Control of coppice regrowth in roadside woodlands

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Introduction

The Highways Agency has established trees by the sides of many motorways and major trunk roads in the UK. These roadside plantings are subject to a regular thinning regime to allow continued access for maintenance of essential emergency equipment, to maintain visibility of signs and at junctions, and to promote healthy trees and shrubs with low level branches for maximum screening effect (Highways Agency, 1992). Many commonly planted broadleaved tree species coppice vigorously after cutting. This regrowth is considered undesirable as it can rapidly grow to the same size as the original stem, and herbicides are commonly used by Highways Agency contractors to prevent it. Glyphosate applied to cut stumps is a commonly used treatment (Highways Agency, 1994), but it has been claimed that in some situations this practice fails to control up to 40 per cent of the stems (M. Farger, personal communication). Timing of spray after cutting, and the product used, may have a considerable impact on the effectiveness of the treatment. One possible reason for ineffective control may be too long a delay between cutting and treating of stumps.

Three experiments were set up to attempt to replicate the reported problem, and to identify the causes. Three experiments were set up to test herbicides for the control of regrowth from cut stumps following Highways Agency thinning operations in roadside (motorway and main trunk routes) woodlands. Of the herbicides tested, a 20 per cent solution in water of Arsenal 50F (50 g l⁻¹ imazapyr) gave adequate control of ash, sycamore and birch, and an 8 per cent solution in water of Timbrel (480 g l⁻¹ triclopyr) gave adequate control of ash and sycamore, though slightly poorer control of birch. Both of these treatments were more effective than Roundup Pro Biactive (360 g l⁻¹ glyphosate) applied as a 20 per cent solution in water.

However, a further trial showed that a 20 per cent solution in water of Roundup Pro Biactive gave the most effective control of existing foliar regrowth of ash. Where control of stump regrowth is required, and existing practice of applying glyphosate has proved ineffective, it is recommended that consideration be given to using an 8 per cent aqueous solution of a 480 g l⁻¹ triclopyr product as a cut stump spray, followed by a foliar spray with a 20 per cent aqueous solution of 360 g l⁻¹ glyphosate product if any regrowth occurs following treatment.

Damage resulting from translocation across root grafts has been reported elsewhere. There was no evidence to suggest any translocation of herbicides from treated stumps to untreated trees in these trials.
potentially more effective treatments. Several possible alternative herbicide products exist, but it was only possible to examine a limited number in this series of trials. It was considered desirable to confirm the effectiveness of glyphosate, and to try to re-create the reported difficulties. Triclopyr and 2,4-D + dicamba + triclopyr were chosen as herbicide actives used for control of woody weeds in forestry (Willoughby and Dewar, 1995). However, little information exists on the relative efficacy of these herbicides for the control of regrowth from cut stumps, and it was considered desirable to examine this in roadside plantings. Imazapyr is used as a pre-planting weedkiller in forestry, and for total vegetation control in amenity and industrial situations. It has shown some promise in previous trials for the control of *Rhododendron ponticum* L.¹ (Edwards and Morgan, 1996) and other woody weeds (Edwards and Morgan, 1997) when applied as cut stump sprays.

An alternative to cut stump sprays is to treat foliage regrowth. Success of such treatments is likely to be affected by the date (time of year) when the applications are made. All the herbicides mentioned are either recommended in forestry (Willoughby and Dewar, 1995), or show promise (Edwards *et al*., 1993) for use as foliar sprays, but again, comparative information on the problem species in roadside situations is sparse. It was therefore decided to test the relative efficacy of the herbicides as foliar as well as cut stump sprays.

Roots of trees of the same species grown close together can graft (fuse) together (Kramer and Kozlowski, 1979). The potential then arises for water, and also herbicide, to move from a treated stump across root grafts to an untreated tree stem and hence damage non-target trees (Strouts and Winter, 1994). All herbicides that are of use in controlling woody vegetation are readily translocated around the treated plant. Hence, it is likely that all applications to cut stumps among closely planted trees growing together for several years carry some risk of damage to non-target trees. Damage of this nature has occurred in the past on Highways Agency sites (D. Rose, personal communication). Some herbicides may be more readily translocated than others and some information on this problem can be obtained from trials set up primarily to test herbicide efficacy. Trees are however probably more at risk from spray drift and overdosing (Derr and Appleton, 1988), and it is quite possible that much reported herbicide damage results from reasons other than root translocation.

Materials and methods

Two experimental programmes were set up: one to look at cut stump treatments and the other to look at the treatment of foliar regrowth.

The cut stump work was carried out at three experimental sites. One site was on the side of a cutting on the westbound M4 motorway near Chieveley (Grid Reference SU477729). The roadside had a slope of up to 30°, and the main ground vegetation was a grass cover, with some bramble (*Rubus fruticosus* L.) and ragwort (*Senecio jacobaea* L.). Thick natural regeneration of ash (*Fraxinus excelsior* L.) 2–5 m tall, 4–12 cm in diameter at ground level, was the species treated; among this were planted specimens of oak (*Quercus* spp.), willow (*Salix* spp.) and aspen (*Populus tremula* L.). Rainfall was around 580 mm per year. Another site was located at Popham Down Copse, near Woodmancott, Hampshire (Grid Reference SU574440). The site was flat and comprised mature oak and ash woodland, with bluebell (*Hyacinthoides non-scripta* (L.) Chonard ex Rothm.), nettle (*Urtica* spp.) and dog's mercury (*Mercurialis perennis* L.) as ground vegetation. Sycamore (*Acer pseudoplatanus* L.) had invaded the site and was the species treated – it was on average around 5–8 m in height, with most diameters in the range 6–15 cm at ground level. Rainfall was approximately 580 mm per year. The third site was located within Alice Holt Forest, Hampshire (Grid Reference SU811423). The site was gently sloping, and composed of regrown/reseeded birch (*Betula* spp.) trees, which were the species treated. The birch were around 4–5 m in height, and 7–10 cm in diameter at ground level. Ground vegetation was sparse, and consisted of bramble and bracken (*Pteridium aquilinum* (L.) Kuhn). Rainfall was approximately 630 mm per year.

¹ Nomenclature throughout follows Stace (1991).
At each site, 30 plots of nine treatment trees (ten at Alice Holt) were marked out on the ground, with each tree being individually labelled, and the plot marked on the ground. Plots were located so that, as far as was possible, there were untreated stems left adjacent to the nine (or ten) treated trees. There were two replicates (blocks) at each site. Identified trees were felled between 19 and 21 March 1996, and each tree stump was then sprayed with one of the following herbicide treatments in aqueous solution:

- **H0** – Control, no application
- **H1** – 360 g a.i.l⁻¹ glyphosate (Roundup Pro-Biactive) as a 20 per cent solution
- **H2** – 480 g a.i.l⁻¹ triclopyr (Timbrel) as an 8 per cent solution
- **H3** – 200:85:65 g a.i.l⁻¹ 2,4-D + dicamba + triclopyr (Broadshot) as a 15 per cent solution
- **H4** – 50 g a.i.l⁻¹ imazapyr (Arsenal 50F) as a 20 per cent solution

Applications were sprayed to the point of runoff with knapsack sprayers using green polijet nozzles at 1 bar pressure, at the following times after cutting:

- **T1** – Within 1 hour of felling (effectively ‘immediately after felling’)
- **T2** – 24 hours after felling
- **T3** – 1 week after felling

The application date was chosen to avoid time of spring sapflow, which can reduce efficacy by preventing herbicide penetration into the stump. All applications were made in frost-free conditions, with very low wind speed to reduce the possibility of drift. A very light drizzle occurred during the day of the first and second (T1 and T2) applications at Chieveley and the day of the second (T3) application at Woodmancott. This was sufficiently light and sporadic to be judged to have had very little effect on the treatments. The stumps treated 1 week after felling (T3) were covered with small plastic covers to prevent wash-off of herbicide from rainfall that occurred soon after spraying. These covers were removed a week later.

Health and survival of treated stumps and adjacent trees, was assessed on 17–19 June 1996. Trees were allocated a score of 1–5 with 1 being fully healthy and 5 being dead. This assessment was repeated on 16–19 September 1996, when the height of any regrowth from treated stumps was also measured. The diameter of each treated stump was also measured, to determine if this affected the efficacy of treatment.

The second programme of experimental work was set up to investigate the treatment of regrowth from previously cut stumps. One site was used – the side of a cutting of the northbound M23 motorway (Grid Reference TQ308463). The site was steeply sloping (40°), and ground vegetation was mainly grasses, bramble and willow herb (Epilobium spp.). Rainfall was approximately 650 mm a⁻¹. Among apparently planted cherry (Prunus spp.) and Norway maple (Acer platanoides L.), there was abundant natural regeneration of ash and sycamore. Much of the ash had re-grown from cut-over stumps (probably 1–2 years previously), was primarily single stemmed, and around 1–3 m in height with stump diameters between 10 cm and 30 cm.

On 14–15 May 1996 two blocks (replicates), comprising 30 plots of nine trees each, were identified and marked on the ground. Regrowth above safe spraying height was cut back to around 1.8 m, and each tree labelled individually. Trees were sprayed with one of the following four treatments using aqueous solutions:

- **H0** – Control, no application
- **H1** – 360 g a.i.l⁻¹ glyphosate (Roundup Pro-Biactive) as a 20 per cent solution
- **H2** – 480 g a.i.l⁻¹ triclopyr (Timbrel) as an 8 per cent solution
- **H3** – 200:85:65 g a.i.l⁻¹ 2,4-D + dicamba + triclopyr (Broadshot) as a 15 per cent solution
- **H4** – 50 g a.i.l⁻¹ imazapyr (Arsenal 50F) as a 20 per cent solution

Tree foliage was sprayed with knapsack sprayers fitted with green polijet nozzles, at 1 bar pressure, to the point of runoff, in dry, wind-free conditions. The rates used were the same as those in the cut-stump experimental work, which was higher than originally intended. It was anticipated therefore that level of control might be very good, with few identifiable differences in treatments. Applications were made at one of three treatment dates on 30 May 1996, 25 June 1996 and 30 July 1996, to assess the extent of any differences.
arising from treatments as different times or
growth stages of trees.

Health, and hence survival, of treated regrowth
was assessed on 19 September 1996. Trees were
allocated a score of 1–5, with 1 being completely
healthy and 5 being dead. The diameter of each
treated stem was also measured, to determine if
this affected efficacy of treatment.

Data was subject to analysis of variance using
GENSTAT (Genstat 5 Committee, 1993). The \( P \)
value produced indicates the level of probability
at which the overall variation in the means could
not be produced by chance. Fisher's Least Signifi-
cant Difference test was then performed – those
treatment means differing by more than the l.s.d.
given are significantly different at the \( P = 0.05 \)
level. Survival data were transformed to angles to
allow the assumptions of normality for analysis
of variance to be met.

Results

Stump treatment
All herbicide treatments significantly reduced the
survival of treated stumps compared with the
control \((P < 0.05)\) (Tables 1–3). In addition, at all
sites, triclopyr, 2,4-D + dicamba + triclopyr and
imazapyr all significantly reduced survival more
than glyphosate \((P < 0.05)\). The only exception to
this was at the Alice Holt site, where 2,4-D +
dicamba + triclopyr did not differ significantly
from the glyphosate treatment. Fewer than 10 per
cent of the ash and sycamore survived after treat-
ment with triclopyr, 2,4-D + dicamba + triclopyr
or imazapyr but these treatments were less effec-
tive on the birch at Alice Holt, where only imaza-
pyr (15 per cent survival) gave good results.

Height of regrowth and health of treated stumps
reflected the trend in the survival figures. Again,
all herbicides significantly reduced regrowth
height or health compared with the control \((P <
0.05)\). There was little difference in the effects on
height of regrowth between herbicides, but tri-
clopyr, 2,4-D + dicamba + triclopyr or imazapyr
affected health significantly more than glyphosate
on all three species, and on the birch at Alice
Holt, imazapyr was significantly more effective
than the other herbicides \((P < 0.05)\).

Few consistent significant effects from timing
were identified. On the ash at Chieveley, survival
after the earliest application timing (25.7 per
cent) was significantly lower than after the latest
application timing (48.3 per cent) \((P < 0.05)\).
However, this trend was not repeated in health

### Table 1: Mean survival and health of stumps, and height of regrowth for sycamore at Woodmancott, September 1996

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mean survival</th>
<th>Mean height of regrowth</th>
<th>Mean health of stump</th>
<th>Mean health of adjacent untreated stumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100.0</td>
<td>33.9</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>26.7</td>
<td>4.0</td>
<td>4.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>1.7</td>
<td>0.4</td>
<td>5.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2,4-D + dicamba + triclopyr</td>
<td>8.3</td>
<td>1.4</td>
<td>4.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>3.3</td>
<td>3.4</td>
<td>4.9</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>(\text{res d.f.} = 13)</td>
<td>(\text{s.e.d.} = 5.61)</td>
<td>(\text{s.e.d.} = 2.10)</td>
<td>(\text{s.e.d.} = 0.15)</td>
</tr>
<tr>
<td></td>
<td>(t = 2.17)</td>
<td>(\text{l.s.d.} = 12.17)</td>
<td>(\text{l.s.d.} = 4.56)</td>
<td>(\text{l.s.d.} = 0.33)</td>
</tr>
</tbody>
</table>

s.e.d., standard error of difference of means.
l.s.d., least significant difference of means \((P < 0.05)\).

\* s.e.d. refers to survival data transformed to angles given in brackets.
scores, and the trend was reversed for height of regrowth, with the greatest regrowth occurring after the first application timing. There were no consistent significant timings or timing × herbicide interactions at the other two sites. Diameter of stumps had little effect on efficacy of treatments – although this measure was used as a covariate, it had no significant impact on results ($P > 0.05$).

Health of adjacent untreated stems was significantly worse after imazapyr treatments compared with the control or any other herbicide treatments ($P < 0.05$) at Chieveley. However, no herbicide treatments resulted in health scores increasing

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**Table 2:** Mean survival and health of stumps, and height of regrowth for ash at Chieveley, September 1996

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mean survival (%)</th>
<th>Mean height of regrowth (cm)</th>
<th>Mean health of stump</th>
<th>Mean health of adjacent untreated stumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100.0 (90.0)</td>
<td>82.0</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>58.3 (48.1)</td>
<td>3.9</td>
<td>4.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>8.3 (8.0)</td>
<td>2.4</td>
<td>4.9</td>
<td>1.1</td>
</tr>
<tr>
<td>2,4-D + dicamba + triclopyr</td>
<td>16.7 (18.7)</td>
<td>3.4</td>
<td>4.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>6.3 (10.6)</td>
<td>0.9</td>
<td>4.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>

res d.f. = 13

$s.e.d.$ = 7.06 $s.e.d.$ = 3.37 $s.e.d.$ = 0.11 $s.e.d.$ = 0.17

$t = 2.17$

l.s.d. = 15.32 l.s.d. = 7.31 l.s.d. = 0.24 l.s.d. = 0.37

s.e.d., standard error of difference of means.

l.s.d., least significant difference of means ($P < 0.05$).

* $s.e.d.$ refers to survival data transformed to angles given in brackets.

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**Table 3:** Mean survival and health of stumps, and height of regrowth for birch at Alice Holt, September 1996

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mean survival (%)</th>
<th>Mean height of regrowth (cm)</th>
<th>Mean health of stump</th>
<th>Mean health of adjacent untreated stumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>98.3 (86.0)</td>
<td>77.5</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>75.0 (61.4)</td>
<td>26.5</td>
<td>3.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>42.2 (39.7)</td>
<td>25.5</td>
<td>4.0</td>
<td>1.1</td>
</tr>
<tr>
<td>2,4-D + dicamba + triclopyr</td>
<td>51.7 (47.4)</td>
<td>20.0</td>
<td>4.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>15.0 (15.8)</td>
<td>5.2</td>
<td>4.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

res d.f. = 13

$s.e.d.$ = 9.54 $s.e.d.$ = 6.82 $s.e.d.$ = 0.20 $s.e.d.$ = 0.09

$t = 2.17$

l.s.d. = 20.70 l.s.d. = 14.80 l.s.d. = 0.63 l.s.d. = 0.20

s.e.d., standard error of difference of means.

l.s.d., least significant difference of means ($P < 0.05$).

* $s.e.d.$ refers to survival data transformed to angles given in brackets.
above 1.8 – i.e. no unacceptable herbicidal effects were observed on adjacent untreated stumps.

Overall, triclopyr and imazapyr consistently gave the best control using cut-stump sprays.

Foliar applications

For the foliar applications to ash at Redhill, compared with the control, survival was significantly reduced by all herbicides except for imazapyr (Table 4). Glyphosate gave the best control, although this was not statistically significantly better than triclopyr or 2,4-D + dicamba + triclopyr. Health of the treated regrowth was significantly affected by all herbicides (P < 0.05). Glyphosate, triclopyr and 2,4-D + dicamba + triclopyr were more effective than imazapyr.

Discussion

The results clearly show that, as reported from operational work, a single application of glyphosate to cut stumps at the recommended rate (20 per cent solution) may provide inadequate control of unwanted woody regrowth. Of the three more effective alternatives tested, imazapyr consistently gave the best results. However, imazapyr kills most vegetation, and there was evidence of it creeping in the soil around treated stumps, to kill both desirable ground vegetation and affect adjacent stumps. Triclopyr was also extremely effective on ash and sycamore stumps, although less so on birch. Triclopyr has the advantage that grass surrounding the treated stump will remain largely unaffected – the visual impact of the herbicide will therefore be minimized. 2,4-D + dicamba + triclopyr was slightly less effective, and since these trials have been completed the manufacturers announced that Broadshot will be phased out of production. A similar product, Nufarm Nu-Shot, with the same active ingredients, has recently been approved.

Surprisingly, for all products, time of application after cutting seemed to have little impact on effectiveness of control.

It would be unwise to interpolate from the study that stump treatment can be delayed for long periods after cutting. Previous experience (Willoughby and Dewar, 1995) would suggest that in usual working practice stumps should be treated within 1 week of cutting. However, given the incidence of poor results from field scale applications mentioned earlier, pending further research it would be prudent to maintain a stipulation that applications are made within 24 hours of cutting, while accepting the fact that other factors such as time of year or prevailing weather conditions may have an equally large impact on the success of the treatment.

Applications were made between 19 and 21 March because sites were not identified until relatively late in the winter. The timing used avoided peak spring sap flow, but was towards the end of the manufacturers’ recommended timings for applications of triclopyr and glyphosate. Glyphosate gave relatively poor control in these trials, but it may prove more effective if applied earlier in the winter (Darrall, 1988). All these trials show conclusively is the relative efficacy of the herbicides applied in March. It is likely that the relative efficacy of the different herbicides would be similar earlier on in the winter, but further trials would be required to confirm this.

Few herbicidal symptoms were observed on untreated trees adjacent to treated stumps. The very infrequent damage that did occur was probably the result of imazapyr movement in the soil.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mean survival (%)</th>
<th>Mean health of regrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100.00</td>
<td>1.4</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>22.2</td>
<td>4.7</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>29.6</td>
<td>4.6</td>
</tr>
<tr>
<td>2,4-D + dicamba + triclopyr</td>
<td>40.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>75.9</td>
<td>3.7</td>
</tr>
</tbody>
</table>

s.e.d., standard error of difference of means.

l.s.d., least significant difference of means (P < 0.05).

* s.e.d. refers to survival data transformed to angles given in brackets.

<table>
<thead>
<tr>
<th>res. d.f. = 13</th>
<th>s.e.d.* = 12.30</th>
<th>s.e.d. = 0.26</th>
</tr>
</thead>
<tbody>
<tr>
<td>t = 2.17</td>
<td>l.s.d. = 26.69</td>
<td>l.s.d. = 0.56</td>
</tr>
</tbody>
</table>
It is possible that on very steep slopes, and with very wet weather, this lateral movement of herbicide could be greater. For this reason, it is prudent not to use imazapyr as part of thinning operations. No evidence was found of translocation of herbicide across root grafts from treated to untreated stems. Further work would be required to investigate this phenomenon further, but based upon the thousand stems safely treated with a variety of chemicals in this experimental programme, it appears to be a relatively rare event in ash, sycamore and birch.

Within the ash foliar treatments, glyphosate gave the best control of existing regrowth. The application rate used (20 per cent solution) is higher than recommended on the label, but is permitted under UK pesticide legislation so long as the total amount of chemical used per hectare does not exceed 10 l (NAAC and NTC, 1991). Triclopyr was almost as effective as glyphosate so could be an acceptable alternative. However, given that glyphosate is cheaper and is less hazardous to operators when making applications at waist height or above, it is probably the best option. Imazapyr gave disappointingly poor control, but it is possible that greater kill would be evident in the following growing season. Even with the great care that was taken in these trials, herbicide drift occurred, which made assessment of any translocation of herbicide by root grafting impossible for the foliar spray work.

For the foliar treatment, time of year of application (end of May to end of July) appeared to have little effect on herbicide efficacy. Due to the time involved in gaining the contract and locating the site, it was not possible to treat regrowth in the winter, i.e. outside manufacturers’ recommendations for optimum timing. The experimental work has confirmed that applications during the growing season are effective, but has not shown that applications by contractors at inappropriate times of year are leading to difficulties in control. Thus there is no reason to change the manufacturers’ recommendations, which generally are for applications to actively growing foliage between July and September.

Although there was no direct comparison of stump and foliar treatments it can be seen that the foliar sprays were less effective and offered more potential for herbicide drift and risks to operators than cut-stump applications, even though the same rates were used. Cut-stump applications should be the preferred method of treatment after cutting, and foliar sprays reserved for subsequent repeat treatment of any surviving stems.

To summarize, for treatments in early March, applications of 480 g l\(^{-1}\) triclopyr as an 8 per cent solution, or 50 g l\(^{-1}\) imazapyr as a 20 per cent solution, were more effective cut-stump treatments to prevent woody regrowth of ash, sycamore and birch than applications of 360 g l\(^{-1}\) glyphosate as a 20 per cent solution. Applications are best made within 24 hours of cutting. Cut-stump treatments offered better opportunities for control of unwanted woody regrowth than foliar sprays. Birch appeared to be somewhat more resistant than ash or sycamore, but imazapyr gave consistently good control nevertheless.

When foliar sprays are required to control surviving woody regrowth following cut-stump treatments, glyphosate was the most effective herbicide tested. Approved glyphosate products have a lower hazard rating for operators than the other products trialled, and are therefore better suited than them for foliar sprays.

Translocation of herbicides through root grafts seems to be a comparatively rare event, but could be examined further with specific research programmes designed to address the problem, probably through the use of pot trials in glasshouses.

**Conclusions**

To prevent unwanted woody regrowth, when existing practice of applying a 20 per cent solution of 360 g l\(^{-1}\) glyphosate has proved ineffective, cut stumps should be treated with a 8 per cent solution of 480 g l\(^{-1}\) triclopyr within 24 hours of cutting, in dry, wind- and frost-free conditions. To aid identification of treated stems a suitable dye, such as Red/Scarlet dye available from Hortichem Ltd, or Dyon available from Rhone-Poulenc, could be added to the solution. A record should be kept of total herbicide used – a maximum application rate of 10 l ha\(^{-1}\) is permitted, for each application. A maximum of two applications per year are allowed. It is unlikely that this level will be exceeded in any applications, but if it is, alternative herbicides should be used to complete the operation. Applications can be made at any time of year outside the time of spring sap flow. Best
control will probably be achieved by applications from October to February.

If birch or other species prove consistently difficult to kill, 50 g l⁻¹ imazapyr as a 20 per cent solution might be considered as an effective alternative treatment. However, until more information is known about herbicide movement in the soil, imazapyr should only be considered when other treatments have repeatedly proved to be ineffective, and not as part of any thinning operation.

If some stems do regrow after cut-stump treatment, then either recut the stems and treat as outlined above, or spray foliage to the point of runoff with a 20 per cent solution of 360 g l⁻¹ glyphosate, between May and August.

Foliar sprays are more likely to result in herbicide drift, or contamination of operators, particularly if regrowth is above waist height. Control is also likely to be poorer. Treatment of regrowth is, however, cheaper than recutting and treating surviving stems.

Triclopyr, imazapyr and glyphosate all have full Pesticide Safety Directorate approval for use in forestry or industrial situations, and hence can be used on roadside verges (NAAC and NTC, 1991) (Godson, 1996).

Acknowledgements

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References


National Association of Agricultural Contractors (NAAC) and National Turfgrass Council (NTC) 1991 Code of Practice for the Use of Approved Pesticides in Amenity and Industrial Areas. ISBN 1871140129.


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