FIELD ASSESSMENT OF HERBICIDES TO RELEASE NATIVE PLANTS FROM WEEDS

K.C. HARRINGTON and S.J. GREGORY

Institute of Natural Resources, Massey University, Palmerston North, New Zealand

Corresponding author: K.Harrington@massey.ac.nz

ABSTRACT

A range of herbicide treatments was applied to 0.5 m^2 zones around native plants, 6 weeks after being transplanted into ungrazed pasture for revegetation purposes. The species studied were toetoe (*Cortaderia fulvida*), mountain flax (*Phormium cookianum*), purei (*Carex secta*), ribbonwood (*Plagianthus regius*), koromiko (*Hebe stricta*) and manuka (*Leptospermum scoparium*). Glyphosate was applied around all species using a half-bucket to shield the native plant, and this was the cheapest and often most effective treatment. A mixture of clopyralid and haloxyfop was tolerated by most species on which this was tested, apart from slight damage to ribbonwood. However, a mixture of simazine and haloxyfop was also tolerated by all native species other than the toetoe, controlled most weeds well and gave longer weed control than the clopyralid/haloxyfop or glyphosate treatments. Other herbicides were also tolerated by some species.
Keywords: herbicide tolerance, native plants, revegetation, amitrole, simazine, clopyralid, haloxyfop, glyphosate, terbuthylazine.

INTRODUCTION

Native New Zealand plants are sometimes planted to restore aesthetically-pleasing vegetation to sites that have been damaged due to construction projects, such as dams and roads (Smale et al. 2001), or that are being retired from farming. For such revegetation projects, the plants are usually transplanted after being established in planter bags in nurseries. This enables more successful establishment than planting seeds in *situ*, but weed control is still required around these transplanted plants and there are a limited number of weed control options in these situations (Porteous 1993). A range of knockdown and selective residual herbicides is used around exotic trees planted in forestry during their first year, including terbuthylazine, haloxyfop and clopyralid (Davenhill et al. 1997). The native species commonly used in New Zealand revegetation projects come from a wide range of families, and include trees, shrubs and grasses. Little information is available on the herbicide tolerance of most of these species, which is why Harrington & Schmitz (2007) applied a range of herbicides to some native species in a pot trial.

The objective of the trial reported here was to evaluate whether some of the less damaging herbicide treatments identified by Harrington & Schmitz (2007) are also safe under field conditions, and whether they effectively control the weeds competing with newly established native plants.

MATERIALS AND METHODS

The trial was conducted at the Moginie Block of the Pasture and Crop Research Unit at Massey University, Palmerston North, on a sloping area of Tokomaru silt loam that had been grazed with sheep up until the time of the trial. On 20 August 2007, approximately 40 plants of each species listed in Table 1 were obtained from a nursery in planter bags, and were transplanted into the site at 2.0 m spacings both between and within rows, with potting mix being left around the roots to minimise root damage. The vegetation present included perennial ryegrass (*Lolium perenne*), browntop (*Agrostis capillaris*), Yorkshire fog (*Holcus lanatus*), white clover (*Trifolium repens*) and sweet vernal (*Anthoxanthum odoratum*), and no control of this vegetation occurred at planting.

TABLE 1: The species tested for herbicide tolerance, with average age (months) and height (cm) of the plants when treated.

Common name	Botanical name	Family name	Age (months)	Height (cm)
koromiko	*Hebe stricta*	Plantaginaceae	6	50-60
manuka	*Leptospermum scoparium*	Myrtaceae	4	30-40
mountain flax	*Phormium cookianum*	Agavaceae	16	35-45
purei	*Carex secta*	Cyperaceae	4	25-35
ribbonwood	*Plagianthus regius*	Malvaceae	16	80-90
toetoe	*Cortaderia fulvida*	Poaceae	16	80-100

On 9 October 2007, once the plants appeared to have recovered from the transplanting process, herbicide treatments were applied around the native plants to release them from the competition being exerted by the surrounding vegetation. Herbicides were applied using a 15 litre Solo back-pack sprayer with a flat-fan nozzle, applying herbicide solution by moving the nozzle around each plant within an 80-cm-diameter ring for a period of 7.0 s, equating to 50 ml of spray solution to 0.5 m^2 and thus 1000 litres/ha. Vegetation surrounding each plant was thoroughly covered in spray, and the lower parts of each native plant also received the herbicide.

The herbicides used are shown in Table 2, while treatments applied around each native plant species are listed in Table 3. Note that not all herbicide combinations were applied to all species because results obtained by Harrington & Schmitz (2007) indicated some treatments would be damaging and thus were not worth repeating. For the one grass species in the trial (toetoe), many of the treatments used on other species were not used as they included haloxyfop, a herbicide known to damage grasses. Instead, a number of treatments were assessed for selective control of grass weeds around the toetoe. If a herbicide treatment was not assessed on a species, the corresponding space within Table 3 is blank. All treatments were compared with unsprayed controls for each plant species, and also with a treatment in which glyphosate was applied to surrounding vegetation using a half-bucket to shield the native plant to give a weed-free comparison. In addition, ribbonwood received dichlobenil in the form of granules applied directly to the ground around the plants.

The weather was fine on the day of herbicide application, with air temperatures reaching a maximum of 16.5°C and an overnight low of 9.5°C, while the soil temperature was 11.2°C at 10 cm. There was 4.6 mm of rain the following day, and 29.4 mm over the next 7 days.

The trial design was a separate randomised block design for each native species, replicated four times, with blocking done based on scores of native plant health the day prior to spraying. The health of both the native plants and the sprayed vegetation were scored at regular intervals in the weeks after treatment. For the native plants, the scoring system ranged from 0 for no effect of herbicides (and no competition on the native plants) through to 10 for total death due to herbicides and/or weed competition. For the weeds growing in the treated zone around each weed, a score of 0 was given if the vegetation appeared no different to elsewhere in the paddock that had not been sprayed, and a score of 10 was given where the soil in the treated zone was completely bare of live vegetation other than the native plant. Grasses and broad-leaved weeds were bulked together for this weed score, but frequent notes were also taken of which species were dominating for each of the herbicide treatments. Data for native plant health were analysed using an analysis of variance and least significant differences were calculated where treatment differences were significant. Data from the weed density scores were pooled across native species and standard errors of the means calculated.

TABLE 2: Herbicide formulations and rates applied around base of native plants.

		Rate applied	
Active ingredient	Trade name	(g ai/100 litres)	(kg ai/ha)
aminopyralid	Tordon Max	9	0.09
amitrole (low)	Amitrole ATA	400	4.0
amitrole (high)	Amitrole ATA	800	8.0
clopyralid	Versatill	45	0.45
dichlobenil[1]	Prefix D	0.74 g/m^2	7.4
glyphosate	Roundup Transorb	270	2.7
haloxyfop	Gallant NF	30	0.30
metsulfuron (low)	Escort	6	0.06
metsulfuron (high)	Escort	12	0.12
simazine (low)	Nufarm Flowable Simazine	450	4.5
simazine (high)	Nufarm Flowable Simazine	900	9.0
terbuthylazine	Gardoprim	900	9.0

[1] dichlobenil was applied as granules directly to the ground around plants.

RESULTS AND DISCUSSION

Application of glyphosate using a half-bucket to shield the native plants was tolerated well by all native plants (Table 3), even the toetoe for which foliage dropped down on to the treated ground once the shield was removed. The glyphosate successfully removed the existing vegetation, though the resulting bare soil became infested with new weeds over the 15 weeks after application (Table 4) due to no residual activity in the soil. Addition of oxadiazon to the glyphosate, a residual herbicide safe around many ornamental species, would have been useful to stop this occurring, though it may have needed to be applied later once the soil was bare.

The shielded glyphosate treatment did help separate the effects of weed competition from damage caused by herbicide for the other treatments. For example, with the koromiko, untreated plants only had a score of 2.8 (Table 3) despite all the healthy weeds present after 15 weeks (Table 4), and this was not very different from the shielded glyphosate, which gave a score of 2.0. As the terbuthylazine treatments caused a score of 5.3 in the koromiko, it is safe to assume the herbicide caused this damage, not the weeds, which were significantly less healthy as a result of this treatment. At a cost of 46 cents per 100 treated plants for materials, this shielded glyphosate treatment was also the cheapest, though it took longer to apply than others and so would cost more in labour. Costs of all treatments were calculated (Table 4) using prices listed by Chaston (2008).

TABLE 3: Mean scores of native plant health (0 = very healthy, 10 = dead) despite presence of weeds and herbicides applied around the base of the native species newly planted into grassland. These measurements were made 15 weeks after herbicides were applied. Blank spaces indicate the treatment was not assessed on that species.

Treatment	Koromiko	Ribbonwood	Manuka	Toetoe	Purei	Flax
untreated	2.8	4.3	3.5	3.5	4.0	4.0
glyphosate (shield)	2.0	1.0	1.3	1.0	2.5	3.3
glyphosate (no shield)	1.3	2.8	4.5	3.8		3.5
haloxyfop	1.8	3.3	0.3	4.8	3.3	3.0
haloxyfop + clopyralid	1.8	2.3	0.1		2.8	3.3
haloxyfop + aminopyralid	1.8		4.5		1.5	2.0
haloxyfop + simazine (low)	2.8	1.3	0.8		1.8	2.8
haloxyfop + simazine (high)					1.5	
terbuthylazine	5.3	2.5	5.8		4.5	4.3
haloxyfop + terbuthylazine	4.8	1.8	7.8		3.5	3.0
dichlobenil		2.8				
metsulfuron (low)		4.5		3.8	6.0	
metsulfuron (high)				4.0		
amitrole (low)				5.0		
amitrole(low) + metsulfuron (low)				6.0		
amitrole (low) + aminopyralid				6.3		
amitrole (high)				5.8		
LSD (P=0.05)	1.8	1.6	4.5	3.3	2.6	2.2

Glyphosate was also applied without a shield to all species except purei, as *Carex* spp. are known to be highly susceptible to glyphosate (Harrington & Schmitz 2007). This treatment was sprayed up to the base of each plant, which meant that basal parts of each plant were covered with herbicide. For species such as ribbonwood and mountain flax, which were large at the time of treatment due to being 16 months old, there was little damage to the plants, as only a small proportion of each plant was sprayed. However, although manuka sustained little damage from exposure to glyphosate in a pot experiment by Harrington & Schmitz (2007) when plants were 9 months old and 80 cm tall, the manuka in the present trial was only 4 months old and 30-40 cm tall, thus was more susceptible to this treatment.

TABLE 4: Mean scores (with standard errors in brackets) of the damage (0 = healthy, 10 = dead) to weeds sprayed around the various native plants (results pooled across all species receiving the same treatments). Costs of herbicide treatments ($ per 100 native plants treated) are also shown.

	Score of weed damage				Cost
Treatment	3 WAT	6 WAT	9 WAT	15 WAT	($)
untreated	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.3 (0.1)	0.00
glyphosate (shield)	9.3 (0.1)	9.2 (0.1)	7.8 (0.2)	5.6 (0.4)	0.46
glyphosate (no shield)	8.7 (0.5)	8.7 (0.5)	7.4 (0.4)	5.9 (0.5)	0.46
haloxyfop	4.0 (0.3)	5.6 (0.2)	5.1 (0.2)	4.7 (0.3)	1.66
haloxyfop + clopyralid	3.9 (0.2)	7.6 (0.1)	7.9 (0.2)	6.8 (0.4)	2.26
haloxyfop + aminopyralid	4.9 (0.5)	7.9 (0.1)	8.1 (0.2)	6.8 (0.3)	2.78
haloxyfop + simazine (low)	6.5 (0.4)	9.3 (0.2)	8.8 (0.2)	8.6 (0.3)	2.08
haloxyfop + simazine (high)	6.5 (0.3)	9.3 (0.2)	9.5 (0.3)	10.0 (0.0)	2.49
terbuthylazine	4.9 (0.4)	8.2 (0.4)	9.4 (0.1)	9.2 (0.2)	0.99
haloxyfop + terbuthylazine	7.8 (0.2)	9.6 (0.1)	9.7 (0.1)	9.8 (0.1)	2.65
dichlobenil	1.3 (0.2)	4.8 (0.5)	6.8 (0.6)	7.3 (1.4)	15.35
metsulfuron (low)	0.8 (0.2)	0.6 (0.3)	0.9 (0.3)	0.9 (0.3)	0.81
metsulfuron (high)	1.0 (0.4)	1.3 (0.9)	2.5 (1.5)	2.5 (0.9)	1.63
amitrole (low)	4.8 (0.5)	3.5 (0.6)	1.3 (0.2)	2.0 (0.8)	0.90
amitrole(low)+metsulfuron(low)	2.8 (0.2)	4.0 (0.7)	3.5 (1.2)	2.0 (0.9)	1.71
amitrole (low)+aminopyralid	4.8 (0.5)	3.3 (0.5)	1.8 (0.6)	1.0 (0.6)	2.02
amitrole (high)	3.8 (0.2)	4.3 (0.6)	1.8 (0.6)	1.3 (0.6)	1.80

Haloxyfop safely removed the grasses from most of the native species, though some damage occurred when it was applied around the base of toetoe plants. Since only a small proportion of each toetoe plant received haloxyfop, damage was slight, unlike the situation in the pot trial by Harrington & Schmitz (2007) in which the entire plant was sprayed for the grass species evaluated. When only haloxyfop was used, the region around each plant soon became dominated by broad-leaved species that had previously been suppressed by grasses, such as white clover, hawkbit (*Leontodon taraxacoides*), catsear (*Hypochoeris radicata*), dandelion (*Taraxacum officinale*), narrow-leaved plantain (*Plantago lanceolata*) and turf speedwell (*Veronica serpyllifolia*). These low-growing species appeared less competitive to the native plants than the taller-growing grasses, and often acted to stop grasses re-establishing. This is illustrated with manuka, which was relatively susceptible to competition due to its small size when planted. The manuka plants treated only with haloxyfop were much healthier than untreated manuka plants (Table 3) as the weeds left by the haloxyfop were less competitive under the conditions of this trial than the grasses. However, this poor control created definite problems on occasions where more competitive species, such as broad-leaved dock (*Rumex obtusifolius*), were present.

The addition of clopyralid or aminopyralid to haloxyfop controlled a wider range of weed species than haloxyfop alone (data not shown), although grasses tended to re-establish more rapidly in these treatments. Some weeds, such as narrow-leaved plantain, were poorly controlled by aminopyralid. Manuka was adversely affected by the aminopyralid, as was the koromiko initially, while the clopyralid caused some damage to ribbonwood plants in the first few weeks after application (data not shown).

Many of the broad-leaved species, especially the white clover, were removed by adding simazine to haloxyfop, and this treatment was tolerated well by all native species to which it was applied. However, dandelion was poorly controlled, and grasses eventually reinvaded when the lower rate of simazine was used. Double the rate of simazine was used only for the purei, which tolerated this higher rate well, and grasses were prevented from re-establishing with this higher rate over the 15 weeks of monitoring. This higher rate of simazine combined with haloxyfop would be an interesting treatment to test on other native species. The addition of simazine to shielded applications of glyphosate would also be worth investigating, as this would help keep glyphosate-cleared ground free of weeds and would only cost $1.30 per 100 plants treated, comparing well with other treatments listed in Table 4.

Terbuthylazine used by itself gave good knockdown of most weed species at the rate used in this trial (Table 4), and gave long-term control around the native plants. The addition of haloxyfop improved initial knockdown of grasses. However, the terbuthylazine generally had some detrimental effects on most native species to which it was applied, apart from the ribbonwood (Table 3).

Dichlobenil can be used to control weeds in a wide range of woody ornamental and fruit species (Young 2009). It was tested on just the ribbonwood, where it gave reasonable levels of weed control over a prolonged period of time without damaging the ribbonwood (Tables 3 and 4). However, at costs exceeding $15 per 100 plants treated, it is much more expensive than all other treatments assessed (Table 4) and would thus probably not be considered viable.

Some treatments combined metsulfuron and amitrole to see if they would give useful control of grass weeds around the grass species toetoe. However, there was no useful differential in susceptibility to these herbicides between the toetoe and the wide range of grass weed species present. The combination of damage from the herbicides and competition from poorly controlled grass weeds affected the toetoe as much or more than unshielded applications of glyphosate or haloxyfop around the plants.

Results from this trial depended very much on how well grasses were controlled, and most treatments were designed to control grasses. Although some revegetation sites may have problems mainly with broad-leaved species, generally grasses are likely to dominate revegetation projects due either to sites formerly being pastures or being in roadsides and other waste areas where perennial grasses have become dominant as part of ecological succession (Porteous 1993). Thus results from this trial should be relevant to a wide range of revegetation projects.

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