CSIRO PUBLISHING
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Dry matter yield, forage quality and persistence of tall fescue (*Festuca arundinacea*) cultivars compared with perennial ryegrass (*Lolium perenne*) in a subtropical environment

M. N. Callow[A,B], *K. F. Lowe*[A], *T. M. Bowdler*[A], *S. A. Lowe*[A] *and N. R. Gobius*[A]

[A]Department of Primary Industries, Mutdapilly Research Station, MS 825, Peak Crossing, Qld 4306, Australia.
[B]Author for correspondence; e-mail: mark.callow@dpi.qld.gov.au

Abstract. The dry matter (DM) yield, plant persistence and forage quality of tall fescue (*Festuca arundinacea*) and perennial ryegrass (*Lolium perenne*) were compared in the subtropical environment of southern Queensland, Australia. The field study was conducted under irrigation with pure, nitrogen fertilised stands of 10 commercial tall fescue cultivars (Advance, AU Triumph, Bombina, Cajun, Dovey, Maximise, Midwin, Torpedo, Quantum and Vulcan), 3 experimental cultivars (ITF 97010, ITF 97020 and PWF 29) and Dobson perennial ryegrass. From July 1997, plots were defoliated at 4-week intervals for 3 years. Changes in crude protein content and *in vitro* DM digestibility (IVDMD) were determined at 1, 2, 3, 4, 6 and 8 weeks post-defoliation in October (spring) 1997, January (summer), March (autumn), June (winter) and September (spring) 1998.

Some cultivars of irrigated tall fescue were shown to be better adapted to a subtropical environment than perennial ryegrass. After 3 years, cumulative DM yields were in excess of 30 t/ha for Dovey, Quantum, ITF 97010, AU Triumph and Cajun tall fescue compared with 12 t/ha from Dobson perennial ryegrass swards.

Plant development had a considerable influence on crude protein content and IVDMD of tall fescue and perennial ryegrass, more so than the length of the regrowth period. As plant tissue matured, the forage quality during spring declined linearly for crude protein content and for IVDMD (1998 only), and declined exponentially for IVDMD during spring (1997), summer, autumn and winter (1998). Quality losses may be minimised if tall fescue cultivars are defoliated every 2–3 weeks during spring and summer and every 3–4 weeks during autumn and winter.

Introduction

Perennial ryegrass (*Lolium perenne*) is a productive pasture species used on dairy farms in temperate regions of Australia. If this species is managed to optimise forage yield and quality (Fulkerson and Donaghy 2001), the survival of plants is increased and the influx of weed species is reduced, extending the productive life of the pasture. However, in subtropical southern Queensland, the hot, humid summers accelerate the decline in perennial ryegrass plant density. As a consequence, most Queensland dairy farmers plant the vigorously growing ‘short-rotation’ ryegrass (*L. multiflorum*), accept little or no forage production during summer and autumn, and re-establish their pasture annually.

Alternatively, tall fescue (*Festuca arundinacea*) has been shown to be more productive during the warmer months and yield more total forage than perennial ryegrass in southern Queensland (Lowe and Bowdler 1984, 1995). However, lower milk production from cows grazing tall fescue pastures when compared with Dobson perennial ryegrass has been reported (Lowe *et al.* 1999*b*) and this lower production is probably associated with the lower forage quality of tall fescue (Lowe and Bowdler 1984; Easton *et al.* 1994; Stone 1994).

New ‘softer-leaved’ tall fescue cultivars have been developed to improve animal acceptance and consequently milk production. The aim of the current study was to evaluate the forage yield, quality and persistence of a range of new tall fescue cultivars when grown in a subtropical environment.

Materials and methods

A field study was conducted from 1997 to 2000 at Mutdapilly Research Station, Queensland (27°46′S 152°40′E; altitude 40 m). The soil type was a heavy black clay with a soil analysis of 84 mg/kg phosphorus (P) (Colwell extraction), 0.83 mmol potassium (K)/100 g and a pH of 6.7 (H_20). The soil was classed as Ug5.15 (Northcote 1971) or Wiesenboden. In April 1997, 1998 and 1999, 300 kg/ha of CK88 fertiliser [43 g P; 113 g K; 136 g sulfur (S); 150 g nitrogen (N)/kg dry matter (DM)] was applied. After each harvest, an additional 120 kg/ha of urea (460 g N/kg DM) was applied. A travelling irrigator applied water to replace evapotranspiration loss, usually 50 mm every 2 weeks.

Forty-two plots of 2.5 by 5 m were laid out in a randomised block design with 3 replicates. The study site was cultivated with off-set discs and then power harrowed to prepare a fine seedbed. Plots were hand-sown in April 1997 with one of 10 tall fescue cultivars (soft-textured leaf types: Midwin, Torpedo and Vulcan; medium-textured leaf types: Bombina, Maximise and Quantum; and hard-textured leaf types: Advance, AU Triumph, Cajun and Dovey), 3 experimental tall fescue cultivars (medium-textured leaf types: ITF 97010, ITF 97020 and PWF 29), all at 20 kg/ha, and Dobson perennial ryegrass, sown at 24 kg/ha. Cultivars of tall fescue were grouped into 3 groups of leaf type

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textures (soft, medium and hard) according to their tensile strength, measured *in situ* by holding a leaf, selected at random, from each plant with 2 hands and applying an equal force.

Pastures were defoliated, a 3 m^2 strip within each plot, at 4-week intervals to 50 mm stubble height using a reciprocating mower. Sampling commenced in July 1997 and was completed in June 2000. A random subsample from the harvested herbage was then sorted into grasses and weeds. Samples were dried in a forced-draught oven at 60°C for 24 h. The remaining pasture residues on each plot were reduced to a 50 mm stubble height either by grazing with calves or by forage harvester.

From October (spring) 1997 and January (summer), April (autumn), June (winter) and September (spring) 1998, herbage samples were collected at 1, 2, 3, 4, 6 and 8 weeks post-defoliation. Plots were divided in half for an 8 week sampling period. Samples for 1–4 weeks regrowth were taken by harvesting two 0.25 m^2 quadrats to 50 mm stubble height at exclusive locations within the first half of the plot. This area was then mown off after 4 weeks to provide a sample area for the next consecutive 4 week defoliation period. The remaining half of the plot was sampled at 6 and 8 weeks, and then the entire plot was defoliated. Subsequent defoliations reverted back to 4 weekly intervals. Replicate samples were pooled and analysed for crude protein (CP) content and *in vitro* DM digestibility (IVDMD) using near infrared spectroscopy (NIR) calibration equations previously derived according to the procedures outlined by Smith and Flinn (1991). The reference methods used for NIR calibration were the Kjeldahl method for N and a pepsin–cellulase technique (Clarke *et al.* 1982) for IVDMD, where analytical values were first adjusted using a linear regression based on similar samples of known *in vivo* DMD.

Plant frequency of tall fescue and perennial ryegrass was determined on completion of the study in June 2000. A 0.5 m^2 quadrat was randomly placed within each plot and the proportion of living plants of the total surface area was established from visual observation.

All data were analysed using the statistical package ‘Genstat’ (Genstat 5 Committee 1993). Data for DM yield were subjected to 1-way ANOVA. Plant frequencies were transformed using inverse sine and then analysed using ANOVA. The relationships between CP content and IVDMD with weeks post-defoliation were determined for each cultivar in each season using linear and quadratic regression analyses. Cultivars were pooled within a season if their regression equations did not significantly (P>0.05) differ from each other.

Results

Climate

Ambient temperatures during the experimental period were similar in each of the 3 years except for the below average minimum temperatures in the winter of 1997, and the above-average maximum temperature during the summer of 1997–98 (Fig. 1). The annual rainfall for 1998 and 1999 was 670 and 840 mm, respectively.

Dry matter yield

Highest grass DM yields were achieved by Quantum, Dovey, AU Triumph, Cajun and ITF 97010 in year 1; ITF 97010, Dovey, Quantum, AU Triumph, Maximise, ITF 97020, Cajun and Advance in year 2; and Dovey, ITF 97010 and AU Triumph in year 3 (Table 1). Over the 3 years of the study DM yields were greatest (P<0.05) for Dovey, Quantum, ITF 97010, AU Triumph and Cajun tall fescue with 33.6, 32.6, 32.5, 31.8, and 31.1 ± 1.4 t DM/ha, respectively. Midwin, Advance and Torpedo tall fescue and Dobson perennial ryegrass plots produced in excess of 12 t DM/ha of weed (predominantly low quality summer grass) over the 3 years, compared with the mean of all cultivars of 7.5 ± 1.1 t DM/ha.

From establishment to mid-August 1977, the average daily growth rate of Dobson perennial ryegrass was significantly greater (P<0.05) than tall fescue, 21 and <10 kg DM/ha.day, respectively (Table 2). By the completion of the 1997 summer growing period, growth rates of Dobson perennial ryegrass were significantly reduced (P<0.05) to <10 kg DM/ha.day. Growth rates in year 2 never exceeded 15 kg DM/ha.day and there was no growth in year 3 (Table 2). In contrast, on completion of the 1997 summer period, Dovey, Maximise, ITF 97010 and Cajun tall fescue recorded the greatest growth rates with 30, 29, 26, and 26 kg DM/ha.day, respectively (Table 2). On

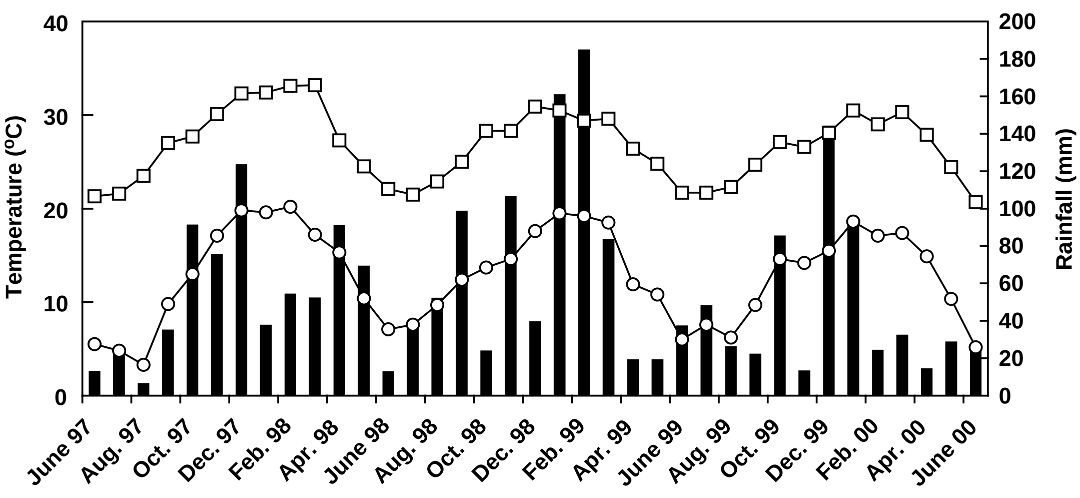

Figure 1. The mean monthly minimum (○) and maximum (□) temperatures (°C) and the monthly rainfall (■, mm) recorded at Amberley, located 10 km west of Mutdapilly Research Station, from June 1997 to June 2000.

Table 1. Mean dry matter yield (t DM/ha) of grass, Dobson perennial ryegrass and tall fescue cultivars, and weeds for years 1 (1997–1998), 2 (1998–1999) and 3 (1999–2000), and total dry matter yield (1997–2000) and plant frequency (percent per unit area) at the completion of year 3 (2000)

Leaf texture was used to qualitatively rank leaf strength

Cultivar	Leaf texture	DM yield (t DM/ha) 1997–1998 Grass	1997–1998 Weeds	1998–1999 Grass	1998–1999 Weeds	1999–2000 Grass	1999–2000 Weeds	Total DM yield 1997–2000 Grass	Total DM yield 1997–2000 Weeds	Plant frequency in 2000 (%)
Dobson ryegrass		7.7	3.8	2.5	9.0	0	0	10.1	12.5	0
Tall fescue cultivars										
Advance	Hard	6.3	4.6	9.7	4.4	6.1	5.0	22.1	13.7	25.4
AU Triumph	Hard	10.7	1.9	10.6	2.0	10.7	1.5	31.8	5.2	52.2
Bombina	Medium	6.1	4.4	4.3	7.7	0.3	0	10.8	11.9	10.2
Cajun	Hard	10.6	1.5	10.1	1.1	10.5	1.0	31.1	3.4	47.5
Dovey	Hard	10.8	1.4	11.3	1.0	11.9	1.2	33.6	3.4	49.5
ITF 97010	Medium	10.1	0.6	11.4	0.2	11.5	0.2	32.5	1.0	67.1
ITF 97020	Medium	9.4	0.9	10.3	0.3	9.4	0.9	28.5	2.0	61.9
Maximise	Medium	8.2	2.4	10.5	1.5	9.6	0.4	28.1	4.2	57.3
Midwin	Soft	5.7	4.8	2.6	9.6	0	0	8.5	14.1	5.1
PWF 29	Medium	6.2	5.0	4.2	7.0	0.1	0.1	10.5	11.9	0
Quantum	Medium	11.0	1.8	11.3	1.4	10.5	1.6	32.6	4.6	46.6
Torpedo	Soft	6.7	4.3	2.6	8.3	0	0	8.9	12.3	5.5
Vulcan	Soft	7.3	1.4	9.1	1.7	8.6	1.5	24.8	4.3	60.6
Comparison of cultivars										
l.s.d. ($P = 0.05$)		1.06	—	2.0	1.8	1.3	0.9	2.9	2.2	12.6

completion of the study in autumn 2000, growth rates were greatest ($P<0.01$) for ITF 97010 and Dovey at 16 and 13 kg DM/ha.day, respectively.

Plant frequency

There were large differences in the persistence of tall fescue cultivars and Dobson perennial ryegrass as determined by their frequency at the completion of this study

Table 2. Growth rate (kg DM/ha.day) of Dobson perennial ryegrass and tall fescue during winter, spring, summer and autumn (winter 1997–autumn 2000)

Spring, September–November; summer, December–February; autumn, March–May; winter 1997, July–August; winter 1998, June–August; winter 1999, June–July

Within columns, growth rates followed by the same letter are not significantly different (l.s.d. at $P = 0.05$)

Cultivar	1997 Winter	1997 Spring	1997 Summer	1998 Autumn	1998 Winter	1998 Spring	1998 Summer	1999 Autumn	1999 Winter	1999 Spring	1999 Summer	2000 Autumn
Dobson ryegrass	21.4d	54.2fg	5.8a	6.8a	6.8a	15.4ab	5.5a	0a	0a	0a	0a	0a
Tall fescue cultivars												
Advance	1.5a	40.3ab	20.9cd	8.0ab	22.8b	49.3d	34.9cd	0.7ab	6.9a	38.9b	17.0b	2.2ab
AU Triumph	6.4c	58.6gh	24.6def	27.0d	26.5b	48.0d	37.5d	6.3cd	35.1de	51.1d	28.0c	5.7bc
Bombina	6.0bc	50.2def	10.6b	2.5a	8.7a	24.3bc	15.1b	0a	4.6a	0a	0a	0a
Cajun	5.0abc	60.7h	26.0efg	24.8d	25.9b	46.2d	36.6d	4.4abcd	21.6bc	55.7d	30.3c	6.2bc
Dovey	8.2c	46.5cd	30.4g	27.2d	27.5b	46.5d	46.9e	5.3bcd	42.1e	49.5cd	29.6c	12.7de
ITF 97010	6.3c	47.6cde	26.1efg	27.8d	22.4b	52.4d	40.2de	11.5e	41.4e	43.3bc	28.7c	15.7e
ITF 97020	4.6abc	43.1bc	22.6de	27.5d	20.5b	49.2d	32.9cd	11.6e	30.6cd	41.7b	25.7c	6.9c
Maximise	2.3ab	37.7a	28.6fg	22.8cd	22.7b	48.5d	36.7d	9.0de	34.3de	37.6b	26.4c	9.7cd
Midwin	5.2abc	48.5de	8.2ab	4.6a	7.2a	11.3a	10.5ab	0a	0a	0a	0a	0a
PWF 29	5.1abc	52.0ef	8.9ab	3.5a	7.2a	28.6c	11.2ab	0a	1.3a	0a	0a	0a
Quantum	5.7bc	62.8h	25.8ef	25.1d	24.3b	55.3d	41.5de	4.5abcd	31.0d	50.7cd	29.6c	5.3bc
Torpedo	7.4c	51.9ef	11.1b	0.9a	4.7a	17.5abc	6.7ab	0a	0a	0a	0a	0a
Vulcan	4.7abc	41.1ab	17.5c	15.5bc	24.5b	47.4d	25.9c	3.6abc	20.5b	40.0b	25.3c	8.0c
Comparison of cultivars												
l.s.d. ($P = 0.05$)	3.73	5.00	4.52	7.97	7.71	12.94	9.15	4.63	9.29	7.65	5.41	4.56

(Table 1). As a percentage of plot surface area, ITF 97010, ITF 97020, Vulcan, Maximise and AU Triumph tall fescue had the greatest ($P<0.05$) frequency, in excess of 62 ± 5.5% (Table 1). In contrast, the frequency of Dobson perennial ryegrass and PWF 29, Midwin, Torpedo and Bombina tall fescue were significantly ($P<0.05$) less at 11 ± 4.2%.

Forage quality

There was a significant ($P<0.05$) negative linear relationship between the CP content and weeks post-defoliation for tall fescue and Dobson perennial ryegrass in spring 1997 and 1998 (Fig. 2). In summer 1997, autumn and winter 1998, there was a quadratic relationship between the CP content and weeks post-defoliation; the CP content changed little for the first 4 weeks before declining rapidly in weeks 6 and 8. The rate of decline in CP was similar ($P>0.05$) for cultivars within seasons; however, CP content varied between seasons. Levels peaked during autumn and winter and were lowest during spring and summer (Fig. 2). The regression equations describing the relationship between CP content and weeks post-defoliation for each tall fescue cultivar and Dobson perennial ryegrass for each season are described in Table 3.

The relationship between IVDMD and weeks post-defoliation ($P<0.05$) (Fig. 3) was quadratic during spring and summer 1997, and autumn and winter 1998; and linear during spring 1998 (Table 4). IVDMD differed ($P<0.05$) between the cultivars in spring 1997 and 1998 but not in summer 1997, autumn and winter 1998.

Discussion

At the conclusion of this 3-year study, grass DM yields exceeded 30 t DM/ha for the hard-textured leaf types: Dovey, AU Triumph and Cajun and medium-textured leaf types: Quantum and ITF 97010 tall fescue. In comparison, the production of the soft-textured leaf types: Midwin and Torpedo; and the medium-textured leaf types: PWF 29 and Bombina tall fescue, and Dobson perennial ryegrass was severely reduced after the establishment year and they accumulated less than 12 t DM/ha over the 3 years. Similarly, Lowe and Bowdler (1995) at Gatton Research Station showed that AU Triumph tall fescue was the highest yielding temperate sward accumulating 56.4 t DM/ha during a 2-year study compared with 42.8 t DM/ha for Dobson perennial ryegrass. The higher yields obtained by Lowe and Bowdler (1995) at Gatton for AU Triumph tall fescue and Dobson perennial ryegrass can be attributed to superior soil structure, drainage and reduced naturalised summer pastures, as both locations are in similar subtropical environments.

Plant persistence remains an important selection criterion for temperate perennial plant accessions for the dairying regions of Australia. In the present study, ITF 97010, ITF 97020, Vulcan, Maximise, AU Triumph, Dovey, Cajun and Quantum tall fescue demonstrated superior persistency, occupying greater than 45% of the plot area by the end of year 3. The remaining tall fescue cultivars and Dobson perennial ryegrass experienced large plant losses. Similarly, in other studies conducted in the subtropics, the plant density of many temperate perennial grasses is considerably reduced after the establishment year (Lowe and Bowdler 1984, 1995; Lowe *et al.* 1999*a*). In a warm temperate environment in New Zealand, when short periods of ambient temperatures higher than optimal for perennial ryegrass growth coincided with water stress, considerable plant loss occurred after 3 years (Thom *et al.* 1998).

Superior DM production is not always associated with increased animal production. In a 3 year grazing study with dairy cows in a subtropical environment at Mutdapilly Research Station, cows grazing a perennial ryegrass sward produced the most milk in the establishment year (16.7 kg milk/cow.day) from the lowest DM yields on offer. In

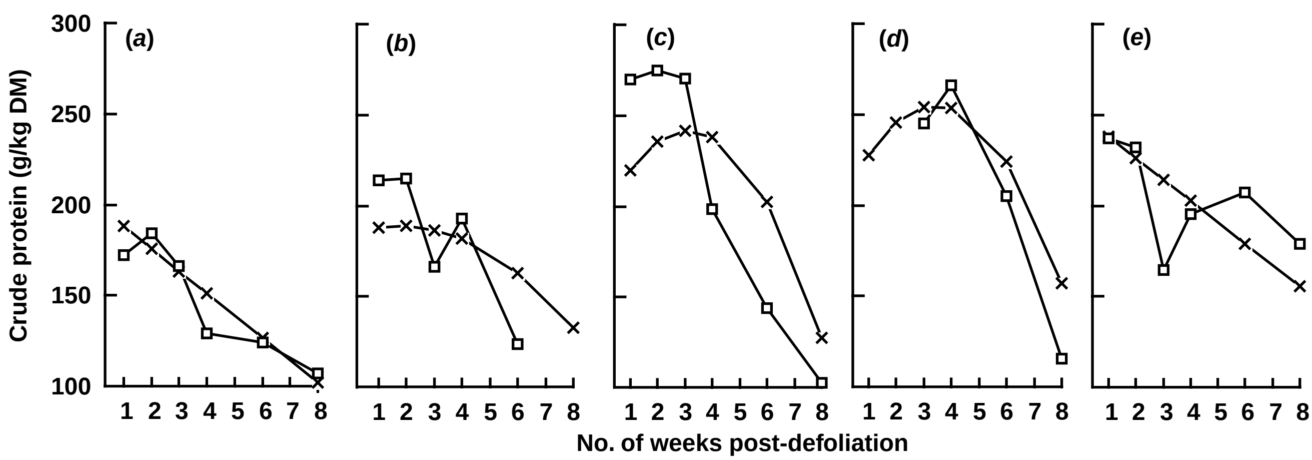

Figure 2. Mean crude protein content (g/kg DM, □) and estimated values modelled from the regression relationships (×) of Dobson perennial ryegrass. Samples were collected for 8 weeks post-defoliation commencing in (*a*) October 1997 (spring), (*b*) January 1998 (summer), (*c*) March 1998 (autumn), (*d*) June 1998 (winter) and (*e*) September 1998 (spring).

Table 3. The relationship between crude protein content (g/kg DM) and weeks post-defoliation for Dobson perennial ryegrass and tall fescue cultivars during each season

Values are mean slope or intercept ± s.e.

	Spring 1997 Oct.	Summer 1997 Jan.	Autumn 1998 Mar.	Winter 1998 June	Spring 1998 Sept.
		Mean slope ± s.e.			
Slope (week)^2	—	–1.4 ± 0.4	–4.5 ± 0.5	–4.7 ± 0.6	—
Slope (week)	–12.3 ± 0.3	5 ± 3.3	30.8 ± 5.1	29.5 ± 5.5	–11.5 ± 6.6
R^2 (%)	94.4	58.5	69.1	72.4	82
		Intercept ± s.e.			
Dobson ryegrass	200.3 ± 3.4	181.3 ± 9.1	196.7 ± 9.8[A]	191.3 ± 14.5	246.3 ± 6.4
Tall fescue cultivars					
Advance	210.4 ± 4.4*	163.2 ± 9.1	—	197.3 ± 15.1	237.5 ± 8.3*
AU Triumph	191.2 ± 4.4*	167.3 ± 9.1	—	176.6 ± 15.1	214.2 ± 8.3
Bombina	213.2 ± 4.4*	155.5 ± 9.1*	—	203.2 ± 15.1	241.5 ± 8.3
Cajun	189.4 ± 4.4*	171.7 ± 9.1	—	207.9 ± 15.1	222.8 ± 8.3*
Dovey	193.1 ± 4.4	154.2 ± 9.1*	—	166.9 ± 15.1	215.3 ± 8.3*
ITF 97010	200.7 ± 4.4	166.7 ± 9.1	—	186.8 ± 15.1	239.7 ± 8.3
ITF 97020	197.4 ± 4.4	176.0 ± 9.1	—	215.7 ± 15.1	232.8 ± 8.3
Maximise	211.2 ± 4.4*	163.5 ± 9.1	—	174.6 ± 15.1	215.7 ± 8.3*
Midwin	212.7 ± 4.4*	158.7 ± 9.7*	—	205.0 ± 15.1	249.7 ± 8.3
PWF 29	215.1 ± 4.4*	175.0 ± 9.1	—	214.9 ± 15.1	236.8 ± 8.3
Quantum	187.2 ± 4.4*	169.7 ± 9.1	—	174.0 ± 15.1	214.8 ± 8.3*
Torpedo	212.2 ± 4.4*	166.9 ± 9.7	—	234.3 ± 15.1*	257.3 ± 8.3
Vulcan	207.9 ± 4.4	183.2 ± 9.1	—	197.3 ± 15.1	248.3 ± 8.3

*Intercept is significantly (P<0.05) different to that of Dobson perennial ryegrass.
[A]No significant (P>0.05) difference between species when comparing intercepts.

contrast, the hard-textured leaf type AU Triumph tall fescue swards produced the most DM but resulted in the lowest milk production (15.2 kg milk/cow.day) (Lowe *et al.* 1999*b*). Slightly lower CP content and IVDMD, and higher neutral detergent fibre (NDF) content of the tall fescue (Lowe *et al.* 1999*a*, 1999*b*) contributed to reduced milk yield. Similarly in a temperate environment, Thomson *et al.* (1988) reported higher DM yields from tall fescue swards than from perennial ryegrass, but no better milk yield from cows grazing them. In the current study, the difference in the intercept of the CP content and IVDMD relationships with weeks post-defoliation between Dobson perennial ryegrass and tall fescue herbage reached 30 g/kg DM and 4 digestibility units, respectively (Tables 2 and 3). While 4 digestible units may seem insignificant, when fed to a lactating cow consuming 15 kg DM pasture/ha.day, it can result in a 1–2 L/day change

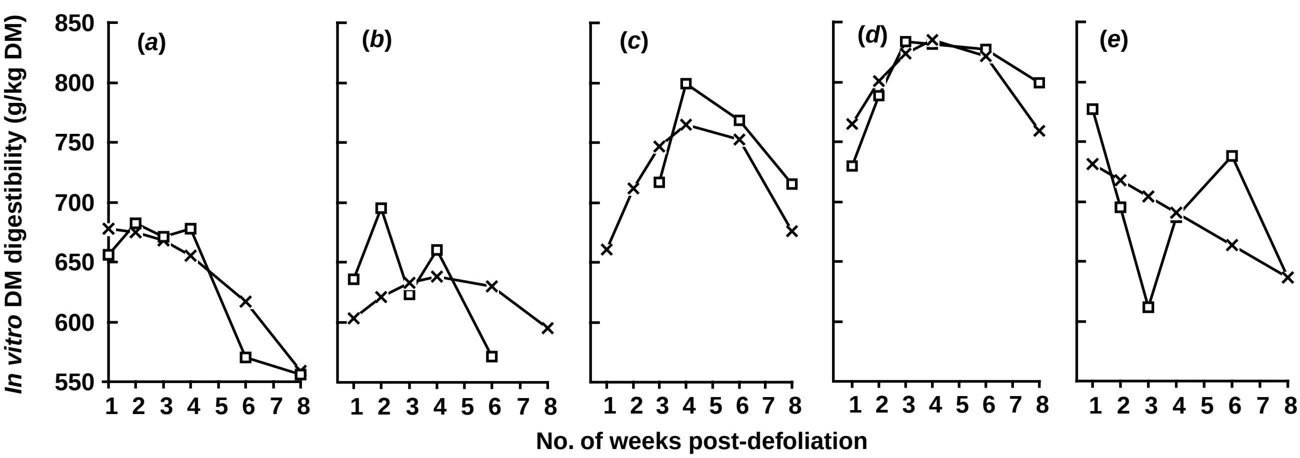

Figure 3. Mean *in vitro* dry matter digestibility (g/kg DM, □) and estimated values modelled from the regression relationships (×) of Dobson perennial ryegrass. Samples were collected for 8 weeks post-defoliation commencing in (*a*) October 1997 (spring), (*b*) January 1998 (summer), (*c*) March 1998 (autumn), (*d*) June 1998 (winter) and (*e*) September 1998 (spring).

Table 4. The relationship between *in vitro* dry matter digestibility (g/kg DM) and weeks post-defoliation for Dobson perennial ryegrass and the tall fescue cultivars during each season

Values are mean slope or intercept ± s.e.

	Spring 1997 Oct.	Summer 1997 Jan.	Autumn 1998 Mar.	Winter 1998 June	Spring 1998 Sept.
			Mean slope ± s.e.		
Slope (week)^2	–2.4 ± 0.4	–3.1 ± 0.6	–8 ± 0.9	–6.1 ± 0.9	—
Slope (week)	4.7 ± 3.4	26.8 ± 5.6	74.1 ± 8.4	54 ± 8	–13 ± 1.1
R^2 (%)	88.4	23	50.5	34.9	66.4
			Intercept ± s.e.		
Dobson ryegrass	675.2 ± 8.9	578.0 ± 10.4[A]	593.2 ± 16.3[A]	719.3 ± 21.3[A]	736.9 ± 10.5
Tall fescue cultivars					
Advance	668.9 ± 9.2	—	—	—	739.1 ± 13.5
AU Triumph	635.9 ± 9.2*	—	—	—	703.2 ± 13.5*
Bombina	655.6 ± 9.2*	—	—	—	717.6 ± 13.5
Cajun	637.7 ± 9.2*	—	—	—	709.9 ± 13.5*
Dovey	652.4 ± 9.2*	—	—	—	714.1 ± 13.5
ITF 97010	657.7 ± 9.2	—	—	—	725.9 ± 13.5
ITF 97020	647.2 ± 9.2*	—	—	—	709.1 ± 13.5*
Maximise	669.5 ± 9.2	—	—	—	722.9 ± 13.5
Midwin	655.5 ± 9.2*	—	—	—	738.4 ± 13.5
PWF 29	652.1 ± 9.2*	—	—	—	729.2 ± 13.5
Quantum	637.6 ± 9.2*	—	—	—	707.7 ± 13.5*
Torpedo	680.2 ± 9.2	—	—	—	744.4 ± 13.5
Vulcan	664.9 ± 9.2	—	—	—	748.2 ± 13.5

*Intercept is significantly (P<0.05) different to that of Dobson perennial ryegrass.
[A]No significant (P>0.05) difference between species when comparing intercepts.

in milk production assuming a cow requires 5 MJ of metabolisable energy to produce 1 L of milk (McDonald 1991). From this study, it was possible to identify soft-textured leaf types Vulcan, Midwin and Torpedo as the some of the highest quality tall fescues, with the hard-textured leaf types Dovey and AU Triumph among the lowest.

The results of this study confirm the strong influence plant development has on forage quality. As plant tissue matured the forage quality during spring declined linearly for CP content and for IVDMD (1998 only), and declined exponentially for IVDMD during spring (1997), summer, autumn and winter (1998). The negative quadratic relationship between IVDMD of temperate grasses and weeks post-defoliation may be explained using the findings of Fulkerson and Slack (1994) that ryegrass leaves have a limited life span of 3-leaf appearance intervals (Fulkerson and Slack 1994). Delaying the subsequent defoliation until after the production of 3 new leaves/tiller increased the amount of senescent herbage and stubble DM yields and, consequently, the IVDMD decreases and the neutral detergent fibre content increases (Fulkerson *et al.* 1998). In this present study, the rapid decline in forage quality of perennial ryegrass was estimated to coincide with the 3-leaf stage. The immediate decline in fescue IVDMD during spring was presumably associated with reproductive development and the harvest of low-quality stem (Callow *et al.* 2000; Cherney *et al.* 1993).

To achieve optimum milk yield from a pasture-based system, the frequency of defoliation must vary with plant development. In the subtropics, it has already been established that yield of perennial and annual ryegrasses follows a quadratic response to length of regrowth interval, reaching a maximum yield at about 4–6 weeks (vegetative and reproductive development, respectively) (Lowe and Bowdler 1988) and it is expected that tall fescue will react similarly. The shape of the quality responses in Figures 2 and 3 suggest that if tall fescue was allowed to continue to grow beyond 2–3 weeks in spring and summer, quality would deteriorate substantially. The slopes in the autumn and winter periods suggest defoliating regrowth at 3–4 weeks to optimise forage quality.

Acknowledgments

The authors thank the Dairy Research and Development Corporation for their financial support. The authors acknowledge the help of Dr W. J. Fulkerson in preparing the manuscript.

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Received 7 January 2002, accepted 18 February 2003