THREE YEARS OF DURATION-CONTROLLED GRAZING: WHAT HAVE WE FOUND?

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Abstract
The practice of standing cows off pasture is used on dairy farms throughout New Zealand and globally to protect cows from adverse climatic conditions, increase production, reduce treading damage to pasture and soil, and minimise the loss of nutrients to waterways.

At Massey University's No. 4 Dairy Farm, the effects of standing cows off pasture year-round is being investigated, using Duration-controlled (*DC*) grazing. The effects of *DC* grazing on pasture accumulation, and the concentrations of nitrogen (N), phosphorus (P) and faecal microbes in mole and pipe drainage and surface runoff water have been measured from 14 pasture plots since June 2008. Seven plots were managed under *DC* grazing (4 hour graze, day or night) and seven plots under 'standard' grazing (*SG;* 7 hour day graze, 12 hour night graze). Slurry was returned to the *DC* plots in the first season with a nutrient loading equivalent to approximately the amount of nutrients produced in slurry from about 18 months of *DC* grazing. Consequently, no slurry was applied during the second lactation season. Four more dilute applications of slurry were applied to *DC* plots in the third season.

The average quantities of drainage over the three drainage seasons studied (2009, 2010 and 2011) were 373, 316 and 329 mm, respectively. The quantities of nitrate (NO_3^-) lost in drainage from the *SG* plots during these seasons were 13.1, 8.0 and 20.9 kg NO_3^--N/ha, respectively. Drainage NO_3^--N losses from the *DC* plots were 43, 65 and 53% lower, respectively, compared with the *SG* grazing plots for the three drainage seasons.

Pasture accumulation measured over the three lactation seasons (2008/09, 2009/10, and 2010/11) was 15212, 12778, and 14990 kg DM/ha per year, respectively, for the *SG* plots. There was no significant difference seen in pasture accumulation on *DC* plots for the first season; however there was a 20% and 9% reduction seen for the second and third seasons respectively. The smaller pasture accumulation achieved on the *DC* plots in the second season was likely due to less dung and urine deposited during grazing and the nil slurry return. It is anticipated that emphasis on frequent slurry return to pasture (e.g. earlier spring applications) can be used to further minimise differences.

Over three seasons, *DC* reduced NO_3^- leaching by more than 50%, which supports the proposal that *DC* could play a very important role in mitigating nutrient losses from dairy farms in some parts of New Zealand. However, slurry should be regularly applied throughout the lactation season if pasture growth is to be optimised under *DC* grazing management.

Introduction
Cattle urine spots are a major source of the nitrogen (N) leached from New Zealand dairy farms (Cameron *et al.* 2007; Wachendorf *et al.* 2005). Restricting the time that cows spend grazing pastures is one way to decrease the deposition of urine spots in paddocks. de Klein &

Ledgard (2001) found that, compared with a conventionally grazed system, restricting the grazing time of cows in the autumn in Southland led to a 35-50% reduction in nitrate (NO_3^-) leaching.

Duration-controlled grazing involves reducing the time cows spend grazing pasture with more time spent on feed pads or animal shelter facilities between grazings. While the increased time spent on stand-off facilities results in greater quantities of excreta being collected as effluent or stored manure, this material can be returned to soils evenly and at relatively low N concentrations.

A three year field trial was established on Massey University's No 4 dairy farm to assess the impacts of year-round, duration-controlled grazing on the quantities of N, phosphorus (P) and faecal microbes lost in drainage and runoff from a dairy farm with fine textured soils. This paper discusses the nitrate leaching and pasture dry matter (DM) accumulation results. It builds on previous papers presented at FLRC Workshops, namely Lindsay *et al.* (2009), and Christensen *et al.* (2010; 2011).

Methods

Trial site

The experiment was conducted on Massey University's No. 4 dairy farm near Palmerston North, Manawatu, New Zealand (NZMS 260, T24, 312867). The trial site was located in a flat landscape (c. <3% slope) which received an average annual rainfall of approximately 1000 mm. The site had a mixed pasture sward of predominantly perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). The trial was established on a mole-pipe drained, Tokomaru silt loam soil, which is classified as a Fragic Perch-gley Pallic Soil (Hewitt 1998).

The research area consisted of fourteen plots (~850 m^2/plot), each with an isolated mole and pipe drain system. Mole channels, ~ 40 m long, were installed at a depth of 0.45 m with an interval between moles of 2 m. Drainage from the mole channels was intercepted by a collecting perforated pipe drain (0.11 m diameter) installed perpendicular to the moles at a depth of 0.60 m. Further description of the topography and soil properties of the site can be found in Houlbrooke *et al.* (2004).

Experimental design

The trial consisted of two treatments. The Standard Grazing (*SG*) treatment involved a grazing duration of ~7 hours for day grazings and ~12 hours for night grazings. The other treatment was Duration-controlled Grazing (*DC*) which involved a grazing duration of ~ 4 hours for both day and night grazings. All plots were grazed on the same day with the same average stocking rate, which was set according to pasture cover (as estimated using a rising-plate pasture height meter). Grazings alternated between 'day' and 'night' regimes to mimic standard farm practice. There were 8-10 grazings per year.

The trial site was established during the summer of 2008. For fertiliser applications and drainage dates for the years 2008 – 2010 refer to Christensen *et al.* (2011).

In the 2010/11 lactation season, ammonium sulphate was applied to all plots at 30 kg N/ha in September, and 25 kg N in October. Cropmaster 20 was applied to all plots in March 2011at a rate of 150 kg/ha. The 2011 drainage season began on 27th April and ended on 17th December 2011.

At each grazing during the lactation season, cows were offered 5-6 kg DM/cow as pasture on the plots and another 2-3 kg DM/cow from another source. Prior to grazing the *SG* plots, cows were fed 2-3 kg DM/cow as supplementary feed on a feed pad. The cows grazing the *DC* plots were removed from the plots after 4 hours and given the remainder of their feed requirements (either pasture or supplement). Removal of the cows from the *DC* plots simulated their return from grazing to a standoff facility.

Estimated pasture dry matter accumulation, cow intakes and dung deposition

A rising-plate pasture height meter was used pre- and post-grazing to estimate the quantity of pasture on all plots. Sixty measurements were made to generate an average pasture mass per plot. These measurements were used to estimate pasture accumulation between grazings, the stocking rate required at each grazing and cow intakes at each grazing.

The dung pats deposited on each plot were counted to give an indication of the total amount of excreta returned to the plots (results not presented here). The difference in average dung depositions between the two treatments was used to estimate the quantity of excreta collected on the feed pad and therefore the amount of slurry to be applied to the *DC* treatment. The amount of slurry returned reflected an assumed N loss in storage of approximately 50%.

Slurry (5 to 10 mm) was first applied to the *DC* plots in mid-December 2008 (Lindsay *et al.*, (2009)). This was the only application of slurry in the 2008/09 season. An amendment has been made to the amount of N in the slurry applied in December 2008 as reported in Lindsay *et al.* (2009). The corrected value, given in Table 1, corresponds to a nutrient loading equivalent to approximately 18 months of *DC* grazing. Consequently, no slurry was applied during the second lactation season. Four, dilute applications of slurry were applied to *DC* plots in the third season (Table 1).

Table 1: Amount of N returned (kg/ha) to *DC* plots in slurry applications

Year	Month	Amount of N applied to *DC* plots *(kg/ha)*
2008	December	212
2010	October	15
	November	11
2011	February	68
	April	21

Drainage water volume measurements and water analysis

Drainage water from plots was channelled through drainage pipes into tipping-bucket flow meters located in sampling pits nearby. Each tipping-bucket was calibrated dynamically to account for slightly larger tip volumes at greater flow rates. All tipping buckets were instrumented with data loggers to provide continuous measurements of flow rate. During each drainage event, a proportion (~0.1%) of the drainage water from every second tip of the tipping bucket flow meter was automatically collected to provide a volume-proportioned mixed sample for water quality analysis.

Drainage water samples were filtered through a 0.45 µm filter and the filtrate analysed for nitrate-N and ammonium-N using colorimetric methods on a Technicon Auto Analyser (Blakemore *et al.* 1987).

Results & Discussion

Pasture accumulation from September 2008 to September 2009 was similar for both treatments. However, in the 2009/10 lactation season, average pasture accumulation was 20% less ($P<0.05$) on the *DC* plots (10204 kg DM/ha) than on the *SG* plots (12778 kg DM/ha) and this difference was increasing with time (Figure 1). In the 2010/11 season, some accumulation periods between grazings were lower ($P<0.05$). The overall accumulation on *DC* plots was 13619 kg DM/ha, and on the *SG* plots, 14990 kg DM/ha.

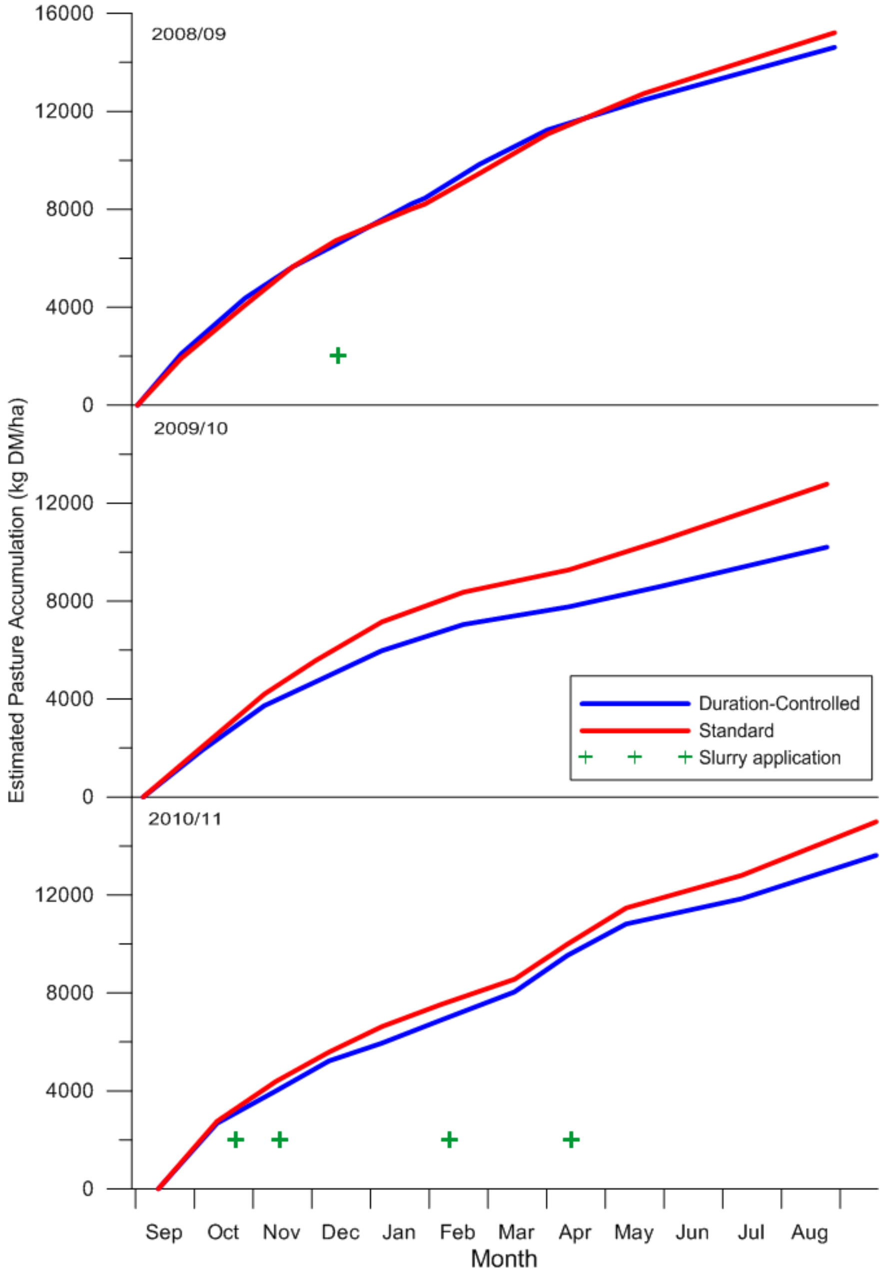

Figure 1: Pasture accumulation for *DC* and *SG* treatments over 3 lactation seasons

The smaller pasture growth accumulation measured on the *DC* plots in the 2009/10 season is predictable and underscores the importance of returning the nutrients excreted on the stand-off facility to paddocks. The results presented here for the three seasons would also suggest that the smaller and regular applications of slurry were more effective than large applications, which will be discussed in future publications. The smaller, more regular applications in 2010/11 resulted in relatively better pasture accumulation on the *DC* plots. This was evident when comparing daily pasture growth rates (kg DM/ha/day) between plots (Figure 2). In the 2010/11 season, there was a sharp decline in growth rates when no slurry was applied. This showed the high reliance of pasture growth through these periods on rapidly recycling nutrients via dung and urine, or effluent application.

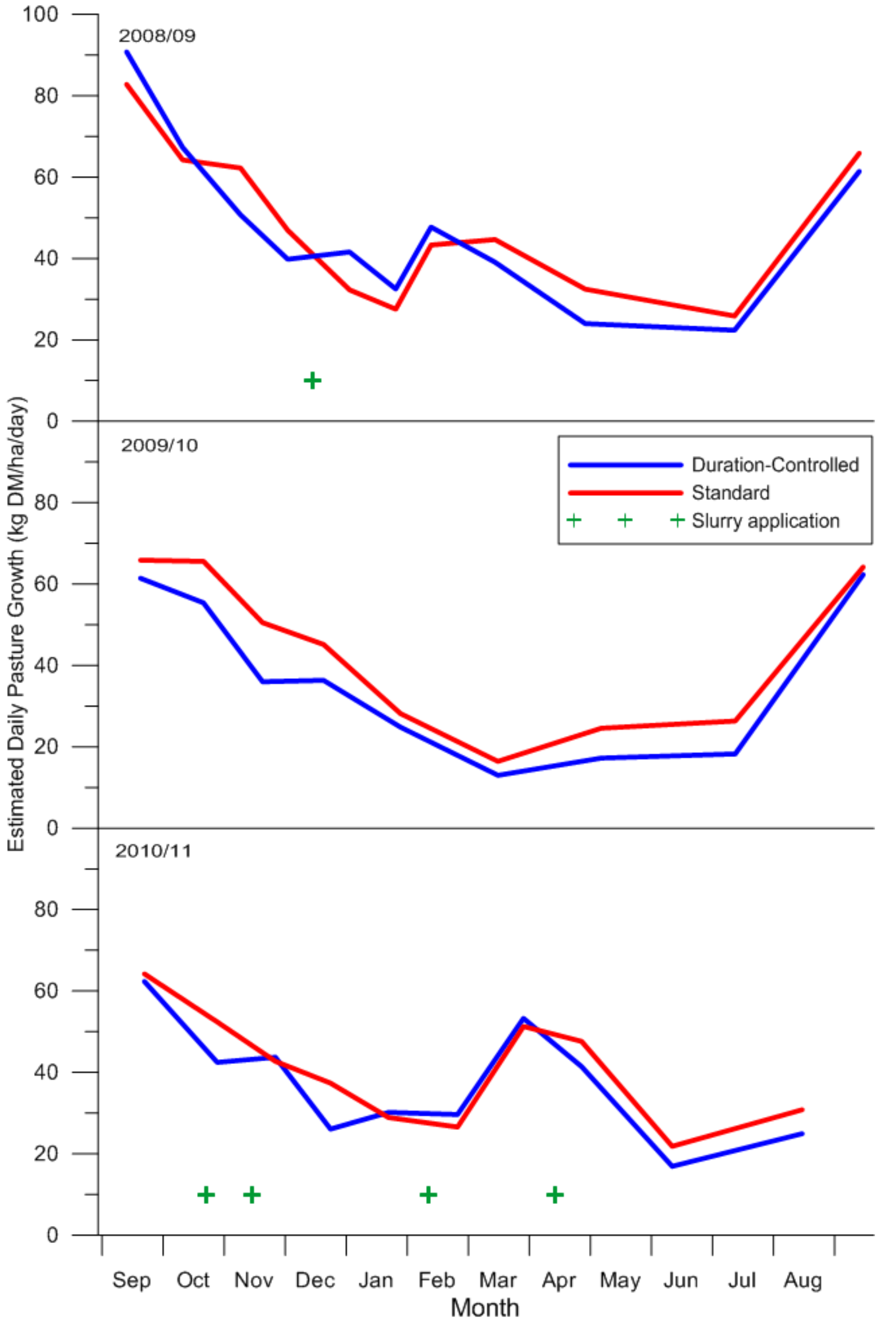

Figure 2: Daily pasture growth rates (kg DM/ha) for *DC* and *SG* treatments over 3 lactation seasons

The cumulative drainage from the *SG* plots was slightly less than that from the *DC* plots in all years (Figure 3). The average amount of drainage from all the plots was 373, 316 and 329 mm for 2009, 2010 and 2011, respectively.

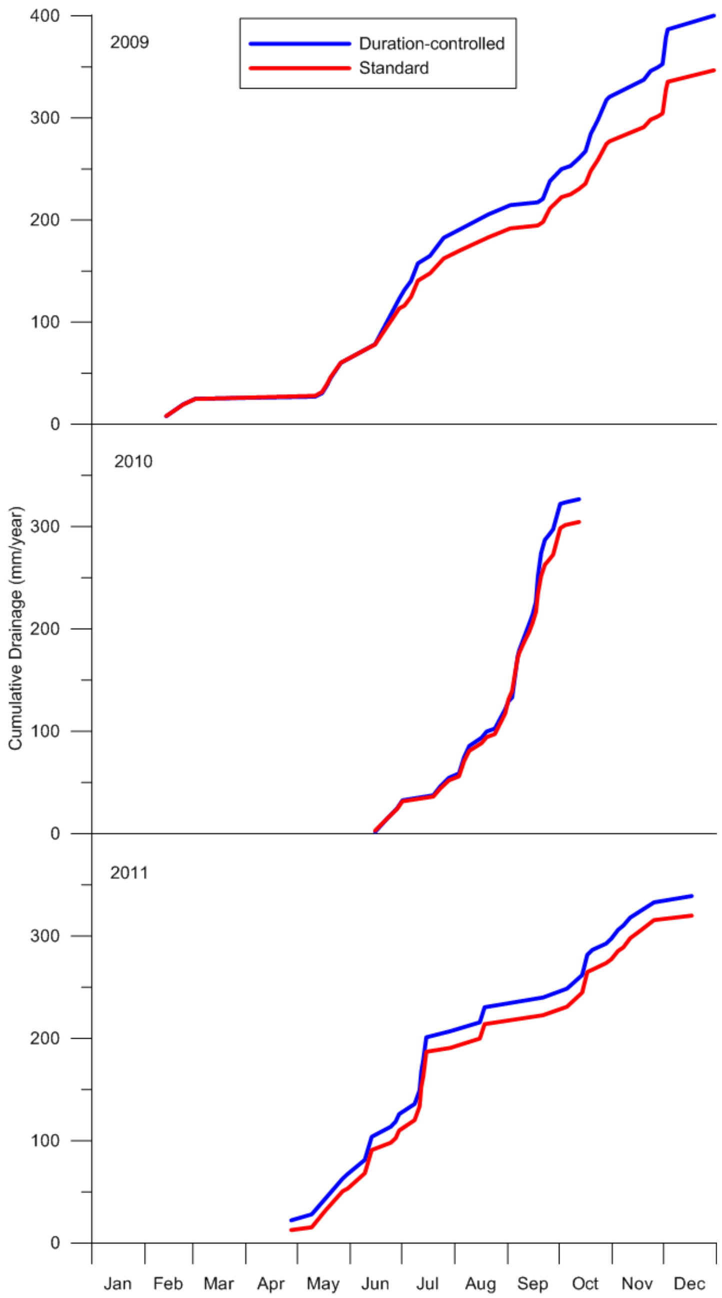

Figure 3: Cumulative drainage (mm) for *DC* and *SG* treatments over 3 years

The nitrate-N (NO_3^--N) concentrations in 2011 were consistently lower from the *DC* plots than the *SG* plots. Also, the concentrations from all plots were very low (<2 ppm) by August. The majority of NO_3^--N leaching occurred in the first few months of winter drainage (Figure 4). This pattern of NO_3^--N leaching has been consistent for all years of the current study Christensen *et al.* (2011) and is a common observation for climates similar to the Manawatu. In 2009, the total NO_3^--N lost from the *DC* treatment plots was 7.5 kg N/ha, which was 43% less than the 13.1 kg N/ha lost from the *SG* plots (Figure 4).

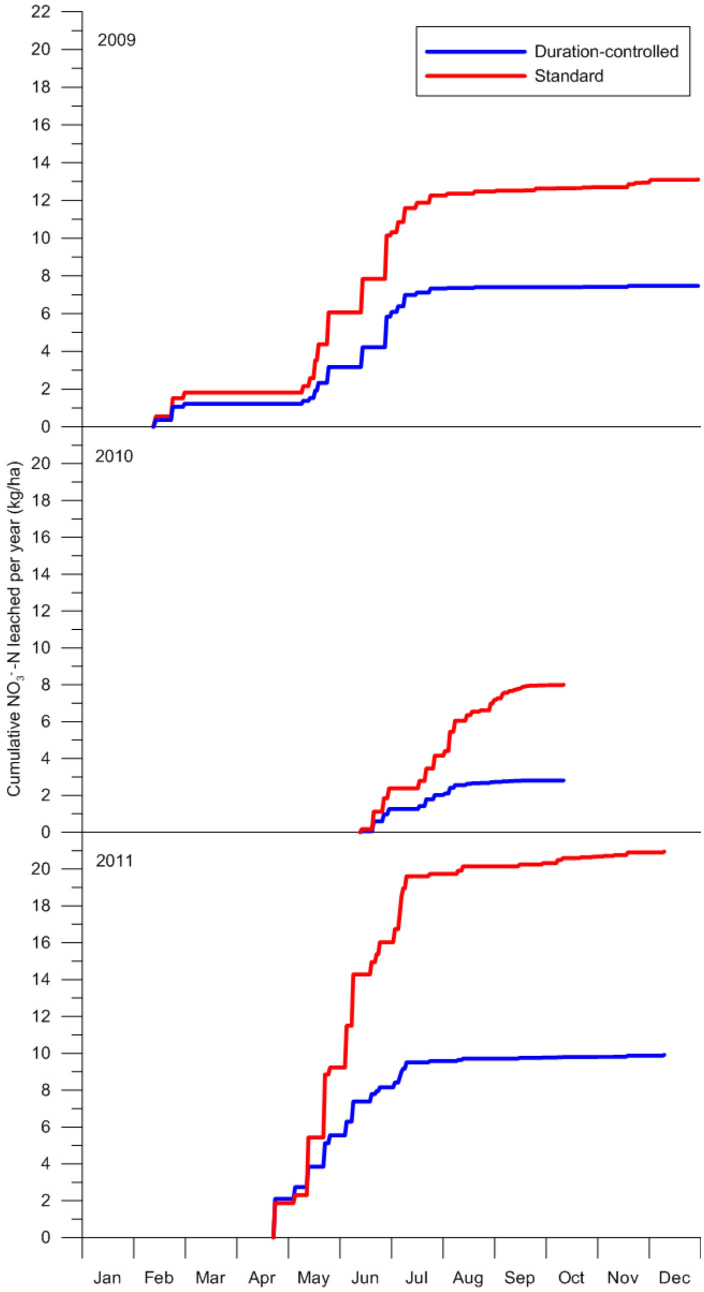

Figure 4: Cumulative nitrate-N leached (kg/ha) in drainage water for *DC* and *SG* treatments over 3 years

The cumulative NO_3^--N (kg N/ha) losses in drainage were smaller in 2010 (Figure 4) than in previous years (Christensen *et al.* 2010). Overall however, the percentage difference in cumulative NO_3^--N lost between treatments was larger, with a 65% reduction from the *DC* plots (2.8 kg/ha), compared with the *SG* plots (8.0 kg/ha).

In the final drainage season (2011), 53% less NO_3^--N was lost in drainage from the *DC* plots (9.9 kg/ha) compared with the *SG* plots (20.9 kg/ha).

Over all 3 years of this trial, DC has resulted in a reduction in NO_3^--N leaching of more than 50%, which exceeds the dairy industry's strategy/target. NO_3^--N leaching from *DC* plots has been consistently lower, regardless of the length or timing of the drainage season.

Conclusion

Duration-controlled grazing has shown to reduce NO_3^--N leaching by ~50% on dairy farms. Therefore, it has the potential to be an important mitigation strategy, particularly in nitrogen-sensitive areas. However, small, regular applications of slurry are required to maintain or even increase pasture growth rates. If this can be achieved, then *DC* grazing could be adopted by many farmers around New Zealand.

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