Quarterly
Journal of Forestry

The Official Publication of
THE ROYAL FORESTRY SOCIETY
OF
ENGLAND, WALES AND NORTHERN IRELAND

ISSN 0033 – 5568

Reprinted from
QUARTERLY JOURNAL OF FORESTRY
Vol.91 No.3 July 1997

GLYPHOSATE RAIN FASTNESS

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SUMMARY

Various new glyphosate formulations and additive combinations were tested for efficacy and rain fastness when applied to grasses, clover and *Rhododendron*. It is concluded that if rainfall is expected soon after application, the preferred option would be to apply conventional glyphosate with Mixture B, as a directed spray. A minimum rain-free period of six hours, but preferably 24 hours, should be aimed for. This is also the most effective glyphosate treatment combination to control *Rhododendron*.

Introduction

In the wetter parts of Britain, finding a suitable weather window for herbicide applications can be particularly problematic. Glyphosate is the most widely-used herbicide in UK forestry, with over 20,000 litres being applied each year. To be fully effective it requires a rain-free period of at least six hours, but preferably 24 hours, after application (Monsanto, 1995). Current recommendations are to apply 2 per cent of the additive Mixture B to the spray solution if rainfall is expected within 24 hours of application (Willoughby and Dewar, 1994). Mixture B is a mixture of hydrophilic (water soluble), and hydrophobic (oil soluble), non-ionic surfactants, which was developed by the Weed Research Organisation for the Forestry Commission. It has proven to be extremely effective at improving efficacy, uptake and hence rain fastness of glyphosate applications, particularly on problem weeds such as *Rhododendron* (Tabbush *et al*, 1986).

However, there is some evidence to suggest that organosilicone surfactants such as Silwett L77 and non-ionic ethoxylated alcohol surfactants such as Galion may be as effective on grasses (Clay and Lawrie, 1990). Polyethoxylated tallowamine adjuvants such as Hyspray which have recently become available have not previously been compared with Mixture B. Synthetic latex stickers such as Bond, developed to make fungicides more rain fast, may have potential for use with herbicides, but this has not yet been subject to test.

Several new glyphosate products have recently come on to the market. Roundup Pro Biactive is a glyphosate formulation which has no hazard rating, and is not harmful to fish. It is claimed that, compared with conventional glyphosate formulations, uptake (and hence rain fastness) is improved (Monsanto, 1995). Touchdown LA contains a trimesium salt of glyphosate, combined with an alkylpolyglucoside adjuvant system. It is claimed that this significantly increases speed of uptake and hence rain fastness, compared with conventional glyphosate. However, the recommended rain-free period is still six hours (Zeneca). Hilite is a Nomix Chipman product formulated as an oil emulsion to reduce spray drift, which may also significantly improve rain fastness.

This paper describes an experiment to compare the relative efficacy and rain

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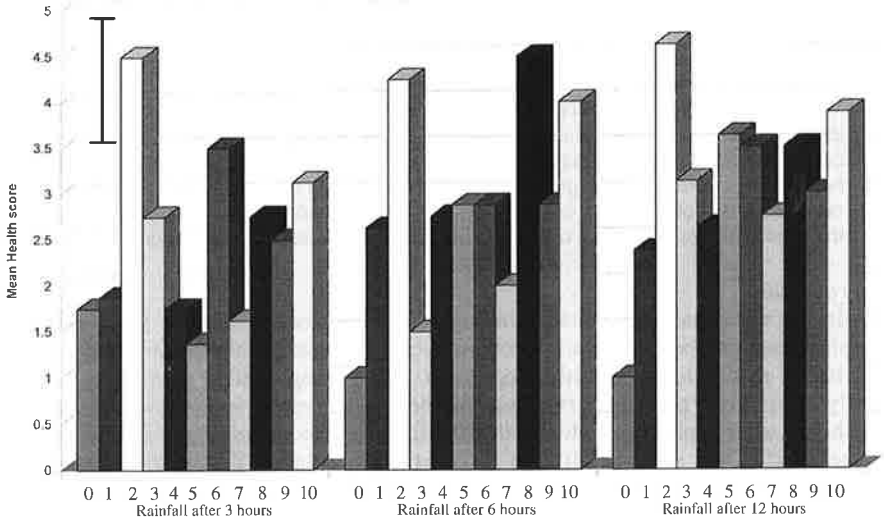
Figure 1. Rhododendron ponticum health at 30 July 1996.



The bar in the top left-hand corner gives least significant difference at 95 per cent, ie means differing by more than the length of the bar are significantly different at P<0.05. The bars representing each treatment are shown in the order H0, H1, H2...H10.

fastness of various glyphosate/additive options.

Materials and Methods

A replicated experiment was laid out in 1995 at Headley Nursery, Hampshire. Plots of annual meadow grass (*Poa annua*), crimson clover (*Trifolium incarnatum*) and wavy hair grass (*Deschampsia flexuosa*) were sown at the end of May. At the same time, plots comprising four 30-60 cm tall *Rhododendron* transplants were planted. The plots were sprayed on 21 September 1996 with one of the following herbicides:

H0 – Control

H1 – Roundup (standard formulation containing 360 g/litre isopropylamine salt of glyphosate)

H2 – Roundup and Mixture B at 2 per cent of final spray volume (non-ionic surfactant containing 500 g/litre nonyl phenol ethylene oxide condensate and 500 g/litre primary alcohol ethylene oxide condensate)

H3 – Roundup and Hyspray at 1 per cent of final spray volume (cationic surfactant containing 800 g/litre polyethoxylated tallow amine)

H4 – Roundup and Bond at 0.14 per cent of final spray volume (450 g/litre synthetic latex to 'stick' herbicide to vegetation)

H5 – Roundup Pro Biactive (new Monsanto 360 g/litre glyphosate formulation)

H6 – Roundup Pro Biactive and Mixture B at 2 per cent of final spray volume

H7 – Hilite (a Nomix Chipman oil emulsion containing 144 g/litre glyphosate)

H8 – Touchdown (new Zeneca formulation containing 480 g/litre glyphosate trimesium salt – equivalent in rates to 330 g/litre conventional glyphosate)

H9 – Touchdown and Hyspray at 2 per cent of final spray volume

Figure 2. Poa annua health at 16 November 1995.

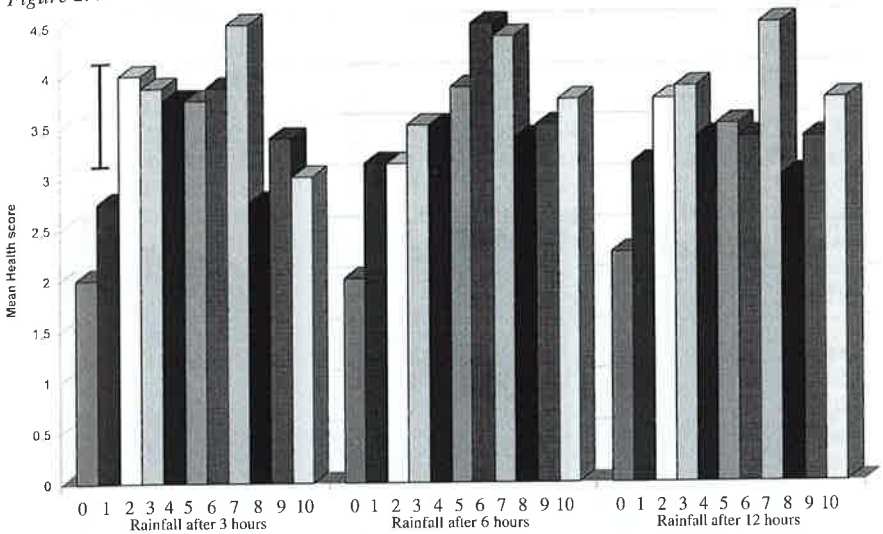


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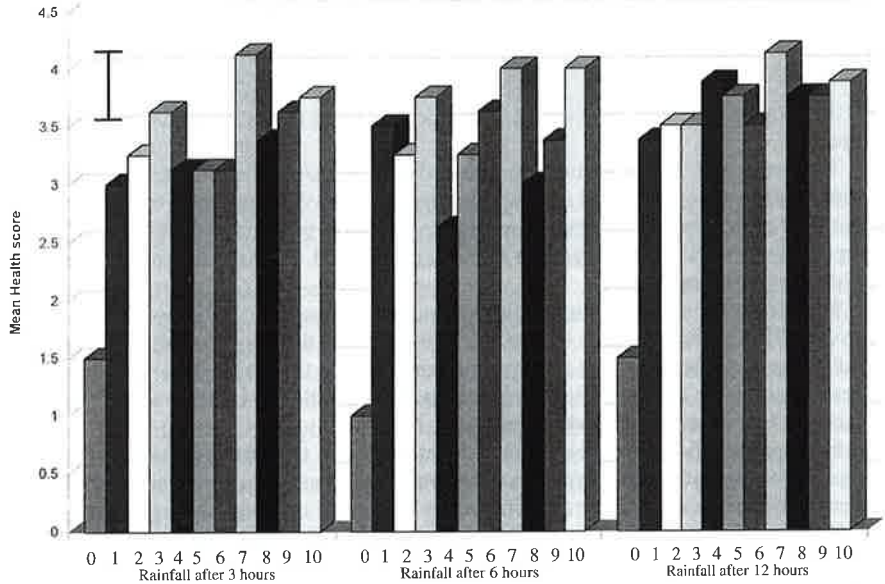
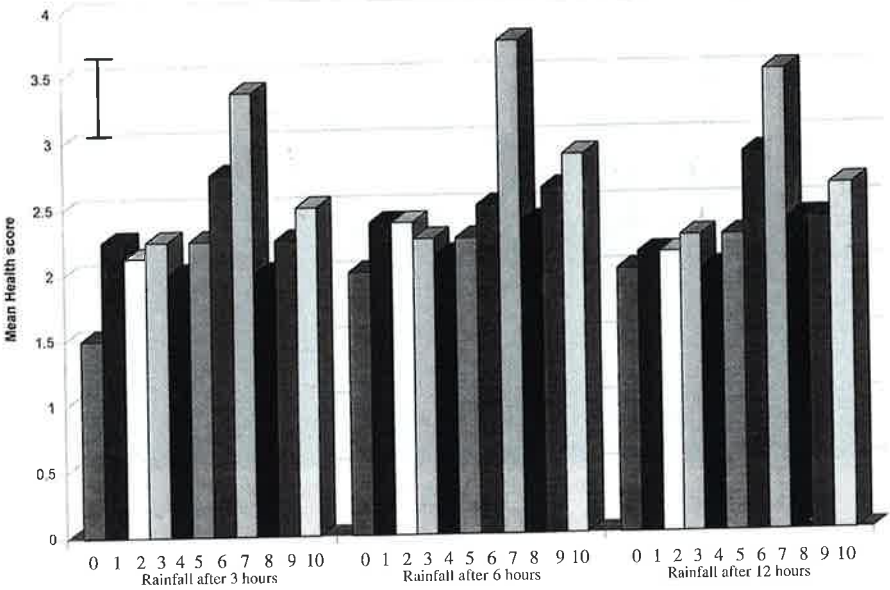
Figure 3. Trifolium incarnatum health at 16 November 1995.



The bar in the top left-hand corner gives least significant difference at 95 per cent, ie means differing by more than the length of the bar are significantly different at P<0.05. The bars representing each treatment are shown in the order H0, H1, H2...H10.

Figure 4. Deschampsia flexuosa health at 16 November 1995.



The bar in the top left-hand corner gives least significant difference at 95 per cent, ie means differing by more than the length of the bar are significantly different at P<0.05. The bars representing each treatment are shown in the order H0, H1, H2...H10.

H10 – Touchdown and FD4459 at 2 per cent of final spray volume (experimental adjuvant).

The grass and clover plots were sprayed at 2 litres/ha of product, equivalent to 0.66 kg/ai/ha of conventional isopropylamine salt, or 0.96 kg/ai/ha of trimesium salt. The *Rhododendron* was treated with 10 litres/ha of product, or 3.6 kg/ai/ha isopropylamine salt or 4.8 kg/ai/ha trimesium salt. All applications were made at a volume of 200 litres/ha.

The Hilite formulation was applied through a 'superpro' lance applicator. This proved difficult to calibrate to the rates required in this experiment, and swathe width was variable, resulting in approximately double the target dose rate of active ingredient being applied. For this reason the results for treatment H7 are not comparable with any of the other treatments.

Each of the 264 plots were then subject to 6 mm of artificial rainfall over 60 minutes through overhead irrigation. This was applied at either three, six or 12 hours after the herbicide applications. Buffer zones prevented drift to non-target plots.

Plant condition was assessed before application, then two, four, six and eight weeks after application. Health was scored on a scale of 1 = healthy to 5 = dead. The *Rhododendron* plots were also assessed in the following growing season on 30 July 1996.

Data were analysed by analysis of variance.

Results

Figures 1-4 show end of season health scores for *Rhododendron ponticum*, *Poa annua*, *Trifolium incarnatum* and *Deschampsia flexuosa*, respectively. Looking at all herbicides H0-H10 together, there was no statistical difference between applications made with rainfall at three, six or 12 hours after treatment ($P>0.05$). Rainfall apparently caused no overall reduction in herbicide effectiveness. Within the Rhododendron plots, all herbicides significantly reduced the health of the plants compared with the control when rainfall was delayed for 12 hours ($P<0.05$). However, only Roundup with Mixture B (H2) gave an acceptable level of control (mean health 4.5). This treatment also gave satisfactory control within the three- and six-hour rainfall treatments. None of the other treatments consistently gave satisfactory control, although Touchdown (H8) and Touchdown and FD4459 (H10) achieved a mean health of more than 4 within the six-hour rainfall treatment.

Within the *Poa annua*, averaging across all the rainfall treatments, all herbicide treatments significantly reduced health, compared with the control ($P<0.05$). However, only Roundup with Mixture B (H2) within the three-hour rainfall treatment and Roundup Pro Biactive with Mixture B (H6) within the six-hour treatment gave anything consistently near adequate levels of control (health of 4 or greater). Overall, treatment H6 gave the best control.

Within the *Trifolium incarnatum* plots, averaging across all rainfall treatments, all herbicides significantly damaged the vegetation as compared with the control ($P<0.001$). However, there was little variation between treatments, and none of the herbicides gave adequate control at the rates tested.

Within the *Deschampsia flexuosa* plots, averaging across all rainfall treatments, all herbicides except Roundup with bond (H4) significantly reduced the health of the vegetation compared with the control ($P<0.001$). Although on average Roundup Pro Biactive with Mixture B (mean of 2.71) and Touchdown with FD4459 (mean of 2.67) were more damaging than the other herbicides, none of the treatments gave adequate control at the rate tested.

Discussion

One of the main aims of this experimental work was to determine the relative rain fastness of various glyphosate formulations and additive combinations. The lack of any significant rainfall effect makes this comparison difficult. Most of the treatments with rainfall three hours after application were equally effective when rainfall was applied 12 hours after spraying. However, it is unwise to extrapolate this result to field conditions. In this experiment, all weeds were relatively young, actively growing and were not under any form of moisture or nutrient stress. This is unlikely to be the case in all field situations, and control generally is likely to be poorer. In addition, although the artificial rainfall applied attempted to simulate quite heavy natural rainfall, conditions such as summer showers could produce heavier rainfall, bigger water droplets and hence greater runoff of herbicide, and reduced levels of control.

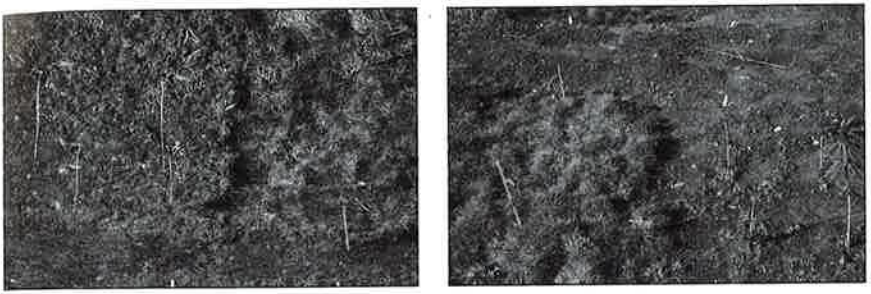
Within the *Deschampsia* and *Trifolium* plots, no herbicides gave adequate levels of control. This does not mean that the treatments would fail to give suitable control at higher application rates – indeed Hilite (H7) gave adequate control in the clover plots as it was effectively applied at 5 litres/ha, although *Deschampsia* can be difficult to control effectively with any glyphosate treatment. What the results do

Foreground shows poor control of Poa annua with application of Roundup followed by rainfall three hours later. Better control can be seen in the plots in the background, where rainfall was delayed until 12 hours after herbicide application.

give us is a comparison in the effectiveness of the different herbicides.

Touchdown with FD4459 and Roundup Pro Biactive with Mixture B were more effective than the other herbicides on *Deschampsia* ($P<0.001$). Within the *Poa annua* plots, Roundup Pro Biactive with Mixture B and Roundup with Mixture B appeared to be most effective, but they were not statistically significantly different ($P>0.05$). Generally, for the *Poa*, *Deschampsia* and *Trifolium* plots, there were few clear advantages to using any of the herbicides tested rather than another.

A clearer pattern is evident within the *Rhododendron* plots. Within these treatments, the maximum permitted rate of glyphosate was used, and only Roundup



Left-hand photo shows good control of Rhododendron after application of Roundup with Mixture B, compared with poor control with just Roundup applied shown in the right-hand photo.

with Mixture B consistently gave adequate control. Roundup Pro Biactive with Mixture B (mean health score 3.29), Touchdown (mean health score 3.58) and Touchdown with FD4459 (mean health score 3.60) were significantly more effective than conventional Roundup (mean health score 2.292). With a mean health score of 4.46, Roundup with Mixture B was significantly more effective than any of the other treatments ($P<0.05$).

Conclusions

For controlling *Rhododendron*, users should continue to apply Roundup (or any equivalent conventional formulation) at 10 litres/ha with Mixture B at 2 per cent of the final spray volume.

For controlling grass and herbaceous weeds, there appeared to be little difference between different glyphosate formulations. The most effective control is likely to be gained from using Roundup with Mixture B, Roundup Pro Biactive with Mixture B or Touchdown with FD4459. Neither Touchdown nor additive FD4459 is currently commercially approved for use in forestry situations.

Hilite at 5 litres/ha effectively controlled all grass and herbaceous species tested. No conclusions can be drawn about its relative efficacy compared with other glyphosate formulations.

Rainfall after three hours is unlikely to significantly affect efficacy, as long as weeds are relatively young, actively growing and not under stress at the time of application. In practical field situations, a minimum rainfall-free period of six hours, and preferably 24 hours, should still be aimed for.

Recommendations

Rhododendron

Apply conventional glyphosate formulations (360 g/litre isopropylamine salt of glyphosate) at 10 litres/ha with Mixture B at 2 per cent of final spray volume. The use of imazapyr may be more effective at controlling *Rhododendron* (Edwards *et al*, 1993; Willoughby and Dewar 1995).

Grass and herbaceous weeds, overall spray

Apply conventional glyphosate or Roundup Pro Biactive at 1.5-2 litres/ha.

Grass and herbaceous weeds, directed or pre-plant spray

Apply conventional glyphosate or Roundup Pro Biactive at 3-5 litres/ha.

Deschampsia

Deschampsia is difficult to control with glyphosate, although directed applications of 5 litres/ha may be satisfactory. Alternatives such as cycloxidim or imazapyr may be more appropriate – refer to Willoughby (1996).

General

Touchdown at 3-5 litres/ha is a satisfactory alternative as a directed or pre-plant spray but is **NOT APPROVED FOR USE IN FORESTRY SITUATIONS**.

Hilite is a suitable alternative as a directed or pre-plant spray against grass and herbaceous weeds, which may be more expensive than other glyphosate formulations.

Roundup Pro Biactive has no hazard rating and is not harmful to fish. This may justify its use instead of cheaper generic glyphosate products in some situations. This benefit is lost when Mixture B is added to the mix.

Rain fastness

If rain is expected within six hours, use Roundup (or an alternative generic glyphosate formulation) with Mixture B at 2 per cent of the final spray volume. Always aim for a minimum rain-free period of six hours, and preferably 24 hours, after spraying. For herbaceous or woody weeds, consider using triclopyr, which is likely to be rain fast in two hours.

NEVER OVERSPRAY CROP TREES WITH ANY GLYPHOSATE PRODUCT WHEN USING MIXTURE B.

Acknowledgements

John Budd and the team at Headley Nursery carried out the experimental work. Tracy Houston and Juliet Streeter provided the statistical analysis. Bob Farmer and Gary Kerr made helpful comments on the text. Zeneca Crop Protection kindly supported some of the experimental work.

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