CONTROL OF GORSE (*ULEX EUROPAEUS*) IN DRYLAND PASTURE CONVERTED FROM *PINUS RADIATA* FOREST

G.R. EDWARDS, K.N. TOZER, T.M.R. MAXWELL
and A.J. MARSHALL

Agriculture Group, Agriculture and Life Sciences Division, PO Box 84, Lincoln University, Lincoln 7647, New Zealand

Corresponding author: edwardsg@lincoln.ac.nz

ABSTRACT

The effect of crop sequence, pasture species mixture and nitrogen fertiliser on gorse establishment was monitored over 23 months in land converted from pine forest to a dryland sheep pasture. There were fewer gorse plants in plots sown initially into the forage crop triticale and then into grass-legume pasture than plots sown directly into grass or grass-legume pasture. Once the triticale was grazed, under-sowing grass-legume pasture beneath rape to establish clover rich pastures suppressed gorse more than sowing grass-legume pasture directly. There was no effect of nitrogen fertiliser applied at 150 kg N/ha/year on gorse plant density or cover. Appropriate management tools to control gorse in forest to pasture conversions include a combination of crop sequences where forage crops are followed by pasture and the establishment of pasture legume rich herbage. This type of pasture is preferred by livestock and results in high grazing intensity of gorse seedlings growing in the pasture.

Keywords: competition, gorse, grazing, forage crop, land conversion, pasture, pine forest.

INTRODUCTION

Declining returns from forestry and increased demands for land for pastoral farming has lead to large areas of land being converted from *Pinus radiata* plantation forest to pasture in both the North and South Island. Once the trees are removed, pasture establishment and production are constrained by several key factors, including a low soil pH (4.6-4.9) leading to toxic levels of available aluminium; a low available soil N and high soil C:N ratio due to the presence of woody debris; a lack of earthworms; and a large seed bank of woody weeds, such as gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) that establish and compete with the new pasture (Hawke 2004; Lloyd et al. 2007).

One of the key decisions that managers face in the conversion process is whether to establish pasture directly or following forage crops, such as triticale or rape. Choice of cropping sequence may have important implications for weed control (Bell et al. 2006), with rapidly establishing, cool season active, forage crops potentially providing more competition than pastures with lower cool season activity. Also, forage crops are suitable for intense rotational grazing, which gives better control of weeds such as gorse than set stocking (Hartley & Phung 1979). In the pasture phase, choice of species or management strategies to promote a particular pasture component may also be important. Hartley & Phung (1982) reported pasture grass species varied in their competitive effect on gorse, and gorse seedling survival was reduced by the addition of white clover.

This paper is part of a package of work investigating the conversion of pine forest owned by the Selwyn Plantation Board Limited on the Canterbury plains to productive dryland pasture. The aim is to complete the conversion process with little soil erosion, minimal loss of soil nutrients (e.g. nitrogen) and little weed establishment. The specific objective of the trial reported here was to quantify the effects of crop sequence, pasture species mixture and nitrogen fertiliser on gorse seedling density and cover.

MATERIALS AND METHODS

Experimental site

The trial was located on a 30 ha dryland research site at Darfield, Canterbury. The site had been through three rotations of *Pinus radiata* timber production between 1890 and 2003. Trees were felled and timber cleared during 2003. Following the removal of larger timber to burn piles, stumps and woody debris were mulched from September 2003 to March 2004. The site was then cultivated in preparation for sowing of crops and pastures in autumn 2005.

The soil type was a Lismore stony silt loam. Soil tests taken in March 2005 after site clearing and mulching showed: soil pH = 4.6, Olsen P = 12 mg/kg, sulphate-S = 8 mg/kg, aluminium = 2.5 me/100 g and C:N ratio = 23 (soil component only). To correct initial soil deficiencies, the site was fertilised with 10 t lime/ha, 300 kg superphosphate/ha, 0.5 kg boron/ha and 5 kg copper sulphate/ha in March 2005. This gave soil test results of soil pH = 5.9, Olsen P = 21 mg/kg, sulphate-S = 12 mg/kg and aluminium <0.1 me/100 g in September 2005.

Experimental design

The experiment was a split plot design laid out in four randomised blocks with N fertiliser (0 or 150 kg N/ha/year) as the main plot treatment and eight cropping sequences as the sub plot treatment (Lloyd et al. 2007). The eight cropping sequences were combinations of: autumn (13 April 2005), spring (28 September 2005) and autumn (3 March 2006) sowing; pastures sown either directly or after forage crops; and pastures containing different grass, clover and herb species. Sub-plots were 20 × 50 m (0.1 ha) and eight contiguous cropping sequence plots were combined to form a main plot to which N fertiliser was or was not applied. Detailed measurements were made on four of the eight cropping sequences. These were:

- GGG – 20 kg/ha Tabu Italian ryegrass sown in autumn 2005.
- PPP – 12 kg/ha Meridian perennial ryegrass, 3 kg/ha Demand white clover, 8 kg/ha Leura subterranean clover and 2 kg/ha Bolta balansa clover (*Trifolium michelianum*) sown in autumn 2005.
- TPP – 100 kg/ha DoubleTake triticale sown in autumn 2005, followed by 12 kg/ha Meridian perennial ryegrass, 3 kg/ha Demand white clover, 3 kg/ha Pawera red clover, 1 kg/ha Puna chicory and 1 kg/ha Lancelot plantain sown in spring 2005.
- TRP – 100 kg/ha DoubleTake triticale sown in autumn 2005, followed by 1.5 kg/ha Winifred rape, 3 kg/ha Demand white clover, 3 kg/ha Pawera red clover, 8 kg/ha Endura Caucasian clover, 1 kg/ha Puna chicory and 1 kg/ha Lancelot plantain. The triticale was grazed on 15 August 2005 and the pasture was undersown beneath rape, which was grazed off in January 2006. Meridian perennial ryegrass (12 kg/ha) was direct drilled into the existing pasture on 3 March 2006.

These cropping sequences and pasture species were representative of the sequences used on the 2000-3000 ha of land being converted by the Selwyn Plantation Board Limited. Initial crops were established by conventional drilling following cultivation; subsequent pastures were direct drilled. Nitrogen fertiliser was applied as urea in three split applications of 50 kg N/ha in autumn, early spring and late spring. The eight plots in each N fertiliser treatment were rotationally grazed in common 5 to 6 times per year with Corriedale ewes and hoggets at a stocking rate of 600 sheep/ha. The first grazing was on 15 August 2005. Grazing typically took 2 days to complete.

Measurements

Detailed measurements were made for gorse, the dominant woody weed at the site. Gorse seedlings were counted in two 0.2 m^2 quadrats per plot in May, August (prior to first grazing), September (post first grazing) 2005, April 2006 (5 quadrats rather than 2) and February 2007. Botanical composition was assessed by visual assessment, calibrated by double sampling, in two 0.2 m^2 quadrats per plot in February 2006 and 2007. Post grazing pasture mass was assessed by 30 rising plate meter readings per plot taken immediately after grazing. Data were analysed by ANOVA of a split plot design.

RESULTS

Gorse seedling density throughout the 23 month period is shown in Table 1. Initial seedling density in May 2005 did not differ between cropping sequences, indicating little difference in initial seedling establishment between treatments. Seedling density declined in all cropping sequences prior to the first grazing but the decline was greater in triticale plots (TPP and TRP) than plots sown directly into grass (GGG) or pasture (PPP). Seedling death was marked during the initial grazing, but was greater in triticale than pasture or grass plots, so that in September 2005 there was fewer gorse seedlings ($P<0.01$) where triticale had been sown (TPP and TRP). From September 2005, seedling numbers declined in all treatments except GGG so that the final ranking of seedling density in February 2007 from lowest to highest was TRP<TPP<PPP<GGG. No seedlings were found in TRP in February 2007. Nitrogen application had no significant effect on seedling density at any time.

TABLE 1: Mean gorse seedling density (no. /m^2) for the main effects of cropping sequences and N fertiliser. Means followed by different letters within a measurement date are significantly different according to LSD (P=0.05) test following a significant ANOVA.

	May 2005	Aug 2005	Sept 2005	April 2006	Feb 2007
Cropping sequence					
GGG	40.1a	37.2a	21.2a	16.0a	14.7a
PPP	44.1a	35.6a	20.3a	6.6b	2.8b
TPP	39.1a	29.7b	6.6b	1.6c	1.6b
TRP	38.4a	28.4b	7.8b	1.1c	0.0b
SEM	2.6	2.1	1.5	2.1	1.8
P value	0.44	0.03	<0.01	<0.01	<0.01
Nitrogen fertiliser					
0 kg N/ha/year	40.6a	32.8a	15.5a	7.0a	5.0a
150 kg N/ha/year	40.2a	35.6a	12.5a	5.7a	4.5a
SEM	1.7	1.9	1.2	1.2	2.0
P-value	0.86	0.91	0.19	0.31	0.87

The percentage of gorse in the pasture from lowest to highest was TRP<TPP<PPP<GGG in February 2007 (Table 2). The percentage of pasture legume showed the opposite trend, being highest in TRP (Table 2). Nitrogen fertiliser decreased the percentage of pasture legume in 2007, but did not affect the percentage of gorse (Table 2). Pasture residuals at the first grazing were higher in PPP and GGG than TRP and TPP (Table 2). Averaged over the rest of the grazing period, pasture residuals were lower in TRP than TPP, with both lower than PPP and GGG (Table 2). There were no significant interactions between cropping sequence and N fertiliser for any response variable.

TABLE 2: Mean percentage of gorse and pasture legume (%) and post grazing pasture residuals (kg DM/ha) for the main effects of cropping sequences and N fertiliser. Means followed by different letters within a measurement date are significantly different according to LSD (P=0.05) test following a significant ANOVA.

	February 2006		February 2007		Pasture residuals	
	% gorse	% pasture legume	% gorse	% pasture legume	Aug 2005[1]	Aug 2005-Sept 2006[2]
Cropping sequence						
GGG	3.1a	0.6a	3.2a	3.6a	772a	471a
PPP	1.3b	23.0b	0.6b	22.2b	742a	455a
TPP	0.6c	35.6bc	0.3c	49.6c	406b	383b
TRP	0.2c	43.0c	0.0d	58.8d	412b	225c
SEM	0.21	4.80	0.18	1.73	31	21
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrogen fertiliser						
0 kg N/ha/year	1.4a	33.2a	0.9a	36.0a	606	361
150 kg N/ha/year	1.3a	17.9a	1.1a	31.1b	560	406
SEM	0.12	4.40	0.21	1.05	21	27.4
P-value	0.40	0.09	0.50	0.04	0.10	0.30

[1]First grazing of plots.
[2]Average over the rest of the grazing period.

DISCUSSION

Crop sequences where land was first sown into the forage crop triticale had lower gorse densities and cover than those sown directly into grass-legume or grass-based pasture. The suppression of gorse prior to establishment of pasture occurred in two stages. First, survival was lower prior to the initial grazing of pastures and crops. This result probably reflects the greater cool season growth of triticale compared to ryegrass, which enabled a taller canopy to develop and inhibit growth of gorse seedlings. Second, seedling mortality was higher at the initial grazing in August in triticale than pasture. This was probably due to more intense trampling and defoliation of seedlings (Hartley & Phung 1979) in triticale than pasture following the removal of the upper part of the triticale canopy. Post grazing pasture residuals indicated more intense grazing in triticale than pasture. Furthermore, as triticale is a more open crop (i.e. plants more spaced) than pasture, seedlings would have been particularly prone to defoliation and trampling.

Pastures with a higher legume content throughout the trial had less gorse at the end of the trial. This is demonstrated by the lower final gorse densities and cover in PPP than GGG and in TRP (where no gorse seedlings remained) than TPP. This result confirms previous studies (Hartley & Phung 1979; 1982) reporting reduced gorse seedling survival where white clover was added to the grass based pasture mixture. The lower seedling densities are likely to be associated with increased pasture density where pasture legumes are abundant (see Hartley & Phung 1979) combined with more intense grazing and lower pasture residuals (Table 2) in the pastures containing a higher proportion of pasture legumes.

Nitrogen fertiliser application has been shown to suppress gorse seedling establishment in previous studies (Thompson 1974; Hartley & Phung 1982; Popay et al. 1990).

However, despite increasing pasture growth (G.R. Edwards, unpubl. data) and reducing legume abundance (Table 2), no effect of N fertiliser on gorse was detected in this study. This may reflect that shifts in pasture growth and competition at the current N rate (150 kg N/ha/yr) in this nitrogen deficient site were not sufficient to suppress seedlings. Moreover, by suppressing pasture legumes, N fertiliser may have offset the potential negative impact of pasture legumes on gorse that has been demonstrated.

It is noteworthy that the low post-forest soil pH of 4.6 in this study was corrected by the application of 10 t lime/ha prior to crop establishment. Gorse prefers acid conditions (Grubb & Suter 1970) and a previous study (Hartley & Phung 1979) indicated that the application of 5 t lime/ha suppressed gorse establishment even when the initial soil pH was 5.6. Ongoing lime rate experiments at the same site as the current study (G.R. Edwards, unpubl. data) confirm that lime application suppresses gorse, hence indicating that the quick correction of soil pH is an important part of gorse control in forest to pasture conversions.

In summary, crop sequences utilising forages with greater cool season growth (e.g. triticale) that can be grazed to low pasture masses, followed by establishment methods that enhance pasture legumes (e.g. under-sowing beneath rape) minimise gorse in the development of dryland pasture on former forestry land. Intense livestock grazing is vital in suppressing gorse and for this it is important to have available and utilise classes of stock that are not heavily penalised by being forced to graze hard (e.g. mature rather than growing stock). The proposed crop sequences for weed control fit well with other objectives during the conversion process, such as having clover dominant pastures to enhance livestock feeding value and increase N inputs into the soil, which in turn should promote pasture growth and decomposition of woody debris.

ACKNOWLEDGEMENTS

Selwyn Plantation Board Limited provided financial support for this project.

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