Methods of reducing ripgut brome seed production and carcass damage

K.N. TOZER[1*], A.J. MARSHALL[1] and G.R. EDWARDS[1]
[1]*Lincoln University Agriculture Group, Agriculture and Life Sciences Division, PO Box 84, Lincoln University, 7647 Lincoln, New Zealand*
[*]*Present address: AgResearch, Ruakura Research Centre, East Street, Private Bag 3123, Hamilton, New Zealand*
katherine.tozer@agresearch.co.nz

Abstract

Ripgut brome (*Bromus diandrus*) is an annual grass weed prevalent in dry, hill and high country regions throughout the South Island. Its large seeds contaminate wool and carcasses. Two studies were undertaken in 2006/2007 to test strategies to control and mitigate its impacts. The first study (South Canterbury) tested different rates and timing of application of herbicides on ripgut brome. Glyphosate applied in spring as a spray-topping application (112 g a.i./ha) showed potential as a control strategy, reducing ripgut brome seed production and seedling densities without large increases in bare ground caused by the other broad spectrum and grass selective herbicides. Herbicides had no effect on the cover of perennial grasses, dicots or forbs. In the second study (Marlborough and Central Otago), shearing lambs at weaning reduced the number of carcasses that were detained due to seed contamination (0.33 and 0.41 respectively, proportion of shorn and unshorn carcasses detained) but did not reduce the number of seeds contaminating each carcass. Shearing at weaning, combined with herbicide application targeted at ripgut brome dominant areas may be useful strategies to help reduce seed contamination.

Keywords: annual grass weeds, weed control, weed mitigation, ripgut brome, *Bromus diandrus*

Introduction

Ripgut brome (*Bromus diandrus* Roth) is an annual grass weed found on dry, overgrazed slopes in hill and high country regions throughout the South Island (Tozer *et al.* 2007). The large seeds of ripgut brome (1.5 - 2.5 cm) can contaminate wool, pelts and carcasses of sheep, particularly lambs, and lead to carcasses being downgraded at the meat processor (Hancock & Schuster 2004). In arable systems, where ripgut brome can reduce crop yields, herbicide programmes have been developed to control this weed (Dastgheib *et al.* 2003). However, strategies to control or mitigate the effects of this weed in dry, hill country pastures are less well developed and need further research (Tozer *et al.* 2007).

In pastures, glyphosate and paraquat are effective and readily available knock-down herbicides that can be used to control weeds. When employed at full rates, these herbicides also kill desirable species which might have colonised bare areas left after the death of ripgut brome. An alternative option is to apply glyphosate or paraquat at lower rates (spray-topping/chemical topping) to prevent seed production of annual grasses (Leys *et al.* 1991). 'Spray-topping' with glyphosate has the further advantage of increasing carbohydrate reserves and crude protein levels, thus increasing forage quality (Leys *et al.* 1991). Also, it does not kill perennial grass species, thus increasing the potential for these species to occupy gaps created by ripgut brome mortality. While broad-leaved species may occupy some of these gaps, little benefit would be gained as most of them are unpalatable and provide poor quality forage. In Australia, spray-topping with glyphosate at 135 or 270 g a.i/ha has significantly reduced vulpia hair grass (*Vulpia* spp.) seed production (Leys *et al.* 1991).

An alternative strategy that may be used in conjunction with herbicide application to reduce the effects of ripgut brome seed is to shear lambs at weaning to reduce seed contamination of wool and subsequent damage to pelts. As ripgut brome seeds become attached to woolly sheep in late summer, shearing at weaning in February has the potential to remove seeds caught in the fleece before they penetrate the carcass. The potential for this to be an effective mitigation strategy is highlighted by an Australian study in which shearing increased growth rate and carcass weight, and reduced pelt scarring of weaner lambs that had grazed on mature barley grass pastures in November and December (Holst *et al.* 1996).

Thus as part of a package on management of ripgut brome we sought to determine:

(1) The effect of herbicides, including glyphosate, paraquat and haloxyfop on ripgut brome cover, seed production and seedling densities; and
(2) The effect of shearing Merino lambs at weaning on seed contamination of carcasses.

Methods

Herbicide study

The site was established 19 March 2007, near Twizel, South Canterbury, at 770 m a.s.l. on a gentle, north facing slope. It was chosen because of its high and relatively uniform cover of ripgut brome. Soil tests taken on 19

Table 1 Description of herbicide treatments applied in 2007. Glyphosate was applied as Roundup Transorb ® (560 g/L glyphosate), paraquat as Gramoxone ® (250 g/L) and a grass-selective haloxyfop, formulated as a methyl ester (100 g/L) applied as Gallant ®. Rates were label recommendations for control of annual grass weeds in pasture.

Treatment	Date applied	Concentration (g a.i./ha)	Rate (L/ha)	Aim
Glyphosate	19 May	370	0.66	Remove emerging ripgut brome
Paraquat	19 May	600	2.40	Remove emerging ripgut brome
Glyphosate	4 Oct	370	0.66	Remove established ripgut brome
Haloxyfop	4 Oct	60	0.60	Remove established ripgut brome
Glyphosate	9 Nov	112	0.20	Reduce seed production of ripgut brome
Untreated		0	0	Comparison with other treatments

March showed that Olsen P = 74 mg/kg, pH = 5.9, potassium = 2.79 me/100 g, calcium = 7.5 me/100 g and magnesium = 2.00 me/100 g. At the start of the experiment the site was dominated by ripgut brome, sweet vernal grass (*Anthoxanthum odoratum*), downy brome (*Bromus tectorum*), haresfoot trefoil (*Trifolium arvense*), horehound (*Marrubium vulgare*), mouse-ear hawkweed (*Hieracium pilosella*), verbascum (*Verbascum thapsus*) and fescue tussock (*Festuca* spp.) with small amounts of cocksfoot (*Dactylis glomerata*), perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and goose grass (*B. hordeaceus*).

Five herbicide treatments were applied with a calibrated knap-sack in a randomised, complete block design. There were three replicates of each treatment and plot dimensions were 3 m by 5 m. Herbicide application rates and application dates are shown in Table 1. The spray-topping treatment was applied when seedheads were beginning to emerge in ripgut brome populations at the field site. Application at this stage has effectively suppressed seedhead production of *Bromus* species, including ripgut brome (Dowling & Nicol 1993). No wetting agents were applied with the herbicides.

In addition to herbicide treatments, plots were split and one half of each plot was broadcast with a mixture of perennial ryegrass (15 kg/ha), cocksfoot (2 kg/ha), white clover (3 kg/ha), subterranean clover (*T. subterraneum*, 8 kg/ha) and balansa clover (*T. michelianum*, 2 kg/ha) on 19 March after autumn rains had fallen. However, there was no evidence of germination or establishment of any of these species during the following months (April 2007-May 2008). Therefore the split-plot treatment was eliminated from the analysis and main plot treatment effects only were analysed.

Percent cover of annual grasses (*Bromus* spp.), perennial grasses, dicots and bare ground was estimated on 19 March, 24 July, 18 September, 3 October, 9 November and 4 December 2007 and 30 May 2008. During the vegetative stage of development (March to November) it was not possible to separate ripgut brome from downy brome or goose grass. Therefore all cover measurements are of total annual grass (*Bromus* spp.) cover.

Ripgut brome seed production measurements were taken on 4 December 2007. The number of seedheads was counted in three 0.4 m^2 quadrats in each plot. Up to 16 seedheads were harvested from each plot and the number of seeds and spikelets counted for each seedhead. In addition, seedling densities of *Bromus* spp. were measured on 30 May 2008 in three 0.1 m^2 quadrats in each plot using stratified random sampling.

All data were analysed in Genstat using one-way ANOVA with blocking. Only seedheads/m^2 and seeds/m^2 required transformation (natural log) to normalise the variance; percent cover and seedling density data were not transformed.

Shearing study

A shearing study was conducted on four farms in 2006 (two Central Otago, two Marlborough) and three farms in 2007 (two Central Otago, one in Marlborough) to determine if shearing lambs around weaning would reduce seed contamination of carcasses. These farms were chosen because of their wide distribution of ripgut brome and because they had previously identified a seed contamination problem. A total of 100 Merino lambs, predominantly wethers, were selected on each property and 50 were allocated to be shorn at, or soon after, weaning (February). Following shearing, lambs were run together as a single mob and all were subsequently shorn in late October prior to slaughter. At the meat processor, the number of sheep in each group that were placed on the detain rail (side rail where carcasses are placed to have seeds removed) for seed contamination was recorded. Carcasses are placed on the detail rain if one or more seeds are observed. For animals placed on the detain rail, the number of seeds embedded in each carcass was counted. Seeds were extracted and identified to species.

The proportion of carcasses placed on the detain rail was analysed using a Generalized linear model with binomial errors and logit link function. The number of seed per carcass was analysed using ANOVA with farm as block.

Table 2 Effect of herbicide application on percentage cover of annual grasses and of bare ground in September, October, November and December 2007. Missing values denote measurement dates before a treatment was applied. Treatments with the same subscript within a row did not differ significantly from each other according to a LSD test (P = 0.05) following a significant ANOVA.

Date	Untreated	Gly-aut	Paraquat	Gly-spr	Haloxyfop	Spraytop	P value
	Autumn applied			Spring applied			
Annual grasses							
Sept	82.3 a	20.3 b	16.3b	-	-	-	<0.01
Oct	69.0 a	21.3 b	18.7 b	-	-	-	0.05
Nov	94.0 a	66.3 b	62.3 b	5.7 c	1.7 c	-	<0.001
Dec	95.0 a	61.0 b	65.7 b	13.3 c	10.0 c	87.3 a	<0.001
Bare ground							
Sept	13.7 b	76.7 a	80.0 a	-	-	-	<0.01
Oct	10.0 b	69.0 a	70.0 a	-	-	-	<0.01
Nov	2.0 c	29.3 b	32.7 b	86.0 a	87.3 a	-	<0.001
Dec	3.3 c	36.3 b	32.3 cb	73.7 a	79.7 a	3.0 c	<0.001

Table 3 The effect of herbicide application on ripgut brome fecundity. Data presented are arithmetic means. Seedheads/m^2 and seeds/m^2 were log transformed ($\log_e(n + 1)$) prior to ANOVA. Within each row, treatments with the same subscript are not significantly different according to a LSD test (P=0.05) following a significant ANOVA.

Measurement	Untreated	Gly-aut	Paraquat	Gly-spr	Haloxyfop	Spraytop	P value
	Autumn applied			Spring applied			
Spikelets/seedhead	4.9 ab	4.2 bc	5.7 a	3.2 dc	2.2 d	4.1 bc	<0.01
Seeds/seedhead	6.0 ab	4.2 ab	6.8 a	3.6 bc	1.1 c	4.4 ab	<0.05
Seedheads/m^2	37.5 a	13.6 ab	1.4 c	6.7 bc	0.3 c	0.4 bc	<0.01
Seeds/m^2	225 a	57a	10 b	24 ba	0.3 c	2 b	<0.01

Results

Herbicide study

Glyphosate and paraquat applied in autumn substantially reduced annual grass cover in September and October (Table 2). Annual grass populations recovered in November and December but still remained significantly less than in untreated plots. The amount of bare ground increased in September, October and November, when compared to untreated plots. Glyphosate applied in spring and haloxyfop also reduced annual grass cover and increased the amount of bare ground in November and December when compared to untreated plots. However, even in these treatments, annual grass populations began to recover in the few months after herbicide application.

Spray-topping did not affect annual grass cover or the amount of bare ground in December, 1 month after its application, when compared to untreated plots. By May 2008, there was no difference between any treatments (including untreated plots) in the cover of the annual grasses (*Bromus* spp.) or bare ground.

Mean percent cover of perennial grasses remained below 2% while dicots comprised up to 11% throughout the study in all treatments. There was no difference between treatments (including untreated plots) in March (baseline measurements prior to herbicide application) or July 2007 in perennial grasses, annual grasses, dicots or bare ground. There was no difference between treatments in percent cover of perennial grasses and forbs in May 2008.

There was no difference between any of the treatments (including untreated plots) in the number of seeds/spikelet (P>0.05, mean =1.0 seed/spikelet) of ripgut brome. There were fewer spikelets/seedhead (P<0.01) in the haloxyfop and glyphosate-spring treatments than in untreated plots and paraquat treatments (Table 3). There were also fewer seeds/seedhead in the haloxyfop than in untreated plots, glyphosate-autumn, paraquat and spray-topping treatments (P<0.05) and fewer seedheads/m^2 in the haloxyfop, glyphosate-spring, paraquat and spraytop treatments than in untreated plots (P<0.01). Finally, there were fewer seeds/m^2 in the haloxyfop, paraquat and spraytop treatments than in untreated plots (P<0.01).

In May 2008, seedling densities (No./m^2) of *Bromus* spp. were less (P<0.05) in the glyphosate-spring (94), spray-topping (103) and haloxyfop (116) treatments than in the paraquat treatment (260) and untreated plots (293). None of these treatments differed from the glyphosate autumn treatment (199 seedlings/m^2).

Shearing study

The proportion of carcasses placed on the detain rail for seed contamination varied among farms (range 11-80%) and was significantly lower (χ^2= 6.9, 1 df, P<0.01) in shorn than unshorn sheep (Table 4), However, nearly

Table 4 Mean proportion of hogget carcasses placed on the detain rail at the meat processor for seed contamination and the mean number of ripgut brome seeds per carcass for unshorn and unshorn lambs. Seeds per carcass data are only for carcasses placed on the detain rail.

Shearing treatment	Proportion of carcasses on detain rail	Seeds/ carcass
Shorn	0.33	4.6
Unshorn	0.41	6.6
P value	<0.01	0.33

one third of carcasses from shorn lambs were still placed on the detain rail. For those carcasses placed on the detain rail, there was no difference in the number of seeds/carcass (Table 4). All the seeds found in carcasses were ripgut brome.

Discussion

There was some evidence that shearing lambs at weaning may reduce seed contamination of carcasses, with fewer lambs placed on the detain rail but no reduction in the number of seeds per carcass. This finding agrees with previous New Zealand work showing that shearing in December may reduce pelt damage by barley grass (Hartley & Atkinson 1973). In Australian dryland pastures, shearing also reduced barley grass contamination of pelts and increased growth rate in lambs (Holst *et al.* 1996). However, in our study, carcasses of shorn and unshorn lambs were contaminated with similar numbers of seed. Seeds may have already been embedded in the pelts and carcasses prior to shearing or sheep may have been contaminated with seeds after shearing in February. Visual observations indicate that seeds of ripgut brome may remain in the seedhead in poorly utilised areas of pasture until June.

As shearing did not prevent seed contamination of carcasses, alternative strategies are also required to reduce ripgut brome contamination in infested paddocks. One of the herbicides that showed promise was spray-topping with glyphosate (112 g a.i./ha) when most ripgut plants were just beginning to flower. Spray-topping had little impact on plant cover but did reduce seedhead and seed production in summer compared to untreated plots. This also corresponded to lower seedling counts the following autumn compared to untreated plots.

Other herbicide treatments also reduced ripgut seedhead production and/or seedling densities (e.g. haloxyfop, glyphosate applied in spring). However, they also increased the percentage of bare ground. With pasture establishment via oversowing being difficult in the steep, sunny faces where ripgut brome often grows (as was demonstrated in this study), such an increase in bare ground may be undesirable due to an increased risk of erosion. These competition free sites also remain prone to re-invasion of ripgut brome, as seed bank studies indicate that a small proportion of ripgut seeds survive for 2 to 3 years (Cheam 1987). This was especially evident in the autumn treatments, where annual grass presence had increased dramatically by the end of the experiment. Further, haloxyfop and paraquat are more expensive than glyphosate and would not be economically justifiable if their effect on ripgut brome is limited. Therefore spray-topping with glyphosate would appear to be the most economically viable option.

The effect of spray-topping on ripgut brome is consistent with a previous study in arable fields (Dowling & Nicol 1993) which noted that *Bromus* species (which included ripgut brome) were effectively controlled by applying rates of glyphosate (110 g a.i./ha) similar to those used here when ripgut brome and other *Bromus* species were in early flowering stages. For other grass species such as vulpia, the critical time of herbicide application has been defined more clearly (e.g. inflorescence fully emerged, Leys *et al.* 1991) and this needs to be done also for ripgut brome.

Despite very low seed production in several treatments (e.g. haloxyfop and spray-topping), a significant number of seedlings still emerged (>100 seedlings/m^2). Most of these seedlings probably originated from the seedbank and to a lesser extent from reproductive tillers that matured and produced seed after herbicide application. Thus, herbicide application such as spray-topping may have to be conducted over several years to reduce the weed to low levels in pasture. Nonetheless, it appears to be a useful strategy to direct at areas such as localised patches on sunny faces with a high density of ripgut brome, and so assist with the creation of paddocks where there is a reduced chance of contaminating Merino lambs. On farm studies are proceeding to examine the economic benefits of targeted herbicide application.

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