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Response of perennial ryegrass *(Lolium perenne)* to renovation in Australian dairy pastures

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Abstract. This study reports on the effect of oversowing perennial ryegrass (*Lolium perenne* L.) into a degraded perennial ryegrass and white clover (*Trifolium repens* L.) pasture to extend its productive life using various intensities of seedbed preparation. Sites in New South Wales (NSW), Western Australia (WA), South Australia (SA) and Tasmania (Tas.) were chosen by a local group of farmers as being degraded and in need of renovation. Control (nil renovation) and medium (mulch and graze, spray with glyphosphate and sow) renovation treatments were common to all sites whereas minimum (mulch and graze, and sow) and full seedbed (graze and spray with glyphosphate and then full seedbed preparation) renovation were imposed only at some sites. Plots varied in area from 0.14 to 0.50 ha, and were renovated then sown in March or April 2000 and subsequently grazed by dairy cows. Pasture utilisation was estimated from pre- and post-grazing pasture mass assessed by a rising plate pasture meter.

Utilised herbage mass of the renovated treatments was significantly higher than control plots in period 1 (planting to August) and 2 (first spring) at the NSW site only. There was no difference among treatments in period 3 (first summer) at any site, and only at the WA and NSW sites in period 4 (March to July 2001) was there a response to renovation. As a result, renovation at the NSW site only significantly increased ryegrass utilisation over the whole experimental period.

Ryegrass plant density was higher at the NSW, WA (excluding minimum renovation) and Tas. (excluding full renovation) sites 6 months after renovation but this was only sustained for 12 months for the minimum and medium treatments at the NSW and Tas. sites, respectively, presumably due to reduced competition from naturalised C_4 summer grasses [kikuyu (*Pennisetum clandestinum*) and paspalum (*Paspalum dilatatum*)] in NSW. At the NSW, WA and SA sites, the original ryegrass plant density was low (<35 plants/m^2) compared with the Tas. site where density was around 185/m^2.

The response to renovating a degraded perennial ryegrass pasture varied between sites in Australia. Positive responses were generally small and were most consistent where renovation removed competing C_4 summer grasses.

Introduction

A national survey, conducted in 1999 to quantify the persistence of perennial ryegrass (*Lolium perenne* L.) in dairy pastures in Australia (D. Donaghy unpublished data), showed a decline in plant density at sites in New South Wales (NSW, warm temperate), Western Australia (WA, Mediterranean with flood irrigation) and South Australia (SA, Mediterranean). Only in the cool temperate climate of Tasmania were perennial ryegrass plant populations stable or increased in persistence after the establishment year. In agreement with the findings of this survey, swards of perennial ryegrass in the warm temperate dairy region of northern New Zealand had low persistence due to invasion by the C_4 species paspalum (*Paspalum dilatatum*) (Thom *et al*. 1993).

On farms, a response to a degraded ryegrass pasture is to oversow the sward in order to extend its productive life by 1 or 2 years. Renovation techniques to oversow or renovate these pastures may range from full cultivation, establishing a clean weed-free seedbed, to simply broadcasting or direct-drilling seed into an existing pasture after controlling competition of resident species by judicious grazing or herbicide (Carter 1999). In NSW and WA, the invading weeds are naturalised C_4 summer grasses, usually kikuyu (*Pennisetum clandestinum*), paspalum and couch (*Cynodon dactylon*) (van Houtert *et al*. 1999; Reeves *et al*. 1996).

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Table 1. The town nearest to each experimental site, its geographic bearing, elevation above sea level (m) and soil characteristics

P, phosphate; K, potassium; S, sulfur

	NSW	WA	SA	Tas.
Nearest town	Gerringong	Wokalup	Fleurieu Peninsula	Henrietta
Latitude (south)	34°45′	33°8′	35°26′	41°26′
Longitude (east)	150°50′	115°53′	138°37′	145°41′
Elevation (m)	46	40	270	370
Soil texture	Clay loam	Loam	Loam	Loam
Soil colour	Brown	Grey	Grey	Red
pH ($CaCl_2$)	4.6	4.1	4.6	5.0
P (mg/L) Colwell	153	109	58	71
K (mg/L) Colwell	144	262	196	241
S (mg/L) MCP	—	43	6	15
Cation exchange capacity	17.6	10.4	9.5	11.4

Recent studies in northern Victoria (K. Kelly pers. comm.) indicated that the benefits of renovating degraded perennial ryegrass pastures by oversowing were marginal, with herbage production increased by about 10% per annum across the 4 year measurement period.

The objective of the present study was to determine the impact of renovation on herbage utilisation of a degraded perennial ryegrass pasture when new plants were established using a range of pasture renovation techniques in 4 climatically different dairy regions in Australia.

Material and methods

Site descriptions

The dairy pastures used in these studies were selected by steering groups in each region comprising local dairy farmers and dairy extension officers, and were considered to be degraded and in need of renovation. The location and description of each site are presented in Table 1. The NSW, SA and Tasmanian sites were on commercial dairy farms whereas the WA site was located on an Agricultural College.

Prior to the commencement of the study, about 60 soil samples were collected to a soil depth of 7.5 cm over the experimental area at each site and were pooled into at least 3 samples for subsequent chemical analysis (Table 1).

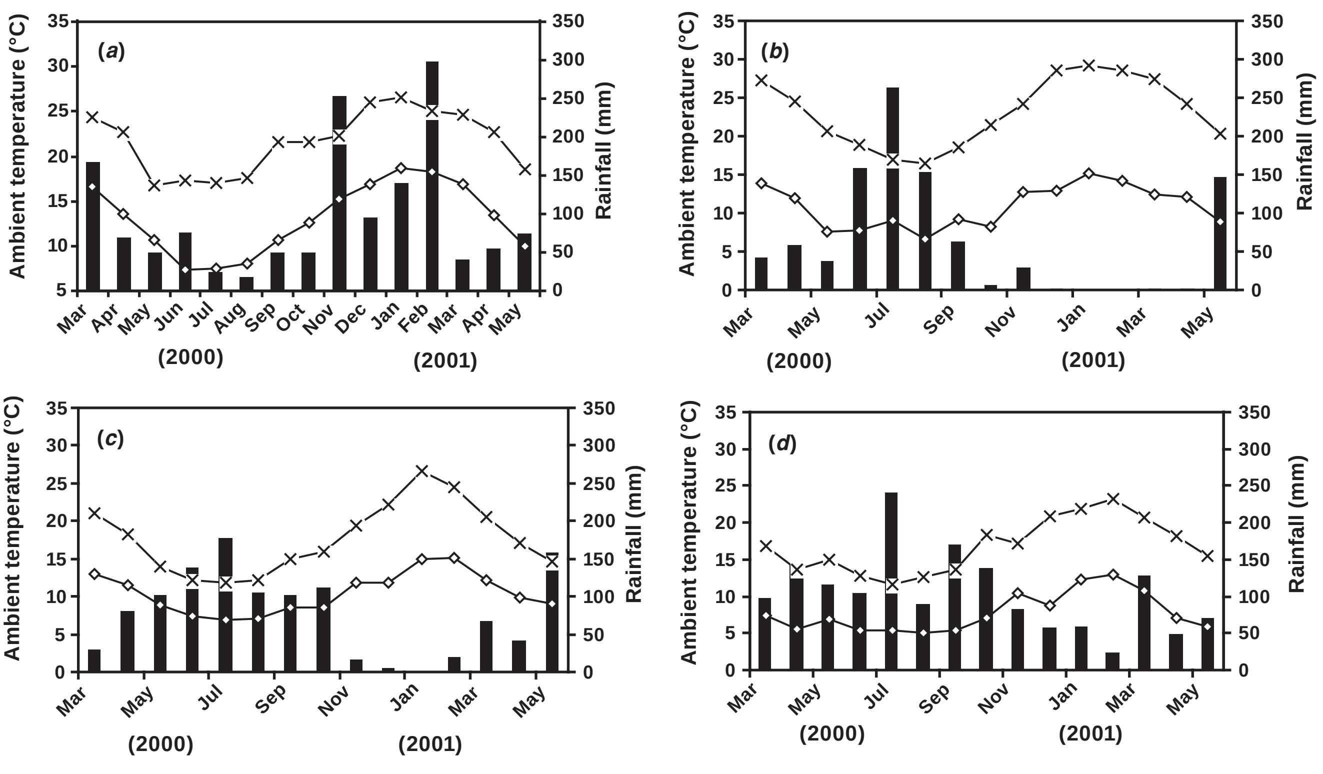

Figure 1. The mean monthly minimum (◇) and maximum (×) temperatures (°C) and the monthly rainfall (black bars) (mm) recorded at study sites during the period of the study in (*a*) NSW, (*b*) WA, (*c*) SA and (*d*) Tasmania.

Table 2. Renovation treatments adopted at each study site, treatment classification, seeding rates for perennial ryegrass (kg/ha), sowing date and ryegrass variety selected

Site	Renovation technique	Perennial ryegrass seed rate (kg/ha)	Planting date in 2000	Ryegrass cultivar
	Control treatment			
All	No renovation	—	—	—
	Minimum treatment			
NSW	Mulch; sow	26	27 Mar.	Impact
WA	Mulch; sow	30	26 Apr.	Mixture[A]
Tas.	Graze; sow	20	1 Mar.	Impact
	Medium treatment			
NSW	2.16 kg a.i. glyphosate/ha; sow	26	17 Mar.	Impact
WA	2.16 kg a.i. glyphosate/ha; sow	30	26 Apr.	Mixture[A]
SA	2.4 L spray seed; sow	10.5	9 May	Ellet/Victorian
Tas.	0.9 kg a.i./ha glyphosate/ha; graze; sow	20	1 Mar.	Impact
	Full treatment			
WA	2.16 kg a.i. glyphosate/ha in spring; sow; millet crop; 2.16 kg a.i. glyphosate/ha in autumn; sow	30	26 Apr.	Mixture[A]
SA	2.4 L spray seed/ha; cultivate; sow	15	9 May	Ellet/Victorian
Tas.	0.9 kg a.i. glyphosate/ha; graze; cultivate; sow	20	1 Mar.	Impact

[A]Mixture contained by weight (%) perennial ryegrass cultivars Bronsyn 32%, Vedette 30%, Impact 20%, and white clover cultivars Aran 8% and Sustain 10%.

The monthly rainfall and mean monthly minimum and maximum temperatures of the towns nearest to each of the study sites are shown in Figure 1. Although the distribution of rainfall was typical for each site, annual rainfall was 12, 22, and 33% less than the long term mean for NSW, WA and Tasmania, respectively, and 7% greater than that in SA. Total rainfall per month during germination and seedling establishment was greater than 40 mm at each site and was considered to be non-limiting.

Treatments

The experimental layout was a randomised block design with 3 replicates of 3 (NSW and SA sites) or 4 (WA and Tasmanian sites) pasture renovation treatments (Table 2). Mulching refers to the mechanical defoliation along an axis perpendicular to the sward that tears and shreds stolons, increasing the area of bare ground and assisting seed establishment.

The control (nil renovation) and the medium renovation (mulch and graze, spray with glyphosphate and sow) treatments were common to all sites; however, the minimum (mulch and graze, and sow) and full seedbed (graze and spray with glyphosphate and then full seedbed preparation) renovations were not. The perennial ryegrass variety selected and the sowing rates used were based on best management practice for each region as proposed by the local steering group. Seed was direct drilled into the swards and rolled if necessary to improve seed–soil contact.

Table 3. Grazing interval (leaves/tiller) and the calibration for rising plate meter (RPM) pasture height (cm) on pasture mass (kg DM/ha) at each site for ryegrass and kikuyu, and description of resident naturalised species

Leaves/tiller values are mean ± s.e.

Site	Grazing interval (leaves/tiller)	Calibration for RPM (cm) Ryegrass *a* (kg DM/ha)	*b* (kg DM/ha)	*n*	r^2	Kikuyu *a* (kg DM/ha)	*b* (kg DM/ha)	Resident naturalised species
NSW[A]	3.1 ± 0.1	0	195	1242	0.80	–1200[E]	200	Bent grass (*Agrostis capillaris*), kikuyu, silver grass, paspalum, capeweed
WA[B]	3.3 ± 0.2	500	180	—	—	500[F]	250	Geranium (*Geranium molle)*, barley grass (*Hordeum leporinum)*, kikuyu, paspalum
SA[C]	2.2 ± 0.1	225	163	193	0.79	—	—	Cocksfoot (*Dactylis glomeratus)*, silver grass, capeweed
Tas.[D]	2.6 ± 0.1	500	250[E]	>200	>0.80	—	—	Bent grass, capeweed, silver grass, winter grass
		500	320[F]	>200	>0.80			

[A]Fulkerson and Slack (1993). [B]Diley and Howes (1998). [C]Mitchell (1997). [D]Michell (1982). [E]March to October. [F]November to February.

Plot size was 0.14, 0.25, 0.50 and 0.25 ha at the NSW, WA, SA and Tas. sites, respectively. Dairy cows grazed all plots in a rotational grazing system with interval and intensity based on recommended management practice (Fulkerson and Donaghy 2001). At the NSW site, 50 kg di-ammonium phosphate/ha (9 kg nitrogen (N)/ha, 10 kg phosphate (P)/ha and 0.75 kg sulfur (S)/ha) was applied at establishment; at the WA site, a blend of triple superphosphate/sulphate of ammonia/muriate of potash equivalent to 350 kg/ha (21 kg N/ha, 31 kg P/ha, 50 kg potassium (K)/ha and 39 kg S/ha) was used at establishment; at the SA site, 100 kg/ha superphosphate (8.7 kg P/ha, 0.2 kg K/ha and 11 kg S/ha) was applied in August; and at the Tas. site, 200 kg/ha di-ammonium phosphate (36 kg N/ha, 40 kg P/ha and 3 kg S/ha) was applied at sowing. The WA site was flood-irrigated (from November to March) when 70 mm of evapotranspiration was recorded with equivalent to 100 mm/ha.

Data collection

To evaluate the response to renovation in terms of pasture utilisation, the study was divided into 4 seasonal periods: period 1, (establishment) planting to August 2000; period 2, (spring) September to December 2000; Period 3, (summer) January to February 2001; and Period 4, (autumn) March to July 2001.

The dates of grazing were noted and related to the number of new leaves/tiller regrown (Fulkerson and Slack 1994) (Table 3). To estimate pre- and post-grazing pasture mass (kg dry matter (DM)/ha), a minimum of 50 recordings/plot were taken using an Ellinbank rising plate meter (Earle and McGowan 1979). The calibration equations used for calculating herbage mass (Table 3) at all sites were pooled equations from similar pastures. The reproductive tiller development of perennial ryegrass at the NSW and WA sites was minimal and pasture became dominated by kikuyu grass from November to February; thus, separate ryegrass and kikuyu calibrations were used. In Tasmania, the standard curve for ryegrass in its vegetative growth stage was used from March to October and after stem elongation a summer curve was used.

Prior to each grazing, 20–30 pasture samples at simulated grazing height were plucked and sorted into perennial ryegrass and other species. At the SA site, the botanical composition of the forage on offer was only estimated visually, except prior to the final grazing in May 2001 when standard methods, as outlined above, were used.

The population of perennial ryegrass plants and other species, including grasses other than ryegrass, weeds and legumes [white clover (*Trifolium repens*), subterranean clover (*T. subterraneum*), lucerne (*Medicago sativa*) and red clover (*T. pratense*)], was estimated by counting plants (including immature seedlings) in 10 quadrats (0.09 m^2) placed at random in each treatment plot. Plant density was recorded at varying dates at each site (see Table 4).

The number of entire plants pulled out of the ground by stock while grazing was only recorded at the NSW site following each grazing from 4 randomly placed quadrats (1 m^2) in each plot.

Statistical analysis

Data on herbage utilisation, plant density and sod pulling were subjected to analysis of variance using the statistical package Genstat (Genstat 5 Committee 1993), without requiring transformation.

Results

Herbage utilisation

The renovation of swards increased ($P<0.05$) cumulative ryegrass utilised over the total study period at the NSW site only (Table 5). Ryegrass herbage utilisation on renovated plots was only significantly ($P<0.05$) higher than the control plots at the NSW site in periods 1 and 2 (Fig. 2). In period 3 (first summer), the ryegrass utilisation of renovated plots did not differ significantly ($P>0.05$) from the control plots at all sites. In period 4 (second autumn), the ryegrass utilised was only significantly ($P<0.05$) higher in the medium and fully renovated treatments at the NSW and WA sites, respectively.

Renovation at the NSW site significantly ($P<0.05$) reduced the herbage utilisation of other species, primarily kikuyu, during all defoliation periods (Fig. 3). In contrast, full renovation at the Tasmanian site increased ($P<0.05$) the utilisation of other species during periods 1, 2 and 4. At the WA and SA sites, there was no reduction ($P>0.05$) in the utilisation of other species from swards that had been renovated.

Table 4. Ryegrass plant density (plants/m^2) for the control, minimum, medium and full renovation treatments at each site at specified dates

Means within each row followed by the same letter are not significantly different at $P = 0.05$

Site	Date	Renovation treatment: Control	Minimum	Medium	Full	l.s.d. ($P = 0.05$)
NSW	6 Apr.	0a	15b	24c	—	8
	25 July	7a	11b	12b	—	4
	12 Sept.	4a	6b	7b	—	1
	13 Nov.	3a	6b	7b	—	2
	22 Jan.	3a	4a	6b	—	2
	7 Mar.	2a	4b	6c	—	1
	21 May	2a	3a	5b	—	2
WA	30 Oct.	34a	40ab	69bc	84c	31
	17 May	17	16	21	28	n.s.[A]
SA	7 July	39	—	219	175	n.s.[A]
	13 Nov.	67	—	124	128	n.s.[A]
	4 May	49	—	56	77	n.s.[A]
Tas.	10 June	185a	342c	259b	206a	46
	28 Oct.	140a	216c	172b	139a	26
	15 June	135ab	200c	144b	120a	22

[A]n.s., not significant.

Plant density

Renovation increased (P<0.05) ryegrass plant density in Tas. during period 1 (first autumn) for the minimum and medium treatments and during period 2 for the minimum treatment only (Table 4). At the NSW site, there was a significant (P<0.05) improvement in ryegrass plant density in the renovated treatments over most sampling dates. In WA, there was a marked increase in ryegrass plant density when medium and full renovation was compared with the control treatment, and while this response remained until spring (Table 4), it had disappeared by May the following year. In SA, renovation did not (P>0.05) increase the density of ryegrass plants. Renovation at the NSW and WA sites presumably benefited from the suppression or removal of competition from the invading C_4 grass species, kikuyu and paspalum (Table 6). In SA, there was little impact of medium and full renovation on weed species [silver grass (*Vulpia bromoides*) and capeweed (*Arctotheca calendula*)]. In Tasmania, the medium renovation treatments actually increased (P<0.05) the plant density of other species by June of years 1 and 2, mainly due to germination of winter grass (*Poa annua*) and reduced perennial ryegrass density (Table 6).

Sod pulling

The medium renovation treatment at the NSW site led to the greatest (P<0.05) number of plants pulled from the ground, 10 ± 1.9 plants/m^2 (mean ± s.e.; P<0.05), during grazing in period 1 (first autumn) compared with less than 2 plants/m^2 for the control and minimum renovation treatments. During periods 2 (first spring) and 3 (first summer), the number of plants removed by grazing stock was less than 1/m^2 for each treatment.

Discussion

The effects of renovating a degraded perennial ryegrass pasture on ryegrass herbage utilisation varied markedly between sites and appeared to be dependent on the initial density of ryegrass and weed species, and their respective seedbanks. In the warm temperate environment of NSW,

Table 5. Cumulative ryegrass utilisation (kg DM/ha) from planting (March or April 2000) to July 2001 for the control, minimum, medium and full renovation treatments at each study site

Means within each row followed by the same letter are not significantly different at P = 0.05

Site	Renovation treatment				l.s.d.
	Control	Minimum	Medium	Full	(P = 0.05)
NSW	2327a	4823b	5848b	—	1442
WA	2453	2543	3999	3785	n.s.[A]
SA	3290	—	2888	2883	n.s.[A]
Tas.	8324	8691	7940	7116	n.s.[A]

[A] n.s., not significant.

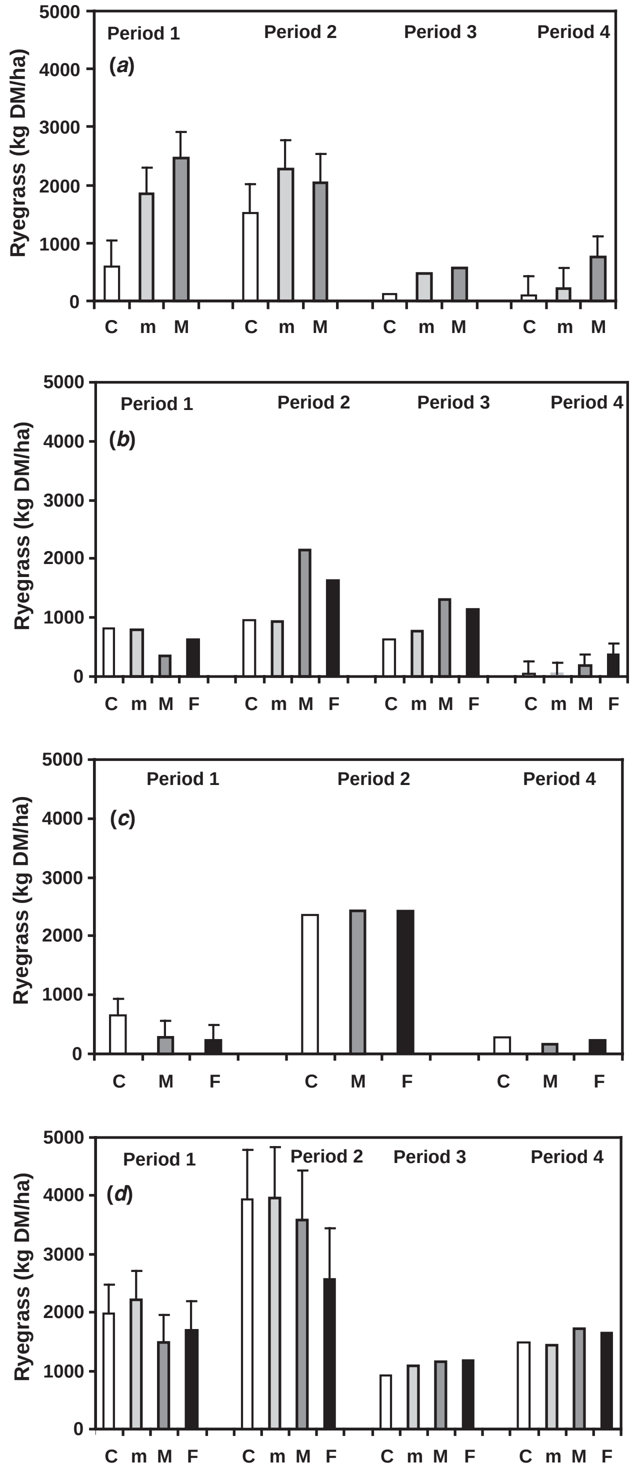

Figure 2. Ryegrass utilisation (kg DM/ha) for control (C, open bars), minimum (m, light grey bars), medium (M, dark grey bars) and full (F, black bars) renovation treatments for defoliation periods 1 (planting to August 2000), 2 (September to December 2000), 3 (January to February 2001) and 4 (March to July 2001) in (*a*) NSW, (*b*) WA, (*c*) SA and (*d*) Tasmania. Vertical bars indicate s.e. for treatments within the same defoliation period.

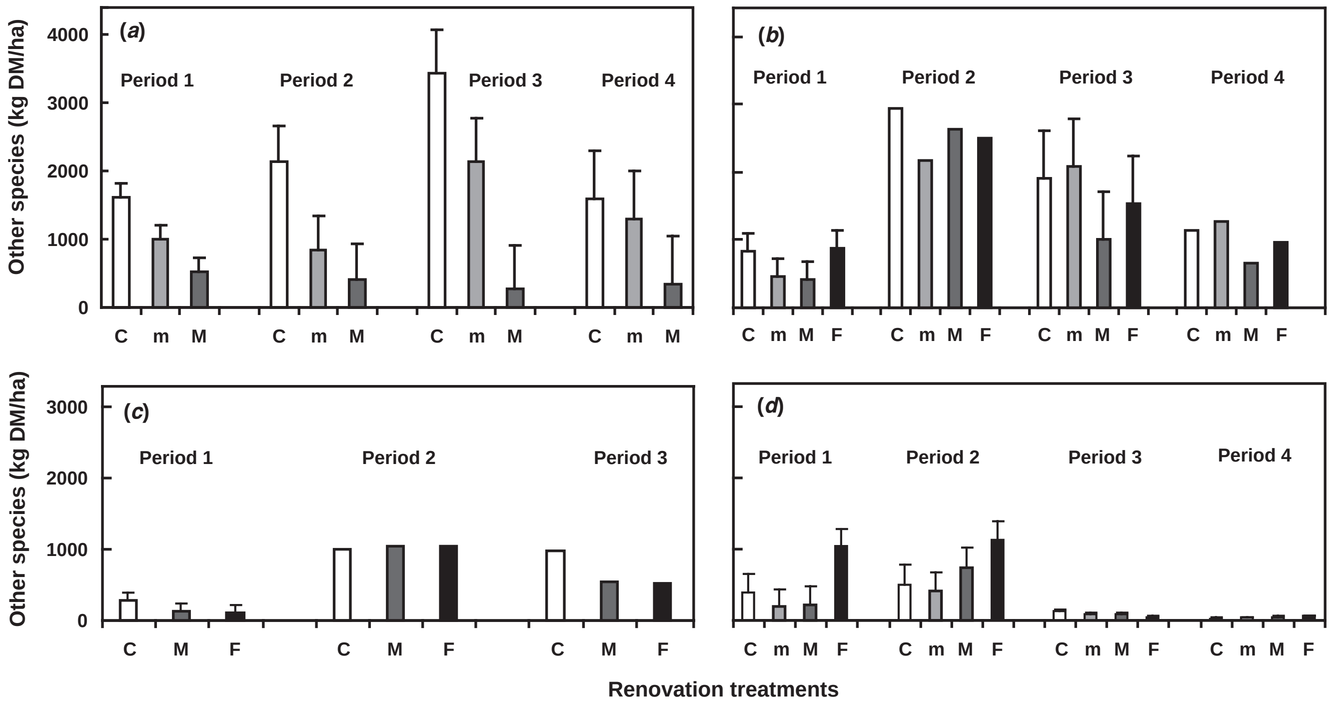

Figure 3. Other species utilisation (kg DM/ha) for control (C, open bars), minimum (m, light grey bars), medium (M, dark grey bars) and full (F, black bars) renovation treatments for defoliation periods 1 (planting to August 2000), 2 (September to December 2000), 3 (January to February 2001) and 4 (March to July 2001) in (*a*) NSW, (*b*) WA, (*c*) SA and (*d*) Tas. Vertical bars indicate s.e. for treatments within the same defoliation period.

renovating increased the amount of ryegrass utilised in the establishment year by 2.5 t DM/ha (107%) and 3.5 t DM/ha (150%) for the minimum and medium treatments, respectively. The response probably reflected reduced competition from kikuyu with herbage utilisation of this species being reduced by 40 and 82% for the minimum and medium treatments, respectively. On completion of the study, the effect of renovation was less obvious for the control and minimum treatments where ryegrass and other species (kikuyu) utilisation were similar. In a similar climatic environment in northern New Zealand, the perennial ryegrass yield response to renovating a paspalum-dominant pasture in winter/spring was 38% higher in swards where paspalum had been reduced by the application of 2.16 kg a.i. glyphosphate/ha before drilling than where no herbicide was used (Thom *et al*. 1993). Again the benefit decreased rapidly during summer and was not significant by the end of the fourth year, as paspalum had reinvaded.

In the cool temperate environment of Tasmania, there was no yield response to renovation. Indeed, full renovation increased the utilisation of other species 2-fold in the establishment period (September to December), suggesting that the 185 plants/m^2 in the original swards was sufficient to maintain production. At the remaining sites, the perennial ryegrass plant population was less than 50 plants/m^2, and this was predictably a key factor in the better response to renovation, with the highest response occurring in NSW where initial ryegrass plant densities were zero. However, in the Mediterranean environment of SA, the plant density of other species was about 785 plants/m^2 and it is likely that this contributed to the lack of response to renovation. In these

Table 6. Other species plant density (plants/m^2) for the control, minimum, medium and full renovation treatments at each site at specified dates

Means within each rows followed by the same letter are not significantly different at $P = 0.05$

Site	Date	Control	Minimum	Medium	Full	l.s.d. ($P = 0.05$)
NSW	6 Apr.	0	0	0	—	n.s.[A]
	25 July	18c	13b	5a	—	4
	12 Sept.	11b	7a	4a	—	3
	13 Nov.	47c	19b	3a	—	9
	22 Jan.	67c	36b	3a	—	14
	7 Mar.	89c	65b	6a	—	10
	21 May	75b	76b	10a	—	11
WA	30 Oct.	87b	99b	43a	13a	40
	17 May	79	67	74	46	n.s.
SA	7 July	785	—	468	498	n.s.
	13 Nov.	160	—	162	157	n.s.
	4 May	569	—	930	727	n.s.
Tas.	10 June	236a	188a	421b	200a	66
	28 Oct.	101	67	95	90	n.s.
	15 June	232b	142a	304c	255bc	68

[A]n.s., not significant.

more marginal environments for perennial ryegrass, the response to partial renovation methods and techniques was questionable, as they only appeared to have limited or no effect.

In the dairy region of northern New Zealand, Thom *et al*. (1993) demonstrated that the number of ryegrass plants in renovated swards stabilised at around 250 plants/m^2 within 4–5 months, while in swards where herbicide was absent, plant density was 80 plants/m^2. In the present study, the ryegrass density in swards renovated in the cooler environment of Tas. stabilised at 120–200 plants/m^2. In the warmer environments at NSW, WA and SA, renovated swards contained 3–77 plants/m^2. These findings show that both the climate and level of renovation influenced establishment and the subsequent survival of ryegrass plants. This is supported by the observations that persistence of perennial ryegrass in the more marginal subtropical environment of northern Australia was very low (Lowe *et al*. 1999).

Increasing the planting rate of perennial ryegrass from 20 to 30 kg/ha in SA provided insufficient competition against the presumably large seed bank of annual weed species. The response in terms of ryegrass utilisation may have been higher if the sowing date was moved forward from 9 May to the first week of April (Hamilton-Manns *et al*. 1995). However, the value of planting perennial ryegrass in a Mediterranean environment, with its hot and dry summers, and without irrigation, is questionable.

In this present study, the selection criteria for renovation were based on the views of a local panel of farmers and extension officers. The variation in response to renovation highlighted that the dairy industry has no template on which to recognise a sward of perennial ryegrass in need of renovation. Rather, the decision to renovate is based on previous experience when possibly climate, soil nutrient and water status, and grazing history differ.

This study demonstrated that the production benefit gained from renovating a perceivably degraded perennial ryegrass pasture depended on the density of the existing ryegrass sward and the store of naturalised weed seed in the soil, as suggested by Carter (1999). In the Mediterranean environments of Australia, the reserve of seed from self-regenerating annual weed species needs to be assessed prior to renovating, as renovation will be unsuccessful if the seed bank is large. Thus, the successful establishment and maintenance of a perennial ryegrass sward may require a comprehensive renovation strategy that includes reducing the soil seed bank of other species to minimise competition during the early stages of establishment and using herbicide to reduce naturalised grasses.

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