Dry matter yield, pasture quality and profit on two Waikato dairy farms after pasture renewal

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Abstract
A planned approach to pasture renewal is recommended for improved feed supply and animal production. From 2006-2010 measurements of pasture dry matter (DM) yield and quality were made on two dairy farms, where pasture renewal was implemented. These measurements were to determine if extra DM and feed quality resulted. In each case, weekly and/or monthly measurements included comparisons with older, established pastures on the same farm. On a research farmlet, with a majority of renewed pasture less than 3 years old, an additional 2.1 t DM/ha (+11%) of pasture was measured compared with another farmlet without renewal for a decade. On a commercial dairy farm, 2 years of monthly cuts of pastures, representing four different stages of the Programmed Approach™ to renewal, showed a DM yield advantage of 4% and feed quality advantage of 7%, generating, according to UDDER modelling, additional profit of more than $900/ha/yr. Higher quality pasture in response to pasture renewal contributed to increased production and profit.

Keywords: Programmed Approach™ to renewal, UDDER model, pasture growth

Introduction
Historically, New Zealand dairy farmers have succeeded in improving the yield and quality of their pastures and crops. Estimates of pasture eaten per hectare on the average dairy farm show an increase of 7.7 t DM over 65 years from 4 t DM/ha/yr in 1935 (Holmes 1989) to 11.7 t DM/ ha/yr in 2007 (Rawnsley *et al*. 2007). Recent estimates from high performing New Zealand dairy farms show pasture eaten to be 15-17.5 t DM/ ha/yr (Holmes 2007; Glassey 2007; Macdonald *et al.* 2008). Hodgson (1989) concluded that there was little change in maximum pasture production in New Zealand over the preceding 50 years, suggesting that increases in milk production and pasture eaten have been influenced more by increased pasture utilisation than increased DM yield.

The gap between average and top performance in pasture eaten/ha (5 t DM/ha) represents an opportunity for NZ dairy farmers, especially when the large pasture yield differences between paddocks on the same high performing farm are also considered (Clark *et al*. 2010). The proportion of this gap that is recoverable by pasture renewal is unknown. Recent estimates of the economic value of improving pastures through pasture renewal in the dairy industry (Sanderson & Webster 2009) are that the opportunity represents $800 million of lost farm gate revenue annually. Few studies exist with measured animal production supporting this contention. Crush *et al.* (2006) found, in a replicated farmlet study, that any gains in herbage production through cultivar development were not translated into measurable differences in MS production but this study did not compare renewal versus non renewal of pastures.

A planned approach to pasture renewal incorporating crops, (The Programmed Approach™), was advocated by Lane *et al*. (2009) for improved feed supply and animal production. Many farmers remain unconvinced of the value proposition and are not renewing pastures at a fast rate. Estimates of existing pasture renewal rates on dairy farms are 6.1% of total area in 2006-2007 (Sanderson & Webster, 2009) and 3.2% recorded on DairyBase (DairyNZ) for 331 farms in 2008-2009 (D. Sutton pers. comm.).

This paper presents measurements on two Waikato dairy farms from 2006-2010, to test the assumption that renewal of established dairy pastures provides opportunities to increase farm feed supply through increased DM yield and improved pasture quality.

Methods
Two separate farm studies were carried out:

1. Pasture measurement on an 8 ha SuperProductivity (SuperP) farmlet, (mean production 1 479 kg MS/ha) and a 7 ha Benchmark farmlet (mean production 1 139 kg MS/ha) over 3 years from June 2006 to May 2009 at DairyNZ's Scott Farm near Hamilton.
2. Pasture measurement on the dairy farm of P.C. and D.L. Swney, SH 3, Te Kawa, 7 km south of Kihikihi, near Te Awamutu. This property supports 360 cows on 95 ha producing 1 460 kg

MS/ha. Measurements took place from January 2008 to January 2010.

Study one

The SuperP Farmlet was established in 2006 based on modelling predictions of annual forage yields exceeding 23.4 t DM/ha from improved ryegrass cultivars. Twenty percent of the farm area also grew maize and annual ryegrass and another 5% grew a summer turnip crop (Beukes *et al*. 2006). Fifty percent of the farm area was double-sprayed with 1.5 kg glyphosate in March 2006, and was direct-drilled with novel endophyte infected (AR1 or AR37) diploid perennial ryegrasses (cultivars 'Revolution', 'Alto', and 'Extreme') and 'Kopu II' white clover. Thirty-seven per cent of the farm was sown with AR1 and 13% with AR37 ryegrass. Additional areas of pasture were renewed following cropping during the 3 years. The SuperP farmlet was stocked with 29 "Kiwicross" cows at 3.6/ha. This farmlet was compared from June 2006 to May 2009 with a Benchmark farmlet at the same location, which represented a high performing Waikato all-pasture farm system relying on home-grown feed off pastures 7 years old in 2006. No cropping or renewal occurred on this farmlet and it was stocked with 21 Holstein Friesian cows at 3.0/ha.

Net herbage accumulation

Average pasture cover (kg DM/ha) on each paddock (n=16, SuperP, n=14, benchmark) was visually estimated, weekly, by four experienced observers calibrated by pasture cuts (L'Hullier & Thomson 1988). On each occasion 10 calibration quadrats (each 0.25 m^2) covering the range of herbage mass on the farm were assessed. After the final assessment, the pasture within the quadrats was cut to ground level, washed, and dried in a forced-draft oven at 100º C for 48 h. Net herbage accumulation rates for each farmlet were estimated by difference using weekly visual paddock scores adjusted by weekly calibration equations, to convert the visual paddock scores to kg DM/ha. Where a paddock had been grazed or ensiled during the week between assessments, it was excluded from the accumulation rate calculation. Annual herbage accumulation was calculated as the sum of the average monthly herbage accumulation rates on a farmlet basis only.

Near infrared spectroscopy (NIRS) analysis of pasture

Each month representative samples of pasture were collected by hand-clipping to grazing height (3.5 cm) from pastures about to be grazed. Crops and silages were sampled both at harvest and feeding. These samples were oven-dried and ground before NIRS analysis (FeedTech, Corson *et al.* 1999), for acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), lipid, soluble carbohydrate, lignin, ash, and *in vitro* digestibility providing an estimate of metabolisable energy (ME) content.

Study two

The Programmed Approach™ (Lane *et al*. 2009) is used on this farm with a planned proportion of the pastures renewed each year. An area of old pasture is replaced with short-rotation ryegrass and chicory for 18 months (two winters and one summer), followed by a summer forage crop (e.g. turnips) and sowing perennial pasture in the autumn. The UDDER model (Larcombe 1990) was used to determine the impact of this approach on the value from growing better quality and quantity after adopting a Programmed Approach™ to renewal. The assumption entered in the model for this exercise was that new pasture performance improves both quality and quantity by 5% compared with pastures more than 6 years old. At the time there was no evidence to support this assumption, thus prompting on-farm measurements to test it.

Table 1 The number of cages cut each year and the number of paddocks selected for each pasture category (Study 2).

Pasture category	No. of paddocks monitored over 2 years	No. of cuts Year 1	No. of cuts Year 2
Old pasture	2	23	27
Lead in SR[1]	3	18	30
New perennial	1	21	30
Established perennial	1	27	30

[1] SR= short rotation

The farm was already 2 years into the programme and had four pasture categories for measurement:

1. Old pasture

Pastures that had not been renewed for 10 years

2. Lead-in short rotation crops

('Delish' AR1 short-rotation ryegrass and 'Puna II' chicory followed by 'Barkant' turnips). The first step in changing old pasture to new pasture. Turnips followed autumn sown short-rotation ryegrass, 18 months after the short-rotation ryegrass was sown.

3. New perennial ryegrass

New pasture in the first year after a summer turnip crop.

4. Established new perennial ryegrass

New pasture more than one year after a turnip crop.

Herbage accumulation cuts and samples for feed quality were taken in four selected paddocks (three grazing exclusion cages per paddock), each representing a stage of the programme as described above. No replication within pasture type was possible.

Year 1: (22 January 2008 to 12 January 2009).
Cage cuts were taken from two paddocks (6 cages, categories 1 and 4), increasing to four paddocks in April 2008 (total 12 cages) after re-sowing of a turnip paddock and establishment of a lead-in short-rotation pasture (categories 2 and 3). Sampling was scheduled every 28 days, or 13 cuts per year. The drought experienced in the Waikato from January to May 2008 reduced the number of samplings to 9 because there was insufficient herbage to collect an NIRS sample and the establishment of new and lead-in short-rotation pasture was delayed.

Year 2: (12 January 2009 to 26 January 2010)
The requirement to fit around the farm operation compromised trial design so paddock and year effects could not be separated, statistically, from pasture category effects (Table 1). In the lead-in short-rotation pastures, yield was assessed from 12-18 months after establishment in one paddock, and from establishment to 8 months in another, and from 8-12 months in a third. The old pasture was measured in two paddocks because the farmer chose to re-grass the Year 1 monitor paddock in Year 2. Each paddock of new and established new perennial pasture was monitored for 2 consecutive years.
At each sampling the following was completed for each cage:

- Herbage was cut using a handpiece set 2 cm from ground level
- The fresh weight of herbage from each cage was weighed and recorded
- The weighed sample from each cage was couriered to Analytical Research Laboratories in Napier for DM and NIRS analysis for CP, lipids, ash, ADF, NDF, soluble sugars, organic matter digestibility (OMD) and an estimate of ME. This laboratory uses similar technology to FeedTech that was used in study one.

Pasture and crop yields measured for each category during Years 1 and 2 were used to calculate the average farm yield (t DM/ha) over an assumed 5 year sequence of the Programmed Approach™ to re-grassing. Year 0 was the mean of 2 years of measurement of old pasture, and years 1-4 had the farm yield calculated using the following assumptions:

- 10% of the farm area was established in short-rotation lead-in pasture sequentially each year and this was then sown with improved perennial ryegrass after a summer turnip crop
- That the climatic effect on yield was the same over 5 years as the mean of the 2 measured years
- Over the lead-in rotation cycle a turnip crop added an additional 3 t DM/ha/yr (12 MJ ME/kg DM) to the measured short-rotation ryegrass yields (turnip yield estimated from 5 x 1 m quadrats)

Total DM yield (lead-in) = (Year 1 measurement + Year 2 measurement + turnip crop yield) /2.

Results

Study one

The net herbage accumulation over 3 years was 2.07 t DM/ha/yr higher (11%) on the SuperP farmlet compared with the Benchmark farmlet (Table 2). The yield of ME/ha was determined by multiplying the annual DM yield for pasture by the annual mean ME content per kg DM (MJ/kg DM), determined from NIRS analysis of pasture samples (Table 2). Annual mean ME yield was 33.3 GJ ME/ha greater (+15.3%) for the Super P farmlet than for the Benchmark farmlet.

Table 2 Annual net herbage accumulation (t DM/ha) and annual ME yield (GJ/ha) for the SuperP farmlet and the Benchmark farmlet for 3 years (2006-2009).

Super P farmlet	2006	2007	2008	Mean	SEM
Net herbage accumulation (t DM/ha)	23.5	17.8	21.8	21.0	±1.69
Annual mean ME content pasture (MJ/kg DM)	11.9	11.8	12.2	12.0	±0.12
Yield of metabolisable energy (GJ ME/ha)	280	210	270	252	
Benchmark farmlet					
Net herbage accumulation (t DM/ha)	20.7	16.0	20.2	18.9	±1.49
Annual mean ME content pasture (MJ/kg DM)	11.5	11.2	11.8	11.5	±0.18
Yield of metabolisable energy (GJ ME/ha)	238	179	238	218	

Table 3 Annual net herbage accumulation (kg DM/ha) for 2 years, plus mean yield (kg DM/ha), mean ME concentration (MJ/kg DM), and annual yield of ME (GJ ME/ha).

Pasture category	DM yield Year 1	DM yield Year 2	Mean DM Yield	ME content Year 1	ME content Year 2	Mean ME content	Annual ME yield
Old pasture	13850	14550	14200	10.7	10.7	10.7	151.9
Lead-in short rotation	10000	17350	13650*	11.4	10.9	11.15	152.1
New perennial	12400	16100	14250	11.6	11.2	11.4	162.5
Established new perennial	19350	13810	16575	11.6	11.6	11.6	192.2

* + 3000 kg DM/ha per year from turnip crop yield

Figure 1 Whole farm pasture DM yield change calculated from measured yields on a farm (Study 2) using a Programmed Approach™ to pasture renewal.

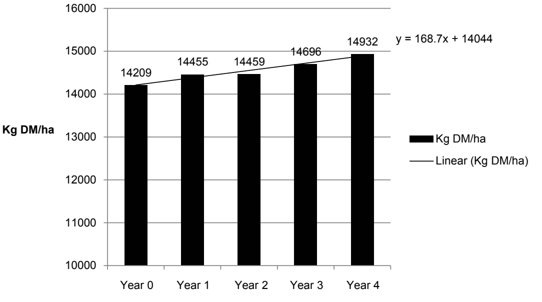
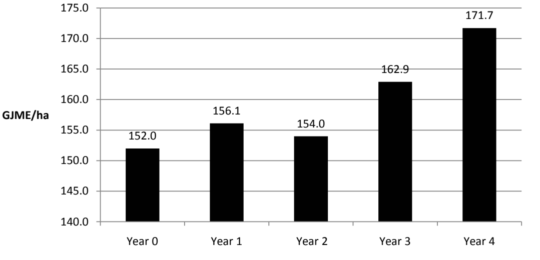


Figure 2 Whole farm pasture ME energy yield changes calculated from measured yields on a farm (study 2) using a Programmed Approach™ to re-grassing.



Study two

The "old pasture" yielded, an average, 14.2 t DM/ha/yr, with a mean ME value of 10.7 MJ ME/kg DM (151.9 GJ ME/ha; Table 3). All other categories of renewed pasture in the programme yielded more GJ ME/ha than the old pasture, but not always as a result of greater DM yield/ha. The improved ME content of pasture always compensated for any DM yield reduction (Table 3).

Table 3 results were used to calculate the change in average yield of pasture (kg DM/ha) and ME (GJ/ha) on this farm over 5 years by introducing 10 % of farm area to a Programmed Approach™ to renewal each year. The result after 5 years was an increase in average farm yield of 723 kg DM/ha (+ 5%) compared with the pasture yield before the pasture renewal programme (Fig. 1), and an increase of energy yield by 20 GJ ME/ha (+13%; Fig. 2).

Discussion

Both studies provide evidence that gains in pasture yield and quality can be expected with establishment of new pastures on dairy farms. Similar evidence was reported from 3 years of monthly pasture quality analysis on the Southland Demonstration Farm (Dalley 2010). Whether pasture renewal is the sole cause of these improvements is not conclusive because neither study involved an experiment to investigate pasture renewal benefits. In study one, evidence of extra feed being available to the herd is supported by extra milk production over 3 years compared with the Benchmark farmlet. The SuperP farmlet used an additional 3.8 t DM/ha of feed compared with the Benchmark to produce an extra 340 kg MS/ha, a response of 89 kg MS/t DM (Glassey & Roach 2010). Of the additional 3.8 t DM/ha of feed available, 2.0 t was increased net herbage accumulation from pasture and 0.8 t DM/ha from forage crops grown. Another 1.0 t DM/ha/yr was imported and fed above what was grown on the farmlet. Approximately 0.3 t DM/ha of the gain in net herbage accumulation could be explained by an additional 33 kg fertiliser N used per ha on the SuperP farmlet. This means that 1.7 t DM/ha can be attributed to additional net herbage accumulation from pasture renewal, equating to 151 kg MS/ha. The response of 89 kg MS/t DM extra feed is consistent with other farmlet MS responses to extra feed (Holmes & Roche 2007), and supports the measurement that 50% of the additional feed required for extra milk production came from increased net herbage accumulation resulting from pasture renewal. However, other reasons for increased net herbage accumulation cannot be ruled out. It is possible that at least some of the extra herbage accumulating on the SuperP farmlet could also be the result of the higher stocking rate used rather than pasture renewal. Macdonald *et al.* (2008) showed a tendency for pasture grown to increase linearly with increasing stocking rate along with increased pasture consumed per ha.

In addition to the 11% extra pasture DM grown on the SuperP farmlet, the ME yield of the pasture also increased by 15.3%. Once again, it is not possible to conclude whether this was the result of higher quality pastures as a consequence of pasture renewal or a function of the higher stocking rate on the SuperP farmlet resulting in higher quality pasture regrowth after each grazing (Macdonald *et al.* 2008).

UDDER modelling was used to compare the Programmed Approach™ to renewal with no pasture improvement for study two. The farm profit was predicted to be $928/ha more than a no pasture improvement strategy using $7.00/kg MS payout and assuming the cost of pasture renewal was $2 100/ha. The model predicted an additional 11.9 kg MS per tonne DM eaten as a result of an additional 892 MJ ME per tonne of feed eaten or 0.89 MJ ME per kg of feed eaten. This result is similar to the value of 0.8 MJ ME/kg DM calculated using the measured differences in study 2 (Table 3).

A limitation of both studies was the short measurement period (2 or 3 years), insufficient to determine the rate at which the benefits of pasture renewal diminish over time. This is important because under the programme implemented in study 2, it would take 10 years for the whole farm to be re-grassed.

Conclusions

Planned renewal of pastures produced additional higher quality pasture on both farms over a 2 and a 3 year programme, compared with non-improved pastures. While it appears likely that pasture renewal was a contributing factor to this increase, limitations to the project design prevent the conclusion that increased pasture energy yield is a certain result from pasture renewal. The second study supports the assumptions used in the UDDER modelling that a 5% increase in both pasture quality and yield can be expected after 5 years of a Programmed Approach™ to pasture renewal, sufficient to increase profit by $900/ha after the costs of renewal were met. The measurements in the second study also show that extra feed available as a result of renewal of 10% of the farm, annually, arrives incrementally (+170 kg DM/ha/year, Fig. 1) and is probably not easily detected by the farmer as contributing to improved feed supply for the whole farm. The additional pasture and energy yield of 0.7 t DM/ha and 20 GJME/ha after 5 years, calculated from the measurements in this study, will require considerable patience and planning if it is to be captured in farm profit.

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