DURATION-CONTROLLED GRAZING ON DAIRY FARMS: DECISION SUPPORT FOR TIMING OF SLURRY RE-APPLICATION

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Introduction

It is widely recognised that dairying has an adverse effect on the aquatic environment and that this industry needs solutions to this problem, particularly as it seeks to increase milk production. To this end, a farm-scale systems trial based on duration-controlled grazing has commenced at Massey University's No. 4 dairy farm. A 200-cow freestall barn was commissioned in the 2013/14 dairy season, as part of the Pastoral 21 research programme, known as P21.

The programme is a collaborative venture between DairyNZ, Fonterra, the Dairy Companies Association of New Zealand, Beef + Lamb NZ and the Ministry of Business, Innovation and Employment. P21's goal is to provide accessible systems-level solutions for profitably increasing pastoral production while reducing the environmental footprint of farms. The trial at No. 4 dairy farm builds on earlier smaller-scale research conducted at Massey on duration-controlled (DC) grazing (Christensen, 2013). This prior field trial evaluated a DC grazing regime which involved four-hour grazings after morning and afternoon milkings.

In between grazings the cows were stood off the paddock. Duration-controlled grazing was compared with a 'standard' grazing routine of a seven-hour day grazing and a 12-hour night grazing. Cows in both treatment groups were offered five to six kilograms of dry matter of pasture on plots, with another two to three kilograms of dry matter of supplement (per day or night grazing). Pasture production and nitrate leaching were measured for each trial plot. Nitrate leaching from the DC plots was 43%, 65% and 53% less than that measured on the standard grazing plots over the initial three-year trial period, respectively. This was an average annual reduction of 52% (Christensen, 2013).

The theory underpinning the advantages of DC grazing is simple. As urine spots are the major source of nitrate leaching in New Zealand dairy farming systems, if cows spend less time in the paddock and there is less opportunity to deposit urine, then this results in a reduction in nitrate leaching. Moreover, DC grazing in late summer through autumn – February to May – has the greatest impact on nitrate leaching (Christensen, 2013).

Any time cows spend off the paddock and in a housing or stand-off facility creates the opportunity to collect excreta and store it for future re-application to pasture, as slurry, in a uniform manner. During this study, slurry was re-applied to areas that had DC grazing implemented. This was applied at depths of 5-10 mm using a slurry tanker and tractor. Figure 1 shows the total nitrogen (N) applied in each slurry application over five years of the study. The aim was to apply approximately 120 kg N ha^{-1} yr^{-1} based on the removal of dung and urine from standing cows off, minus storage losses.

Following a single but highly concentrated application in the first year of 212 kg N ha^{-1}, it was deemed unnecessary to apply any slurry in the second year. However, only 17% of this N was in a mineral form. This was primarily due to some of the more liquid effluent, which would have had a higher mineral N concentration, draining to another storage facility so was not applied back in the slurry. Not applying effluent in the second year had a marked effect on reducing subsequent pasture production, with a 20% decrease compared with the standard treatment for that lactation season as shown in Figure 2 (Christensen *et al.*, 2012).

In the following three years, smaller but more regular applications were made to the duration-controlled plots as shown in Figure 1. By the 2012/13 season, pasture accumulation was 6% greater on the DC system than on the standard treatment as shown in Figure 2. This was the effect of an earlier application of slurry (spring 2012), along with a greater mineral nitrogen content of the slurry, which was more readily available to pasture plants.

The main conclusion drawn from the slurry application was that if collected and stored, the slurry should be re-applied as early in the spring as possible. This would be as soon as machinery could get onto paddocks, i.e. the soil had a high enough moisture deficit. Following the winter drainage period, key nutrients have been leached from the soil and wet and cool conditions have not allowed sufficient nitrogen and other nutrients to become available to plants. Growth of pasture can therefore be enhanced if these nutrients are re-applied early as slurry.

In addition, the mineral nitrogen content of that slurry should be a high proportion (i.e. >40%) of total nitrogen to ensure sufficient nutrient is readily available to pasture plants for uptake. This is the proportion that has been measured from housing and stand-off facilities over time in New Zealand (Longhurst *et al.*, 2006). The forthcoming study will be able to further quantify what proportions of mineral nitrogen are in stored housing effluent at different times of the year.

In this study, cows will therefore spend approximately nine hours a day in the house in late summer and autumn to reduce urine deposition in the paddock, and thus nitrate leaching, during the winter drainage season. The cows will also go into the barn for the whole day, or part of the day, during the winter and early spring period to hold them off wet soils to prevent treading damage, which cause poor pasture utilisation and reduced pasture growth. In other words, the barn is being used as a tool to increase productivity and reduce the environmental footprint.

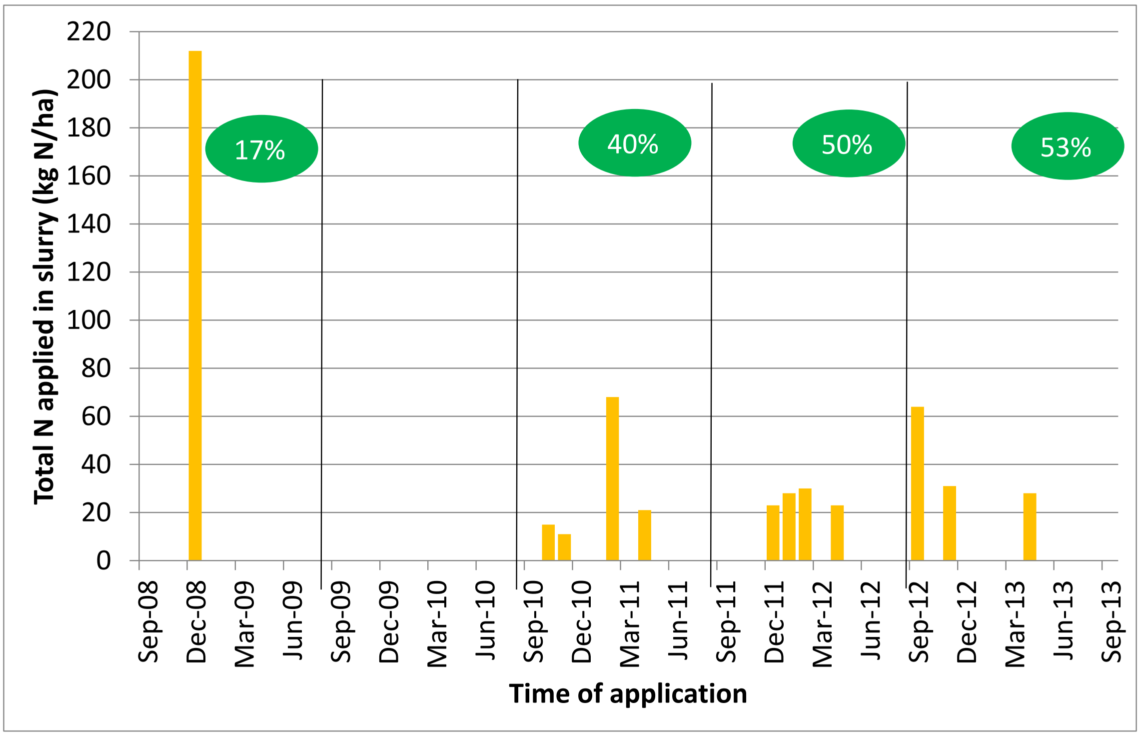

Figure 1. Slurry application timings to duration-controlled plots and the total nitrogen applied (kilograms of nitrogen per hectare) at each application. Text boxes in each season show the average percentage of mineral nitrogen applied.

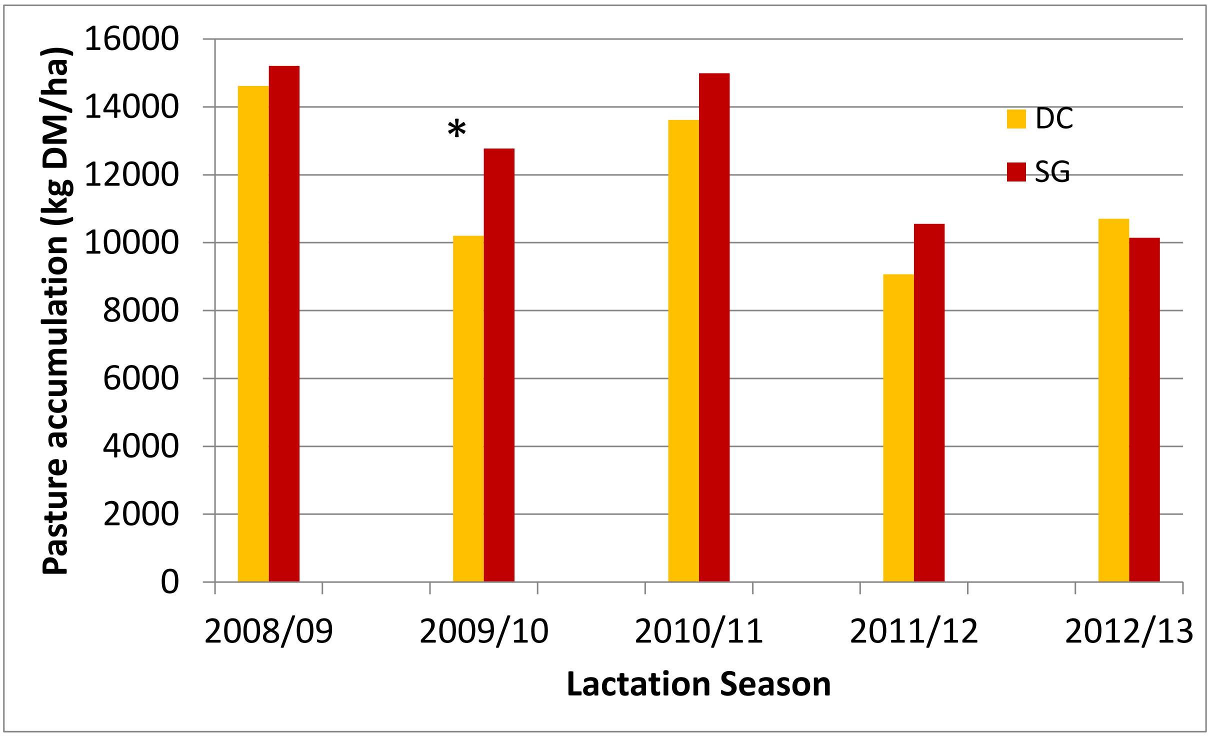

*Figure 2. Pasture accumulation for the two treatments over five lactation seasons (*denotes a significant difference between treatments).*

The trial

The soil at No. 4 dairy farm is Tokomaru silt loam, which is renowned for its poor natural drainage and susceptibility to treading damage. The farm is extensively drained with moles and collecting pipelines. The average annual rainfall is approximately 1000 mm. Soil moisture content is often high in July and August. As this coincides with the beginning of the lactation season, feeding cows adequately can be a challenge and so grazing must be carefully managed.

At the start of the systems trial, 400 cows from the existing milking herd were split into two treatment groups. One group of 200 cows will be managed according to DC grazing protocols, making use of the freestall barn. The other herd will act as a 'control' treatment using a standard feedpad and typical grazing management. The two herds have their own farmlets, which are as similar as could be practicably arranged.

The cows are a mix of Friesian and Friesian-Jersey crossbreds. The two treatment herds have been balanced for breeding worth and age. The herds will effectively have closed membership, although as per usual farm practice heifers will be introduced annually as replacements. The freestall barn is built to an animal welfare standard that means 200 cows can be housed for 24 hours a day for prolonged periods if need be. However, the plan is to use the barn as part of a stand-off strategy to protect soils in the winter and spring and reduce the paddock urine load in late summer and autumn. That is, the barn will be used part-time only so as to maximise consumption of the pasture and crop grown on the farm.

In the barn the cows still produce excreta but this is captured and stored as effluent and returned to soils evenly in ideal environmental conditions. This is at times that match plant requirements and at relatively low nitrogen loading rates based on the previous study that has been described. An objective of the research is to assess whether the capital spent on the barn can be recouped by increasing pasture and crop yield. The potential to increase grown and utilised feed will be determined by quantifying the benefit of reduced pasture treading and carefully timed applications of effluent.

The grazing protocols

A simple model was constructed in Microsoft Excel to identify the amount of time that cows are likely to spend in the house. The model is based on a soil water balance. Housing over the past 10 years – 2003 to 2013 – was simulated in the model using the criteria given in Table 1. The model also predicts slurry dynamics; including effluent generation in the house, the nitrogen concentration of this effluent, slurry application to land and changes in slurry volume in the storage pond.

Table 1. Objectives of housing and the criteria used to achieve these goals.

Objective	Season	Criteria	Hours in house per day
Protect against worst of pugging and pasture damage	Winter/spring	Soil moisture deficit < 1.5 mm	24
Protect against soil compaction	Winter/spring	Soil moisture deficit between 1.5 and 5 mm	12
Reduce the number of the most 'at risk' urine patches	Late summer/ autumn	1 February to 31 May	9

Over the past 10 years, cows would have spent an average of 2,084 hours per year, or 32% of the time, in the house. As expected the cows were mostly housed in winter and spring to avoid pugging damage and compaction, at 57% of the housed time, and to reduce the number of urine patches deposited in late summer and autumn, at 37% of the housed time, as shown in Figure 3.

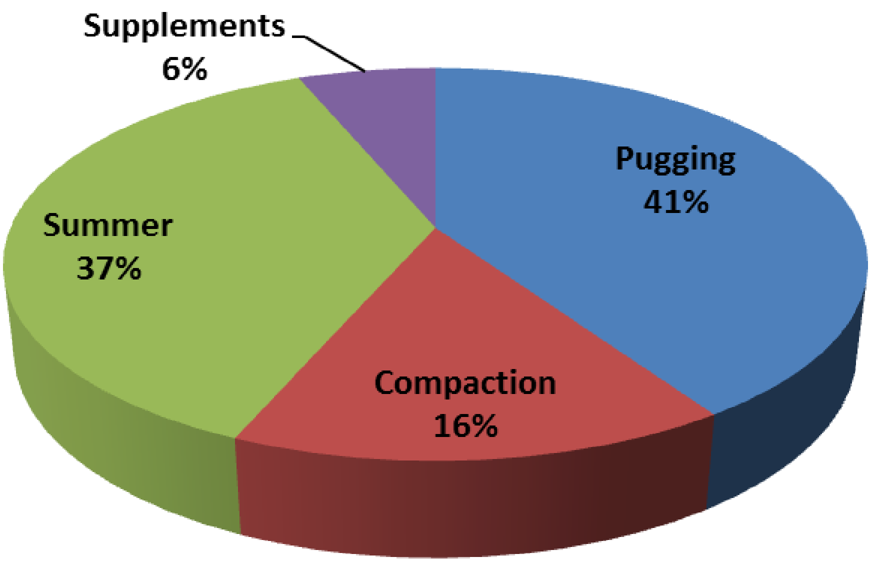

Figure 3. The average contribution (%) of each of the housing objectives, given in Table 1, to the time cows spend in the barn – on average 2,084 hours per year.

On average, a little over 8000 kg of nitrogen will be excreted/collected in the house per year. However, following storage in the pond and losses of nitrogen to the atmosphere the quantity applied to the farm will be significantly less than this. As the cows' diet, and hence nitrogen ingestion and excretion, vary throughout the year, the quantity of effluent nitrogen generated in the house also varies across the seasons.

Housing in late summer and autumn produces the greatest quantity of nitrogen, at 47% of total, even though time in housing is greater in the winter and spring period (Figures 3 and 4). This is because feed intakes are higher in late summer and autumn compared to the winter period when a high proportion of the herd are still non-lactating.

A pond with a working, or pumpable, storage volume of approximately 2,300 cubic metres, i.e. 11 cubic metres cow^{-1}, would be required if all of the criteria described in Table 1 were to be met. The cyclic or seasonal nature of the change in slurry volume can be seen in Figure 5, where for clarity of presentation only the years 2006 to 2013 are shown. Effluent accumulates over the dry summer months and the winter period and is then applied relatively quickly in early spring to coincide with the greatest plant requirement.

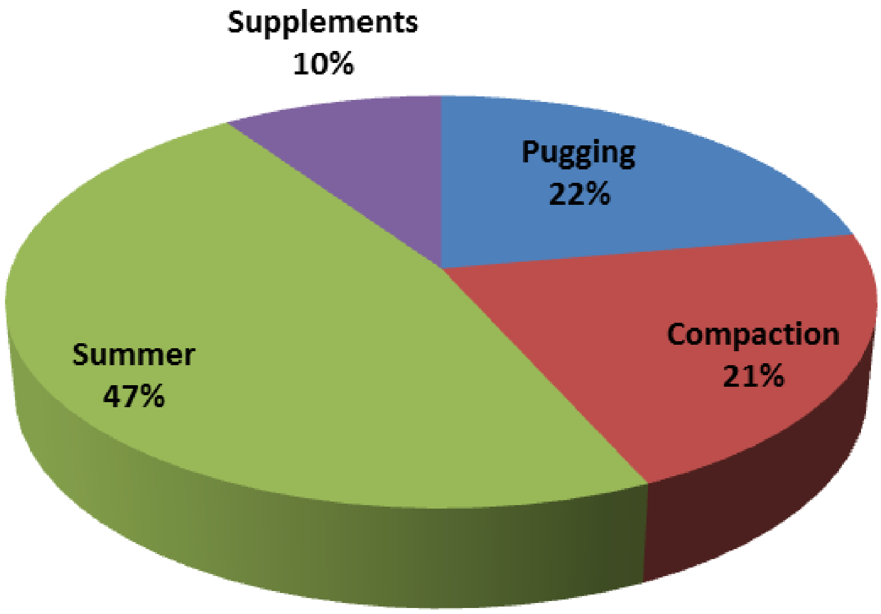

Figure 4. The average contribution (%) of each of the housing objectives, given in Table 1, to the quantity of nitrogen produced in effluent from the house.

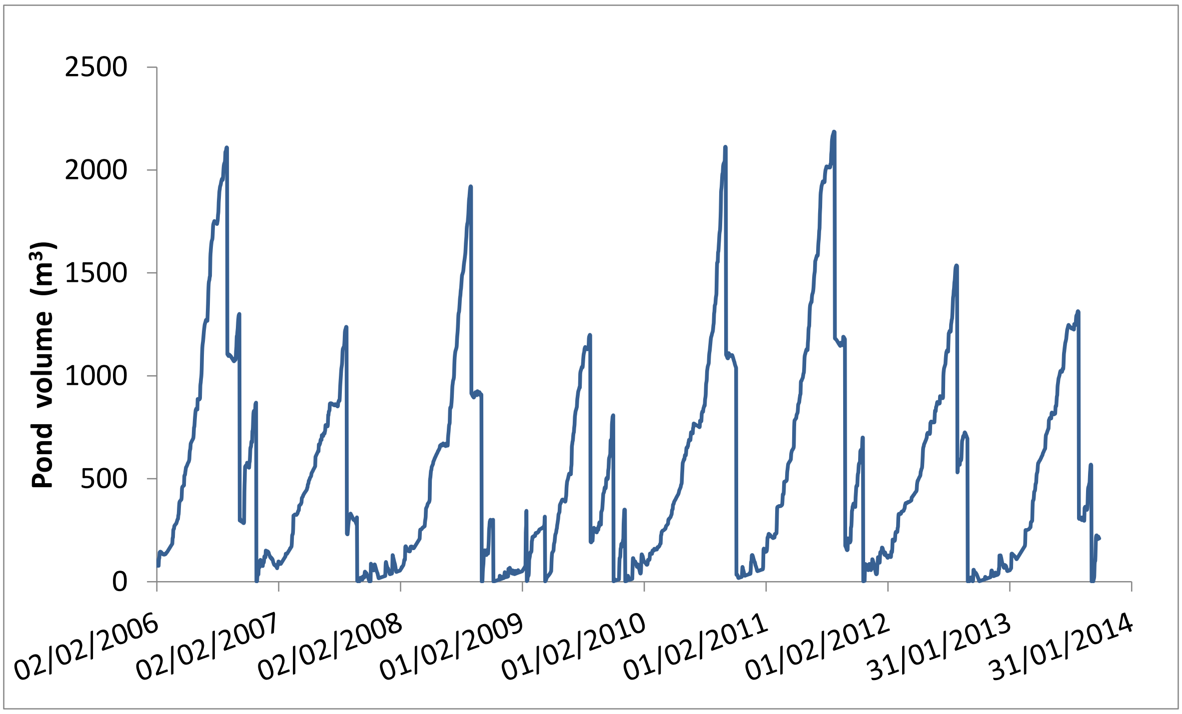

Figure 5. The daily volume of slurry in the pond between 2006 and 2013.

Summary

Increasingly, limits are being placed on the quantity of nutrients that can be lost from dairy farms to waterways. Farmers require technologies and practices that will allow them to farm within these limits. At Massey University's No. 4 dairy farm, the potential of DC grazing to reduce nitrate leaching losses while increasing profitability of a dairy system is being quantified. In addition to reducing nutrient losses, the use of DC grazing has shown potential to increase pasture growth when slurry is returned in spring with a high mineral N content. The ability of DC grazing to achieve further improvements in pasture growth from also reducing treading damaging will be assessed as part of a farm systems study.

References

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