Herbage production from five grazable forages

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Abstract

Maintaining an adequate feed supply throughout the year is an important consideration in dairy systems. Systems based on perennial ryegrass pastures are often limited by poor growth and feed quality when soil moisture is low and temperatures are high. Alternative forage species better adapted to these conditions may provide options for maintaining feed supply. Annual and seasonal dry matter (DM) production, and nutritive value of five grazable forages with and without irrigation were compared under cutting in the Waikato over two successive years. Perennial ryegrass produced the greatest annual DM yield in both years under both irrigation regimes, largely through superior cool season production and mild temperatures with above average rainfall during the experiment. Plantain tended to provide more DM than perennial ryegrass under irrigation in summer and autumn, a time when additional DM is important for maintaining milk production. With the exception of sudan grass, nutritive value of all forages exceeded values expected to limit milk production.

Keywords: dry matter yield, nutritive value, chicory, plantain, perennial ryegrass, sudan grass, sulla

Introduction

The annual production and seasonal supply of feed directly influences farm milk production (Holmes et al. 2007) and profitability. Pastures based on perennial ryegrass pastures are often limited by seasonal variations in dry matter (DM) production and quality, particularly during periods of low soil moisture. Other forage species available to New Zealand farmers (Rollo et al. 1998) show a greater tolerance to drought and improved DM production under low soil moisture and may, therefore, reduce fluctuations in feed supply. Chicory (*Cichorium intybus*) is a tap-rooted herb that has high growth rates in late spring and summer (Hare *et al.* 1990). Moorhead & Piggot (2009) showed that adding the herb plantain (*Plantago lanceolata*) to perennial ryegrass pasture mixes increased DM production by 1.8 t DM/ha in summer. Sudan grass (*Sorghum sudanense*) is a cereal forage that is capable of yielding 12.4 t DM/ha over the 4 months from December to March (Silungwe 2011). Sulla (Hedysarum coronarium L.) is a herbaceous biennial legume that contains condensed tannins and can yield up to 20 t DM/ha/yr (Krishna et al. 1993).

This paper compares the production and nutritive value of chicory/red clover, plantain, sudan grass and sulla with perennial ryegrass production in the Waikato region of New Zealand. Implications for the suitability of these forages in dairy systems are discussed.

Methods

Experimental site, treatments and design

A two-year field plot trial was conducted to allow evaluation of forages under cutting at DairyNZ's Scott Farm near Hamilton (37°47′S, 175°19′E, 40 m a.s.l.). The soil type is Matangi silt loan (typic Ortic Gley). Monthly rainfall and ambient temperatures were recorded at the Ruakura Meteorological Station (37°8′S, 175°3′E).

Treatments consisted of five different grazable forages. The forages sown and sowing rates were: perennial ryegrass (cv. 'Alto' with AR1 endophyte), 18 kg/ha; chicory (cv. 'Choice'), 6 kg/ha with red clover (*Trifolium pratense*) (cv. 'Sensation'), 6 kg/ha; plantain (cv. 'Tonic'), 10 kg/ha; sudan grass (cv. 'Sprint'), 25 kg/ha and sulla (cv. 'Grasslands Aokau'), 15 kg/ha of bare seed. Experimental plots were arranged into two randomised complete blocks with six replicates. Irrigation was applied to one of the treatment blocks (I+) as determined by soil moisture content (SMC); the other block did not receive irrigation (I-).

Establishment and management of crops

Soil samples taken from the study area in August 2008, showed Olsen P levels of 24 µl/ml and pH 6.1. Existing perennial ryegrass and white clover pastures were sprayed with Roundup® Transorb (4 L/ha, glyphosate 540 g a.i./L) plus Pulse® surfactant (200 ml/100 L water) in September 2008. The experimental site was ploughed and power harrowed to prepare a fine, firm seedbed and incorporate Potash Superten 10 K fertiliser (450 kg/ha; 7.2% P, 10% K, 8.4% S, 18% Ca) then rolled. Trial plots (2.5 × 5 m) were sown using an Oyjord drill in October 2008. A pre-emergence herbicide, Treflan (2.5 L/ha, 480 g trifluralin a.i./L) was applied and incorporated into the soil of the sulla and chicory/red clover plots prior to sowing. All seed was coated with Ultrastrike seed coating, except for that of sulla which was inoculated with *Rhizobium hedisari* within 24 hours prior to sowing. An insecticide (Suscon Green: 15 kg/ha; a.i. 100g/kg chlorpyrifos) was applied at sowing to control grass grub. Fertiliser was applied after each harvest by replacing 4% of the measured dry matter (DM) yield as nitrogen using alternate applications of YaraMila Complex fertiliser (12.4% N, 4% P, 15% K, 8% S, 17% Mg, 3% Ca) and urea (46% N).

Soil moisture content was monitored weekly on both the I+ and I- blocks from October to May using a capacitance meter (HydroSense, Campbell Scientific, Australia), taking 20 readings per block using 12 cm probes. When SMC fell below 25% (mid-point between field capacity and permanent wilting point) on the irrigated block, water was applied using sprinkler irrigators at a rate of 6 mm/h until estimated field capacity was reached.

Herbage sampling and measurements

Timing of harvest was determined by best management practices known at the time. Pre-harvest herbage mass or height and cut height are detailed in Table 1.

Forage DM yield was assessed using the strip technique where a 5 m long strip was cut within each plot using either a rotary mower for the perennial ryegrass plots or a plot harvester (Jenquip, New Zealand) for the remaining forages to achieve a cut area of 2.5 m^2 and 4 m^2 respectively. The fresh weight of the cut herbage from each plot was recorded in the field using a hanging scale (Salter, Victoria, Australia) suspended from a tripod. From the weighed cut herbage, a representative subsample was taken for determination of DM content. The fresh weight of the subsample was recorded, and the sample dried in a forced-draught oven at 95°C for 36 h before re-weighing. Herbage yield of each plot was calculated by multiplying the weight of the cut herbage by the DM content of the subsample. Seasonal pasture DM yield was calculated by summing the data collected from within the following periods: autumn – March 1 to May 31, winter – June 1 to August 31, spring – September 1 to November 30 and summer – December 1 to February 28/29. Total annual yield was then calculated by summing the DM yield from all cuts taken over 12 months from the sowing date (1 October–30 September).

Before each harvest, from within each plot, five hand-clipped herbage samples cut to the appropriate height were bulked on a plot basis. The herbage sample was thoroughly blended and botanical composition was determined by separating a sub-sample (approximately 40 g) into perennial ryegrass, white clover, chicory, red clover, plantain, sulla, sudan grass, weeds, other grasses and dead material of all species. Samples were dried in a forced-draught oven at 95°C for at least 24 hours before weighing to determine composition on a dry weight basis. A further sub-sample of approximately 150 g was taken from the bulk sample for estimation of nutritive value. The subsamples were dried in a forced-draught oven at 60°C for at least 24 hours before grinding to pass through a 1 mm diameter sieve. Dried and ground samples were sent to feedTECH®, AgResearch, for estimation of forage nutritive value using near infrared spectroscopy (Corson *et al*. 1999).

Statistical analyses

A mixed models approach to analysis of variance (ANOVA) was used for data analysis (SAS 9.3), followed by a Tukey's t- test for pairwise comparisons. The model included treatment, irrigation, and their interaction as fixed effects. Replicate and replicate-by-irrigation were included as random effects. Data from each year and season were analysed separately. Results are presented as least-squares means and standard error of the difference.

Results

Trial weather conditions

Weather data were recorded at the Ruakura Climatological Centre, 5 km from experimental site. Annual rainfall at 1216 and 1201 mm/yr in years 1 and 2 of the experiment respectively, was greater than the long-term average of 1111 mm/yr, (1999–2007). Seasonally, rainfall was either similar or exceeded the long-term average, except for autumn 2010 where total rainfall was 155 mm, 100 mm less than the average of 257 mm. Summer rainfall was between 16 and 80 mm

Table 1 Height (cm) or mass (kg DM/ha) at harvest, and residual sward height for each forage.

Forage	Harvest height/forage mass	Residual sward height
Perennial ryegrass	2500-2800 kg DM/ha	5 cm
Chicory/red clover	25 cm	5 cm
Plantain	20 cm	2 cm
Sudan grass	80-100 cm	15 cm
Sulla	75 cm	15 cm

above average. Mean air temperature was 13.3°C in 2008/09 and 13.7°C in 2009/10, below the mean long-term average of 14.0°C.

Annual herbage dry matter production

Total annual DM production was greatest from perennial ryegrass in both years ranging from 18.3 to 20.6 t DM/ha from I+ and I- (Table 2). Plantain produced 3.1 and 4.2 t DM/ha more than chicory/red clover under I+ and I- respectively in year 1, but in year 2 the two forages were similarly productive (15.9 t DM/ha). Sudan grass and sulla recorded the lowest annual DM yields, yielding 8.0–8.8 and 6.3–6.6 t DM/ha respectively.

There was a significant treatment by irrigation interaction observed in year 2 of the study, where forages receiving irrigation produced 12–17% more DM than the unirrigated swards (Table 2).

Seasonal distribution of dry matter production

Summer DM production was greatest (P<0.001) from

Table 2 Seasonal and annual dry matter yield (kg DM/ha) of five forages.

		Forage						p-value	
Season	Irrigation	Chicory/ red clover	Perennial ryegrass	Plantain	Sudan	Sulla	SED	Treatment	Treatment *Irrigation
Summer	I+	5.0^{c}	6.3^{b}	7.1^{a}	6.9^{a}	2.8^{d}	0.27	***	NS
	I-	4.9^{b}	5.7^{a}	6.0^{a}	6.1^{a}	2.0^{c}		***	
Autumn	I+	3.3^{ab}	3.1^{b}	3.5^{a}	1.9^{c}	1.4^{d}	0.15	***	***
	I-	2.8^{a}	2.5^{a}	2.8^{a}	1.8^{b}	1.9^{b}		***	
Winter	I+	2.1^{b}	3.1^{a}	1.6^{c}	-	0.7^{d}	0.13	***	***
	I-	1.6^{b}	3.6^{a}	1.6^{b}	-	0.9^{d}		***	
Spring	I+	6.1^{a}	6.6^{a}	5.0^{b}	-	1.4^{d}	0.25	***	NS
	I-	5.9^{b}	6.6^{a}	5.0^{c}	-	1.8^{d}		***	
Year 1	I+	15.5^{c}	19.6^{a}	18.6^{b}	8.8^{d}	6.3^{e}	0.34	***	NS
	I-	14.9^{c}	20.6^{a}	19.1^{b}	8.0^{d}	6.6^{e}		***	
Year 2	I+	16.4^{b}	20.6^{a}	17.4^{b}	-	-	0.60	***	*
	I-	14.7^{b}	18.3^{a}	14.9^{b}	-	-		***	

Treatment means with no letters in common are significantly different (P < 0.05).

Table 3 Average seasonal growth rates (kg DM/ha/day) of five forages under irrigated (I+) and non-irrigated conditions (I-). Figures in parenthesis are the highest growth rate (kg DM/ha/day) measured for each forage each season.

		Forage				
Season	Irrigation	Chicory/red clover	Perennial ryegrass	Plantain	Sudan	Sulla
Summer	I+	71	83	90	94	30
		(107)	(135)	(158)	(123)	(52)
	I-	60	64	78	91	22
		(96)	(129)	(141)	(101)	(47)
Autumn	I+	42	34	44	-	70
		(60)	(73)	(92)		(91)
	I-	38	30	38	-	65
		(66)	(68)	(91)		(89)
Winter	I+	22	33	19	-	-
		(25)	(51)	(26)		
	I-	17	31	19	-	-
		(21)	(41)	(22)		
Spring	I+	63	71	55	-	15
		(140)	(87)	(87)		(31)
	I-	62	72	54	-	19
		(129)	(91)	(91)		(45)

the sudan grass (6.9 t DM/ha) and plantain (7.1 t DM/ha) under I+ (Table 2), achieving daily growth rates of up to 123 and 158 kg DM/ha respectively (Table 3). In the absence of irrigation (I-) perennial ryegrass produced a similar summer DM yield to sudan grass and plantain (average 5.9 t DM/ha). In autumn, I+ plantain produced 11% more DM than perennial ryegrass, with chicory/red clover production intermediate between plantain and perennial ryegrass. Under I-, however, perennial ryegrass, plantain and chicory/red clover were similarly productive (2.7 t DM/ha). Perennial ryegrass produced the greatest amount of DM in winter, but I+ chicory/red clover and perennial ryegrass were similarly productive in spring. Average daily growth rates of perennial ryegrass were 32 and 72 kg DM/ha/day compared with 19–20 and 55–63 kg DM/ha/day from the herbs in winter and spring, respectively.

Sward composition and nutritive value

Sudan grass maintained a pure sward until final harvest, and the plantain and perennial ryegrass swards contained a high proportion of sown species at the completion of the experiment, 81 and 90% from plantain and perennial ryegrass respectively. The chicory/red clover sward contained an average of 69% chicory and 11% red clover; but the proportion of sown species in the sward at the completion of the experiment (May 2011) had declined to 58%.

Forage from the chicory/red clover, perennial ryegrass, plantain and sulla swards was of high nutritive value (>10.5 MJ ME/kg DM; Kolver 2000) (Table 4). Forage from the sudan grass swards was of poorer nutritive value with greater fibre and lower crude protein content and lower predicted digestibility.

Discussion

Perennial ryegrass pastures produced the greatest annual DM yield in both years of the study, resulting from superior cool season production compared with the other forages evaluated. Annual DM production from plantain and chicory/red clover were similar to that reported by Powell *et al*. (2007), but annual DM yield of sudan grass and sulla were lower than values reported in the literature (Rhys *et al.* 1988; Silungwe 2011). Stand establishment of sudan grass and, therefore, yield may have been compromised by an earlier than optimal sowing date (Silungwe 2011). Decline of sulla plant density and ingress of weeds contributed to the poor DM yield achieved, although yield was similar to that reported by Minneé *et al*. (2004). Irrigation did not consistently improve annual DM production, possibly because seasonal rainfall was often above average. Therefore, under the conditions of this study, alternative forage species did not increase annual DM supply, when compared with perennial ryegrass pasture production.

The seasonal distribution of perennial ryegrass DM production was more even than that of the other forage types evaluated in this study. This was due to the greater capacity for cool season growth of ryegrass, and similar warm season DM yields to the other most productive forages achieved without irrigation (I-), possibly due to the mild temperatures and above average rainfall received. Thus it is unlikely that perennial ryegrass growth was severely limited in this study.

In the presence of irrigation (I+), plantain was more productive than perennial ryegrass in summer and autumn. Irrigation improved the DM production of plantain by 15% in summer, compared with increases of 2 and 9.5% for chicory/red clover and perennial ryegrass, indicating that plantain is more responsive to irrigation than the other two forages and suggests that irrigated plantain is an option for increasing summer feed supply.

In autumn 2010, when rainfall was well below average, DM yield from irrigated perennial ryegrass,

Table 4 Estimates of nutritive value from each forage type, averaged across the experimental period.

	Irrigation	Forage: Chicory/red clover	Perennial ryegrass	Plantain	Sudan	Sulla
NDF[1]	I+	35.3	44.8	36.2	56.6	37.6
	I-	34.9	44.8	36.8	57.7	38.4
CP[2]	I+	24.0	21.4	22.3	16.8	22.9
	I-	23.6	21.5	21.2	15.6	21.3
OMD[3]	I+	81.9	82.4	82.7	70.7	84.8
	I-	82.3	81.1	81.4	70.0	84.1
ME[4]	I+	12.0	12.0	11.6	10.2	12.5
	I-	12.1	11.8	11.5	10.2	12.5

[1] Neutral detergent fibre (g/100 g DM); [2] Crude protein (g/100 g DM); [3] Organic matter digestibility (%); [4] Metabolisable energy (MJME/kg DM).

plantain and chicory/red clover was similar. Without irrigation (I-) chicory/red clover produced 30 and 28% more DM/ha than perennial ryegrass and plantain, highlighting the greater ability of chicory to maintain productivity during water deficit. These findings support Neal *et al*. (2011) who showed that chicory was more water use efficient (i.e. produced more kg DM/ha/mm water applied) than perennial ryegrass under a water deficit. Therefore, incorporating chicory into the farm system may have benefits for mitigating feed deficit during periods of low soil moisture.

Increases in feed production will only enhance milk production if the forage is good quality (Hainsworth & Thomson 1997). Forage from the chicory/red clover and plantain swards were determined to be good quality, and this coupled with improved DM production in autumn and summer are likely to result in gains in milk production. Conversely, while sudan grass was highly productive in summer it was of poor nutritive value and would thus provide less total energy than the lower yielding but higher quality forages. Sudan grass is likely to have insufficient energy or crude protein to meet the needs of lactating dairy cattle if fed as a sole diet (Kolver 2000).

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REFERENCES

Corson, D.C.; Waghorn, G.C.; Ulyatt, M.J.; Lee, J. 1999. NIRS: Forage analysis and livestock feeding. *Proceedings of the New Zealand Grassland Association 61*: 127-132.

Hainsworth, R.J.; Thomson, N.A. 1997. Milk production by dairy cows from different pastures in Taranaki. *Proceedings of the Massey Dairy Farmers' Conference 39*: 55-63.

Hare, M.D.; Rowarth, J.S.; Archie, W.J.; Rolston, M.P.; Guy, B.R. 1990. Chicory seed production: research and practice. *Proceedings of the New Zealand Grassland Association 52*: 91-94.

Holmes, C.W.; Brookes, I.M.; Garrick, D.J.; MacKenzie, D.D.S.; Parkinson, T.J.; Wilson, G.F. 2007. Milk production from pasture: Principles and practices. Massey University, New Zealand.

Kolver, E.S. 2000. Nutritional guidelines for the high producing dairy cow. pp. 78-87 *In*: Proceedings of the Ruakura Farmers', Conference.

Krishna, H.; Kemp, P.D.; Newton, S.D. 1990. 'Necton' sulla – A preliminary agronomic evaluation. *Proceedings of the New Zealand Grassland Association 52*: 157-159.

Minneé, E.M.K.; Bluett, S.J.; Woodward, S.L. 2004. Harvesting sulla for yield and quality. *Agronomy New Zealand 34*: 83-88.

Moorhead, A.J.E.; Piggot, G.J. 2009. The performance of pasture mixtures containing 'Ceres Tonic' plantain (*Plantago lanceolata*) in Northland. *Proceedings of the New Zealand Grassland Association 71*: 195-199.

Neal, J.S.; Fulkerson, W.J.; Sutton, B.G. 2011. Differences in water-use efficiency among perennial forages used by the dairy industry under optimum and deficit irrigation. *Irrigation Science 29*: 213-232.

Powell, A.M.; Kemp, P.D.; Jaya, I.D.; Osborne, M.A. 2007. Establishment, growth and development of plantain and chicory under grazing. *Proceedings of the New Zealand Grassland Association 69*: 41-45.

Rollo, M.D.; Sheath, G.W.; Slay, M.W.A.; Knight, T.L.; Judd, T.G.; Thomson, N.A. 1998. Tall fescue and chicory for increased summer forage production. *Proceedings of the New Zealand Grassland Association 60*: 249-253.

Rhys, G.J.; Smith, N.; Slay, M.W. 1988. Alternative forage species in Hawke's Bay. pp 75-80 *In:* Proceedings of the Agronomy Society of New Zealand. Vol. 18.

Silungwe, D. 2011. Evaluation of forage yield and quality of sorghum, sudangrass and pearl millet cultivars in Manawatu. Masters thesis. Massey University, Palmerston North, New Zealand.