 when crop at 1.5 true leaf stage

Estimated date of harvest: 18 August 1999, (49 DAT).

Weather conditions at time of spraying: Mainly cloudy but sunny periods. Light wind. Air temp between 18^o and 20^o C.

Crop assessments:

Crop safety score on a 0-9 scale assessed crop reaction to treatments as expressed by growth and development, leaf number, size and visible leaf condition.

0 = crop killed, 9 = no crop damage.

Weed control efficacy on a 0-9 scale assesses both weed numbers and size and gives an index of the competitive effect of the weeds present. 0 = no control, 9 = total control.

Weed species fully controlled, ie completely killed.

Crop assessment dates and Days After Treatment (DAT)

14 July	first crop safety and weed control scores	(14 DAT)
14 July	control of individual weed species	(14 DAT).
27 July	second crop safety and weed control score	(27 DAT)

Site

Lighthorne Herbs Ltd., Grove Farm, Warmington, near Banbury, Oxon.

Weeds present at spraying:

a) Where residual herbicide applied.

groundsel	up to 15cm and flowering.
mayweed	rosette 8cm diameter.
fool's parsley	5cm high.
sowthistle	10cm diameter.
shepherd's purse	rosette 7cm diameter.

b) Where no residual herbicide applied.

as above plus:-

chickweed	10cm diameter.
red dead-nettle	5cm high.
annual meadowgrass	just tillering.
fat hen	10cm high.
redshank	15cm high.
field pansy	5cm high.

Results

Weed Control

Table 1. Weed Control Efficacy Score

Treatment	Score 14 DAT	Score 27 DAT
1 Unsprayed control	2.50	3.17
2 Atlas Brown 3.0L + Afalon 0.6L	5.83	6.33
3 Atlas Brown 3.0L + Afalon 1.2L	6.00	6.67
4 Gesagard 50WP 1.1kg + Afalon 0.6L	7.00	7.17
5 Gesagard 50WP 1.1kg + Afalon 1.2L	7.50	7.67
6 Gesagard 50WP 0.55kg + Afalon 1.2L	7.00	7.17
7 Sovereign 1.0L + Afalon 0.6L	5.50	5.33
8 Sovereign 2.0L + Afalon 1.2L	6.83	6.67
9 Sovereign 1.0L + Gesagard 50WP 1.1kg	5.67	6.00
10 Sovereign 2.0L + Gesagard 50WP 1.1kg	6.33	5.83
LSD	1.22	1.24

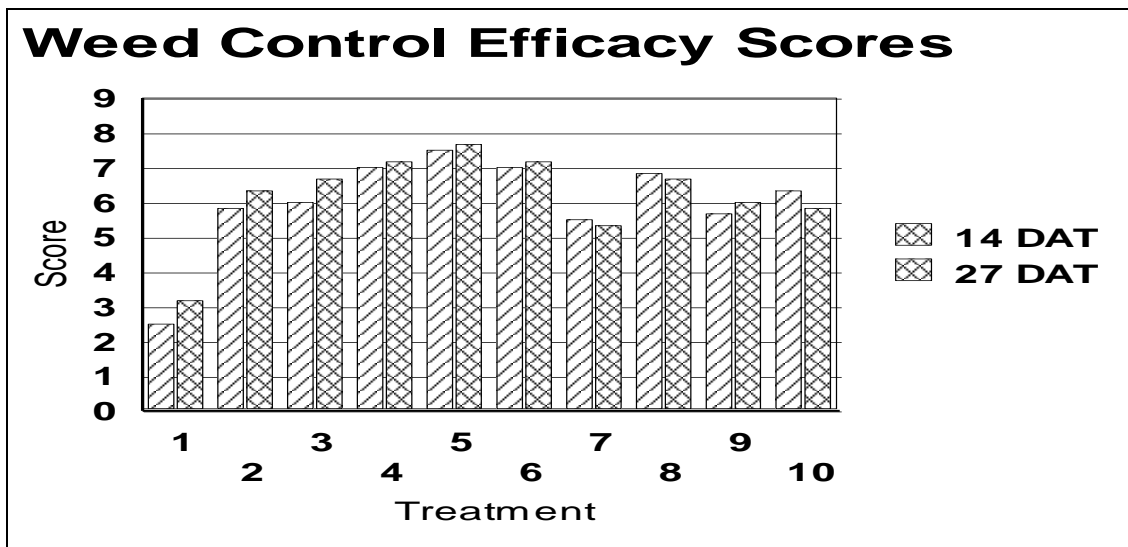


Figure 1. Weed Control Efficacy Scores

Weed control efficacy score on a 0-9 scale covering both weed numbers and size, and giving an index of the competitive effect of the weeds present. 0 = no control, 9 = total control.

Based on an efficacy score of 7 as the threshold at the second assessment the following treatments gave the best weed control.

- 4 Gesagard 50WP 1.1kg + Afalon 0.6L
- 5 Gesagard 50WP 1.1kg + Afalon 1.2L
- 6 Gesagard 50WP 0.55kg + Afalon 1.2L

They were all significantly better than treatments 7, Sovereign 1.0L + Afalon 0.6L, and 10, Sovereign 2.0L + Gesagard 50WP 1.1kg. Treatment 5 alone, Gesagard 50WP 1.1kg + Afalon 1.2L, was also significantly better than treatments 2, Atlas Brown 3.0L + Afalon 0.6L, and 9, Sovereign 1.0L + Gesagard 50WP 1.1kg.

Table 2. Weed Species Fully Controlled

TRT	g'sel	s'th	sh-pu	mwd	chk	fum	f-psly	redsh	f-hen	red-d-n	ch'lk	f-m-n	fld-pan	veron
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	4	4	1	2	0	0	1	0	0	0	0	1	0
3	4	6	3	0	1	0	4	0	1	1	1	0	2	0
4	5	5	6	1	3	1	0	0	2	2	0	0	1	0
5	4	6	4	3	1	1	1	1	3	3	1	1	2	0
6	6	6	3	0	1	2	3	0	1	3	2	1	1	0
7	1	6	3	0	2	0	0	0	0	0	0	2	1	0
8	3	6	4	2	3	3	0	0	2	0	1	1	1	0
9	1	5	2	0	2	1	0	0	2	4	0	1	0	0
10	4	4	4	0	3	1	0	0	2	1	0	1	2	1

Number of plots from 6 replicates where listed species were totally killed.

Key to weed species listed:

g'sel = groundsel, s'th = sowthistle, sh-pu = shepherd's purse, mwd = mayweed,
 chk = chickweed, fum = fumitory, f-psly = fools parsley, redsh = redshank,
 f-hen = fathen, red-d-n = red dead nettle, ch'lk = charlock, f-m-n = forget me not,
 fld-pan = field pansy, veron = speedwell.

The purpose of this table is to provide data so that growers can select appropriate treatments for the weed species present in their crops. It lists the number of plots from the six replicates where total control of the listed species was achieved. Because the trial procedure did not allow for plot by plot identification prior to spraying a zero score will in some cases reflect the absence of that species and not poor control. This may limit the value of the data in respect of the low scores but values of 6 demonstrate full control and values of 4 and 5 suggest at least a high level of activity.

Crop Safety:

Table 3. Crop Safety Scores

Treatment	Score 14 DAT	Score 27 DAT
1 Unsprayed control	8.67	7.67
2 Atlas Brown 3.0L + Afalon 0.6L	7.50	7.33
3 Atlas Brown 3.0L + Afalon 1.2L	5.50	6.33
4 Gesagard 50WP 1.1kg + Afalon 0.6L	5.67	6.50
5 Gesagard 50WP 1.1kg + Afalon 1.2L	6.00	6.00
6 Gesagard 50WP 0.55kg + Afalon 1.2L	6.17	6.67
7 Sovereign 1.0L + Afalon 0.6L	7.33	6.67
8 Sovereign 2.0L + Afalon 1.2L	6.00	6.33
9 Sovereign 1.0L + Gesagard 50WP 1.1kg	7.17	6.83
10 Sovereign 2.0L + Gesagard 50WP 1.1kg	6.67	6.67
LSD	1.02	1.37



Figure 2. Crop Safety Scores

Crop safety score on a 0-9 scale assessed crop reaction to treatments as expressed by growth and development, particularly leaf number and size, and visible leaf condition. 0 = crop killed, 9 = no crop damage.

At the second assessment 27 DAT only treatment 2, Atlas Brown 3.0L + Afalon 0.6L, scored above the threshold of 7. The only significant difference recorded was between the

unsprayed control, treatments 1, and treatment 5, Gesagard 50WP 1.1kg + Afalon 1.2L. There were no significant differences between the untreated control and the other herbicide treatments nor were there any significant differences between any of the herbicide treatments themselves.

Generally plots treated with the higher rate of Afalon (1.2 l/ha) gave lower scores at the first assessment. Crop recovery tended to be slow with the exception of Treatment 3, Atlas Brown 3.0L + Afalon 1.2L. Where the rate of Gesagard was halved in combination with the high rate of Afalon, treatment 6, crop recovery was good

It was noticeable that the inclusion of Sovereign generally impaired crop recovery

Leaf Scorch Assessment 14 DAT

Table 4. Number of plots from 6 replicates in which leaf scorch was recorded

Treatment	Score 14 DAT
1 Unsprayed control	0
2 Atlas Brown 3.0L + Afalon 0.6L	0
3 Atlas Brown 3.0L + Afalon 1.2L	6
4 Gesagard 50WP 1.1kg + Afalon 0.6L	6
5 Gesagard 50WP 1.1kg + Afalon 1.2L	6
6 Gesagard 50WP 0.55kg + Afalon 1.2L	6
7 Sovereign 1.0L + Afalon 0.6L	3
8 Sovereign 2.0L + Afalon 1.2L	6
9 Sovereign 1.0L + Gesagard 50WP 1.1kg	1
10 Sovereign 2.0L + Gesagard 50WP 1.1kg	2
LSD	2.42

Because it was not possible to assess the degree of scorch quantitatively this table shows the number of plots from the six replicates in which some degree of leaf scorch was present.

This table shows that considerable scorch was noted in every case where high rate Afalon was used, Trts 3, 5, 6 and 8. Low rate Afalon + high rate Gesagard, Trt 4, also had the same effect.

Table 5. Weed Control Scores: Effect of Residual Herbicides

Treatment	With residual	Without residual
1 Unsprayed control	3.33	1.67
2 Atlas Brown 3.0L + Afalon 0.6L	6.00	5.67
3 Atlas Brown 3.0L + Afalon 1.2L	7.00	5.00
4 Gesagard 50WP 1.1kg + Afalon 0.6L	7.00	7.00
5 Gesagard 50WP 1.1kg + Afalon 1.2L	7.33	7.67
6 Gesagard 50WP 0.55kg + Afalon 1.2L	7.00	7.00
7 Sovereign 1.0L + Afalon 0.6L	6.00	5.00
8 Sovereign 2.0L + Afalon 1.2L	7.00	6.67
9 Sovereign 1.0L + Gesagard 50WP 1.1kg	5.33	6.00
10 Sovereign 2.0L + Gesagard 50WP 1.1kg	6.00	6.67

Weed control efficacy score on a 0-9 scale covering both weed numbers and size, and giving an index of the competitive effect of the weeds present. 0 = no control, 9 = total control.

Although in most cases the use of a residual herbicide improved the standard of weed control, the opposite occurred in three treatments, No 5, Gesagard 50WP 1.1kg + Afalon 1.2L No 9, Sovereign 1.0L + Gesagard 50WP 1.1kg, and No 10, Sovereign 2.0L + Gesagard 50WP 1.1kg. There was no significant difference between the two areas.

Table 6. Crop Safety Scores: Effect of Residual Herbicides

Treatment	With residual	Without residual
1 Unsprayed control	8.67	8.67
2 Atlas Brown 3.0L + Afalon 0.6L	7.66	7.33
3 Atlas Brown 3.0L + Afalon 1.2L	5.33	5.66
4 Gesagard 50WP 1.1kg + Afalon 0.6L	6.00	5.33
5 Gesagard 50WP 1.1kg + Afalon 1.2L	6.00	6.00
6 Gesagard 50WP 0.55kg + Afalon 1.2L	6.67	5.66
7 Sovereign 1.0L + Afalon 0.6L	7.33	7.33
8 Sovereign 2.0L + Afalon 1.2L	5.66	6.33
9 Sovereign 1.0L + Gesagard 50WP 1.1kg	7.33	7.00
10 Sovereign 2.0L + Gesagard 50WP 1.1kg	7.00	6.33

Crop safety score on a 0-9 scale assessed crop reaction to treatments as expressed by growth and development, particularly leaf number and size, and visible leaf condition.

0 = crop killed, 9 = no crop damage.

Treatments were applied to areas with and without standard residual herbicide to test whether such use increased the risk of damage from foliar active treatments applied later to the crop. There was no significant difference between the two areas and there is no evidence from the data shown above to suggest that this occurred.

Sencorex Observation Plots

Sencorex has off-label approval for use in the umbelliferous root crop carrot and it was decided to look again at it in parsley. Following its use at damaging rates in the screen in 1997 it was tested at lower rates in a number of observation plots in 1999.

Table 7. Crop safety and weed control efficacy scores for Sencorex plots.

Treatment	Crop safety score 14 DAT	Crop safety score 27 DAT	Weed control efficacy score 14 DAT
Sencorex 0.21 kg/ha	3.17	4.17	3.83
Sencorex 0.5 kg/ha	2.50	2.83	6.16
Sencorex 1.0 kg/ha	1.17	1.50	7.17

At all three rates used the Sencorex was again damaging and only at the highest rate used did it give any useful degree of weed control.

There is little point in pursuing this herbicide further in this crop as the crop safety scores and weed control effect were of no possible commercial value.

Discussion

In 1997 eight foliar acting contact herbicides were screened singly and in mixtures on curled parsley, flat leaf parsley, dill and coriander. This work was reported in 1997 (FV 199). Two mixtures that showed particular promise, Atlas Brown + Afalon, and Gesagard + Afalon, were selected for more detailed evaluation at different rates, together with two further mixtures, Sovereign + Afalon, and Sovereign + Gesagard, which were safe in 1997 but of limited efficiency. Generally the safe treatments were not effective against the large weeds present and conversely the effective treatments were not safe and caused crop damage to start with though recovery followed in some cases.

A replicated field trial was successfully carried out in 1999. It was planned to conduct this trial in 1998 but due to problems with crop establishment the trial was held over to 1999,

when an acceptable crop of curled parsley was established in spite of persistent heavy rain before and after drilling that impaired soil structure to some extent and may have been partially responsible for a degree of crop loss due to seedling disease caused by *Pythium* spp.

The trial was divided into two areas one of which was treated with Treflan residual herbicide prior to drilling. It was intended to include a post drilling application of linuron pre-emergence but this was not possible due to adverse weather conditions.

As in 1997 the parsley was slow to grow after emergence. Consequently some weed species were large by the time the crop had reached the treatment stage of 1½ true leaves, in particular groundsel was in some cases 15 cm tall and in flower. The performance of the treatments has to be considered against this background.

Although there were no significant differences between the Gesagard + Afalon mixtures, the Atlas Brown + high rate Afalon, or the Sovereign +high rate Afalon, the Gesagard + Afalon mixtures were all effective in controlling the large groundsel, considered to be a major problem weed in umbelliferous crops and for which there is no effective existing post-emergence treatment. Treatment 5, Gesagard 50WP 1.1kg + Afalon 1.2L, the highest rates of Gesagard and Afalon in the trial gave the best overall weed control. Although the crop received a check from treatment 5, this was not significantly different to the other herbicide treatments. Halving the rates of either the Gesagard or the Afalon in this mixture reduced the weed control efficacy but did not improve crop safety.

The safest treatment was No 2, Atlas Brown 3.0L + Afalon 0.6L (the lower rate of Afalon), commonly used in commercial parsley growing. However this treatment was only moderately effective against the weed present and did not control the large groundsel. Increasing the rate of Afalon reduced crop safety with a moderate increase in weed control and considerably better control of large groundsel.

This control of large groundsel was in contrast to the results achieved in the 1997 screening where this weed species survived. This may be due to the higher rate of Afalon used in the 1999 treatments but does not explain why treatment 4, Gesagard 50WP 1.1kg + Afalon 0.6L, as used in 1997, controlled the groundsel in 1999 but not in 1997. In both years soil moisture levels were high at the time of application of treatments, but in contrast to 1997, a long warm dry period followed treatment application in 1999, which may explain the better results. Because the data suggests that increasing the rate of Afalon in the mixture (Trt 5)

improves efficiency without increasing the risk to the crop, this may be the preferred treatment for commercial application.

Low rates of Sovereign 1.0L + Afalon 0.6L, treatment 7, were safe at first assessment but the crop deteriorated by the second assessment. The higher rates of both constituents (Treatment 8) increased crop damage. Both treatments were only moderately effective weed controls.

Both combinations of Sovereign + Gesagard, treatments 9 and 10, were safe but treatment 9, Sovereign 1.0L + Gesagard 50WP 1.1kg was not an effective weed control, though treatment 10, Sovereign 2.0L + Gesagard 50WP 1.1kg, showed good control of groundsel and other weeds, but did not reduce overall weed competition.

Although the Gesagard + Afalon mixtures caused some initial leaf scorch, crop recovery took place and leaf quality in the cut crop would not be reduced as the affected leaf is too small to be harvested. The crop safety scores were not significantly different from the other herbicide treatments and only treatment 5, Gesagard 50WP 1.1kg + Afalon 1.2L was significantly different from the untreated control. Treatments 4, Gesagard 50WP 1.1kg + Afalon 0.6L , and 6, Gesagard 50WP 0.55kg + Afalon 1.2L , were both effective against the large groundsel which was beginning to compete seriously with the crop in the untreated control.

The initial check to the crop could be regarded as a necessary price to pay for the subsequent weed free conditions, this effect having been noted in earlier similar trials on cabbage, parsnips and salad onions. These experiments involved the application of two treatments a few days apart but this technique has yet to be tested in herbs. It may well be that a sequence of a less damaging treatment at the 1½ true leaf stage followed by one of the better weed control treatments will reduce the initial scorch without sacrificing weed control.

Because the mixtures were tested only on curled parsley in 1999 there is no data on the safety of the treatments on other annual herbs. It should be noted, however, that in the 1997 screening flat leaf parsley, dill and coriander were all more tolerant than curled parsley to the treatments applied in that trial.

Under the conditions under which the trial was conducted in 1999 the 42 day harvest interval required for the successful treatments had elapsed before the crop was ready to harvest. This is unlikely to be the case with the faster growing herbs such as coriander and dill.

The observation plots of Sencorex were evaluated at three low rates of 0.21, 0.5 and 1.0 kg/ha. The lowest rate of 0.21 kg/ha was ineffective and damaging to the crop and the higher rates caused extreme crop damage.

The trial was replicated on areas with and without pre-emergence residual Treflan treatments in order to test for any interaction between residual and contact herbicide in terms of efficacy and crop safety. There was no significant difference between the results obtained from the two areas.

Conclusions

Mixtures of Gesagard and Afalon show considerable promise in the control of large groundsel and other weeds when applied to curled parsley at the 1½ true leaf stage and appear to be more effective than the commonly used mixtures of Atlas Brown and Afalon (or other linuron product). The mixture of Gesagard 50WP 1.1kg + Afalon 1.2L, treatment 5, was particularly effective.

A check to crop growth and some temporary leaf scorch is likely to occur but crop recovery takes place. Leaf quality in the cut crop is not reduced as the affected leaf is too small to be harvested.

The presence of large weeds in some plots was expected to impede the harvesting process and reduce quality and yield, though no data on this aspect was obtained. In the plots treated with the best treatments no such problems were anticipated as there was little weed present.

Acknowledgements

The authors would like to offer their thanks to Peter Turner and Nick Turner of Lighthorne Herbs, for providing the site and daily crop management. Thanks are also due to the BHTA Culinary Group and the Chairman James Lamb for their interest and assistance with details of the proposal. Finally, thanks to the HDC Project Co-ordinators, Tom Davies and Charles Bransden.