Systems to increase grazeable forage production in the Waikato: A progress report on the tall fescue and perennial ryegrass component of these systems

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Abstract
Grazed forage underpins the productivity and economic performance of New Zealand's pastoral industries. This trial aimed to increase grazeable forage grown by 50% from 17 to 25 t DM/ha to meet industry targets. Six treatments consisting of different combinations of pasture species were established in March 2008 with the objective of increasing grazeable forage production by using irrigation, phosphate fertiliser and nitrogen, standoff, new cultivars of ryegrass ('Alto' perennial ryegrass containing AR1 endophyte) and alternative forages such as 'Advance' tall fescue with Max P® endophyte, chicory (cv. 'Choice') or lucerne (cv. 'P54Q53'). The yield of perennial ryegrass was greater than tall fescue in the winter of 2008 (Year 1) and 2009 (Year 2). Tall fescue tended to have a greater summer yield than perennial ryegrass, although this effect was inconsistent between years. Irrigation increased the yield of tall fescue by 50% and perennial ryegrass by 13% in Year 2. Mean yield of milksolids for the six treatments over 2 years was 1 371 for perennial ryegrass and 1 310 kg MS/ha for tall fescue treatments.
Keywords: dry matter production, irrigation

Introduction
The New Zealand dairy industry has set a target (DairyNZ 2009) of increasing forage eaten per ha by 50% and forage grown from 17 to 25 t DM/ha in current top-performing commercial and research farms. Due to the limitations of light and temperature, potential Waikato perennial ryegrass (*Lolium perenne*) production has been estimated as 24 t DM/ha (Mitchell 1963). To reach 25 t DM/ha, use of alternative species, with morphology and physiology better suited to Waikato environmental conditions will be required to complement, or replace, the traditional perennial ryegrass/white clover (*Trifolium repens*) - based pastures.

Summer pasture growth in the Waikato region of New Zealand is highly variable compared with other seasons, predominantly due to variable rainfall (Baars 1976). On average, evaporation exceeds rainfall between November and March leading to a deficit in soil moisture. Increasing soil moisture through irrigation and/or incorporating alternative forages, with deeper penetrating root systems and physiology better suited than perennial ryegrass to summer dry conditions, may increase grazeable forage production. Thom *et al*. (2001) found irrigation increased perennial ryegrass production by 1-2 t DM/ha/yr over 4 years. Relative to perennial ryegrass, continental tall fescue (*Festuca arundinacea*) tends to be more productive during dry summers (Kemp *et al*. 1999).

The objective of this work was to increase grazeable forage production to 25 t DM/ha/yr by removing location-specific limitations to growth with strategic use of irrigation, N fertiliser, a standoff pad, and by evaluating the pasture growth and milksolids (MS) production from alternative species to perennial ryegrass such as tall fescue, chicory and lucerne. This paper reports on the dry matter yield of tall fescue and perennial ryegrass within these systems.

Materials and Methods
The trial was conducted at Scott Farm, DairyNZ, near Hamilton, New Zealand (37°47'S 175°19'E; elevation 40 m a.s.l.).

Design
The trial site was initially 30 ha in the 2008/2009 season on Bruntwood, Horotiu, Te Rapa peaty and humic, Te Kowhai and Matangi silt loam soils (New Zealand classification; Hewitt 1998). In the 2009/2010 season, (Year 2) the total area of the treatments was reduced to 24 ha with 1 ha of pasture dropped from each treatment due to funding constraints. Paddocks were randomly allocated within soil type to treatments ensuring balance for soil type. Treatments in the 2008/2009 season were:

A. Perennial ryegrass (cv 'Alto' AR1) mixed with white clover (cv. 'Kopu II') (5 ha)
B. Tall fescue (cv. 'Advance' Max P®) mixed with white clover (cv. 'Kopu II') (5 ha)
C. Perennial ryegrass (cv. 'Alto' AR1) (4 ha) with chicory (cv. 'Choice') and red clover (cv. 'Sensation') (*Trifolium pratense*) (1ha)

D. Tall fescue (cv. 'Advance' Max P®) (4 ha) with chicory (cv. 'Choice') and red clover (cv. 'Sensation') (1 ha)
E. Perennial ryegrass (cv. 'Alto' AR1) (4 ha) with lucerne (cv. 'P54Q53') (1 ha)
F. Tall fescue (cv. 'Advance' Max P®) (4 ha) with lucerne (cv.'P54Q53') (1 ha).

Establishment

During January 2008, 26 ha of existing perennial ryegrass pasture was sprayed with 5 L Glyphosate 510/ha and wetting agent, and was ploughed and power-harrowed following application of lime (2.5 t/ha) and fertiliser (650 kg/ha 30% Potash Sulphur Super; requirements based on September 2007 soil tests). Weeds that germinated post-cultivation were re-sprayed with 5 L Glyphosate/ha and wetting agent. The grass component of the six treatments was sown by Cambridge roller-drill from 10 to 13 March 2008 at a mean rate (including Superstrike seed treatment) of 18 kg ryegrass/ha for treatments C and E, 15 kg ryegrass/ha with 5 kg white clover/ha for treatment A, 25 kg tall fescue/ha for treatments D and F, 24 kg tall fescue with 5 kg white clover/ha for treatment B. Broad-leaved weeds were sprayed using 2, 4-D amine ('Baton') at 1.5 kg/ha onto non-clover treatments on 13 May. Additionally, 2.5 L/ha Nortron was sprayed onto all tall fescue paddocks on 11 June to eliminate *Poa annua* competition with tall fescue seedlings.

Management

In the 2008/2009 season (Year 1) all 26 ha of grass paddocks were irrigated with 170 mm of bore water by travelling big-gun irrigators. Paddocks were irrigated when soil moisture levels fell to less than 75% of field capacity, with 25 mm per application. Bore water (390 mm) was applied to irrigated paddocks in the 2009/2010 season when only two hectares of pasture were irrigated on each treatment to utilise available water resources more effectively and allow a comparison of unirrigated versus irrigated pasture production.

When the soil moisture level was high in the drainage season (May to July), cows were strategically offered pasture before their removal from grazed paddocks to a plastic lined, woodchip surfaced standoff pad to minimise pasture damage.

Fertiliser was applied according to the recommendations for the paddock with the lowest soil test to ensure non-limiting soil nutrient levels (Roberts & Morton 1999). Nitrogen, as urea, was applied after grazing (25 to 50 kg N/ha per application as per Ball (1970)).

Animals

Ninety-six Holstein-Friesian cows were randomly allocated to treatments from 1 June 2008 based on age (mean 5.1 yrs), expected calving date (mean 27 July 2008), liveweight (mean 503 kg), body condition score (BCS) (mean 4.0) and previous season's MS production (mean 338 kg). Twenty-four Holstein-Friesian heifers were also allocated to farmlets based on liveweight (mean 405 kg) and expected calving date (mean 26 July 2008). This initial number of cows equated to an expected comparative stocking rate of 85 kg liveweight/t DM (Penno 1999) (4 cows/ha) based on a forage yield of 25 t DM/ha. The stocking rate across all treatments was reduced to 3.5 cows/ha in the 2009/2010 season.

Measurements

Three methods were used to determine pasture yield in both Years 1 and 2: weekly calibrated visual estimation of herbage mass, back calculation based on MS production data and standard cow energetic requirements, and cage cuts. For the purposes of this progress report only the cage cut data are presented.

Cages (one per 0.5 ha paddock) were trimmed to 2 cm in Year 1 before cage placement each month. Accumulated herbage was cut to 2 cm within a 0.2 m^2 quadrat before oven-drying at 95°C and weighing. In Year 2 cages were trimmed to 4 cm before cage placement and accumulated herbage cut to 4 cm. Cutting height was changed in Year 2 because the research of Lee *et al.* (2008) showed the negative impact of cutting to 2 cm on subsequent grass growth.

Chicory/red clover and lucerne growth was determined by 6 x 0.2 m^2 quadrat cuts per paddock (considered as 1 ha area of crop in 2008/2009 and 0.5 ha in 2009/2010) before grazing.

Statistical analysis

The pasture component data of each treatment were analysed for this progress report. Individual paddock growth data within each farmlet were analysed using mixed models fitted using REML with treatment main effects and interactions included as fixed effects and paddock as a random effect. Paddock was the experimental unit.

Results

Rainfall, temperature and sunshine hours

The mean daily rainfall for each season, air temperature and mean total sunshine hours for Years 1 and 2 are compared with the 30-year mean (1979-2009) for the Ruakura Climatological Station (5 km west of the trial site) (Table 1). Relative to the 30 yr mean, Year 1 was characterised by high winter rainfall and low sunshine hours/d, high summer rainfall and low autumn rainfall. Year 2 had below average autumn rainfall (1.1 mm/d

Table 1 Seasonal mean daily rainfall (mm/d), air temperature (°C) and total sunshine (h/d) for 2008/2009 and 2009/2010 and the 30-year mean (1979-2009) (Ruakura Climatological Station).

	Rainfall (mm/d)			Air temperature (°C)			Total sunshine (h/d)		
	2008/9	2009/10	30 yr mean	2008/9	2009/10	30 yr mean	2008/9	2009/10	30 yr mean
Winter	5.9	3.8	3.9	9.5	8.7	9.4	4.0	4.6	4.3
Spring	2.9	3.2	3.1	13.1	12.3	13.1	5.9	5.7	5.9
Summer	3.5	3.1	2.9	18.2	18.1	18.0	7.2	6.8	7.4
Autumn	2.2	1.1	2.9	13.9	13.7	14.5	6.5	5.7	5.5

compared with the 30 year mean of 2.9 mm/day).

Forage yield

From establishment through winter of Year 1, perennial ryegrass yield was on average 70% greater (P<0.001) than tall fescue yield (Table 2). For the same period there was an interaction between grass type and treatment with perennial ryegrass yield tending to be greater in treatments with chicory and lucerne relative to perennial ryegrass mixed with white clover. In contrast, the yield of tall fescue in summer was on average 20% greater (P<0.05) than the yield of perennial ryegrass. Perennial ryegrass and tall fescue yields were similar in spring and autumn of Year 1. The total yields of irrigated perennial ryegrass and tall fescue were similar in Year 1.

For Year 2, yield of perennial ryegrass in winter was 70% greater (P<0.001) than yield of tall fescue (Table 2). Tall fescue and perennial ryegrass yields were similar (P>0.05) for all other seasons. The total yields of tall fescue and perennial ryegrass were similar in Year 2.

Irrigation increased pasture yield by 20% (0.9 t DM/ha; P<0.05) and 120% (2.0 t DM/ha) (P<0.001) in the summer and autumn of Year 2, respectively. Irrigation increased total yield of tall fescue by 50% (5.4 t DM/

Table 2 Seasonal mean total yield by cage cut (t DM/ha) and nitrogen (N) application (kg/ha) for grass (G) type (perennial ryegrass, tall fescue) within each treatment (T) (PrCl: perennial ryegrass mixed with white clover, TfCl: tall fescue mixed with white clover, PrCh: perennial ryegrass (chicory/red clover as a crop), TfCh: tall fescue (chicory/red clover as a crop), PrL: perennial ryegrass (lucerne as a crop), TfL: tall fescue (lucerne as a crop) when unirrigated (U) in the 2008/2009 and 2009/2010 seasons and irrigated (I) in the 2009/2010 season.

	Perennial ryegrass						Tall fescue							P-value						
	PrCl		PrCh		PrL		TfCl		TfCh		TfL									
	I	U	I	U	I	U	I	U	I	U	I	U	sed	G	T	G*T	I	I*G	I*T	I*G*T
2008/2009																				
Winter[1]	3.9		4.0		4.7		2.8		2.5		2.2		0.4	***	NS	*				
Spring	5.5		6.1		6.4		5.3		5.6		5.5		0.7	NS	NS	NS				
Summer	5.5		4.7		5.3		6.2		6.7		5.6		0.7	*	NS	NS				
Autumn	3.0		3.6		3.9		3.2		3.3		3.1		0.4	NS	NS	NS				
Total	16.8		17.3		18.5		16.6		17.4		15.7		1.3	NS	NS	NS				
N application	398		545		471		361		488		499									
2009/2010																				
Winter	2.4	2.3	1.8	2.4	1.9	2.2	1.6	1.4	1.7	1.1	1.2	1.0	0.3	***	NS	NS	NS	NS	NS	NS
Spring	5.5	5.8	5.2	5.6	4.6	5.5	5.7	4.0	4.3	3.0	4.9	3.0	0.9	†	NS	NS	NS	†	NS	NS
Summer	5.7	4.2	5.5	4.3	4.4	5.0	7.3	4.7	4.7	5.1	5.5	4.2	0.6	NS	NS	NS	*	NS	NS	NS
Autumn	3.2	1.7	3.0	1.0	3.7	1.9	3.7	2.1	4.4	2.2	3.9	1.1	0.5	†	NS	NS	***	NS	NS	NS
Total	16.8	13.9	15.9	13.3	14.6	14.6	18.3	12.2	15.1	11.4	15.5	9.2	0.9	NS	*	NS	***	*	NS	NS
N application	345		334		270		359		294		317									

[1]Yield from establishment in March 2008 to Winter 2008/9 season

***P<0.001, **P<0.01, *P<0.05, †P<0.1

ha) and perennial ryegrass yield by 13% (1.9 t DM/ha) for Year 2, relative to unirrigated treatments.

Milksolids production

Mean MS yield for the 6 farmlets over 2 years was 1 341 kg MS per ha (1 371 for perennial ryegrass and 1 310 for tall fescue) after adjustments for the quantity of maize silage (brought in feed) used. The fat (mean 4.4%) and protein (mean 3.5%) composition of milk was similar between treatments.

Discussion

Perennial ryegrass and tall fescue yield

Despite similar total DM yields, there were differences in the timing of pasture growth within each year. Yield of perennial ryegrass from establishment to winter was approximately 70% greater (1.7 t DM/ha) than tall fescue. Lower tall fescue winter yield in Year 1 was due to its slower establishment relative to ryegrass (Neal *et al.* 2009), despite 'Advance' tall fescue being one of the quicker fescue cultivars to establish (Fraser & Lyons 1994). The greater yield of perennial ryegrass through the winter of Year 2, once established, suggests that perennial ryegrass has a lower temperature threshold for growth as compared with tall fescue. The yield of tall fescue in summer was 20% greater (1 t DM/ha) than the yield of perennial ryegrass in Year 1. However, there was no difference in summer or autumn yield between species in Year 2, despite low levels of autumn rainfall (Table 1). Rollo *et al.* (1998) in a compilation of data from various trials, found a consistent production advantage to tall fescue over perennial ryegrass in summer of the first 2 years after establishment, however, the difference between tall fescue and perennial ryegrass yield in summer was small (mean 134 kg DM/ha (3% increase)). These data suggest that tall fescue has a higher optimal temperature for growth compared with perennial ryegrass (temperature optimum for perennial ryegrass of 18°C (Kemp *et al.* 1999; Razmjoo *et al.* 1993)).

Irrigation increased the total yield of pasture by 30% (3.6 t DM/ha) in Year 2. The impact of irrigation was greater for tall fescue (50% increase in DM yield) than perennial ryegrass (13% increase DM yield). The additional 2 t DM/ha in perennial ryegrass yield from irrigation is similar to the 1-2 t DM/ha increase (20% more DM) found by Thom *et al.* (2001). The higher irrigation yield response of tall fescue in the summer/autumn highlights the likely suitability of tall fescue for regions with summer temperatures similar to or higher than those experienced in the Waikato.

Milksolids yield

Milksolids yield and profit determines the value of any DM production increases from these pastures. Milksolids yield will be reported at the conclusion of this 3-year study. At an assumed high feed conversion efficiency of 90 kg MS per t DM eaten (at the high end of commercial and research farm measures to date), it was estimated that the average farmlet herd consumed 14.9 t DM/ha of pasture to produce 1 341 kg MS per ha. Mean pasture production presented in Table 2 was 16 t DM/ha for pasture only treatments (A and B), suggesting that an estimated 93% of pasture grown, as measured by cage cuts, was eaten. This brief analysis confirms that the cage cut estimates of pasture grown per ha probably underestimate the actual pasture growth and availability of feed.

Conclusion

Despite similar yields of tall fescue and perennial ryegrass in Year 1 and Year 2, there were differences in the timing of grass growth within each season with perennial ryegrass having a greater yield in winter, and tall fescue a greater yield in summer, although the yield advantage of tall fescue in summer was inconsistent between years. The high response of tall fescue to irrigation in the summer/autumn, relative to perennial ryegrass, highlights the suitability of tall fescue for regions with summer temperatures in excess of those experienced in Waikato, but also suggests that adequate soil moisture would be required through the summer for production to exceed perennial ryegrass. Interim results using cage cut data suggest that the treatments compared in this progress report failed to achieve a greater yield than the benchmark perennial ryegrass.

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