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A survey of dairy cow wintering practices in Canterbury, New Zealand

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Abstract. Low pasture growth rates in the South Island of New Zealand dictate the use of grazed crops and stored supplements over winter to feed dairy cows. However, grazed crops represent a significant risk for nutrient loss. Little is known about the extent of different wintering practices. The aim of the present research was to document the prevailing winter management practices in Canterbury, allowing changes in management to be tracked in the future. A telephone survey of 238 dairy farms in Canterbury (20% of the total 1208 farms) was completed in March 2016. Results indicated a heavy reliance on wintering off the milking platform (93% of the cow.weeks), mostly on support blocks managed by the dairy farmer (68%). Twenty-five per cent of the wintering occurred on a farm not owned or managed by the dairy farmer, commonly on arable farms. Kale (46%) and fodder beet (40%) were the most common winter crops fed to cows. Optimising kale and fodder beet management represents a significant opportunity to improve nutrient management and reduce nutrient loss from grazed crops.

Additional keywords: fodder beet, grazing, kale, support block, winter crop.

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Introduction

The winter months of June and July are a key period for non-lactating dairy cows to achieve body condition-score targets before calving in August for the South Island of New Zealand, of which Canterbury is a key region. The temperature over these months results in little to no pasture growth. Consequently, conserved feed, either as standing crop or silage, must be fed during this period.

Typically, ~20% of farm working expenses in the region are associated with wintering (Dalley 2010). Due to the cost and the influence on farm productivity in the subsequent season, wintering is a critical factor influencing the business profitability in the South Island.

The predominant wintering system in this region is for cows to be grazing a forage crop (e.g. kale, fodder beet), usually supplemented with baleage or silage from pasture or cereals, or straw. Forage crops are typically sown in late spring (October–November), grazed in winter (June–July), then the paddock is re-sown in late spring either into another forage crop or back into permanent pasture. The forage crops can be located on the dairy farm (milking platform), on a separate farm managed by the dairy farmer (support block) or on a farm owned by another farmer (grazier). For support blocks and graziers, after the herd is dried off, cows are either walked or trucked from the milking platform (May–June), depending on distance, where they remain for approximately 8 weeks before going back to the milking platform to calve (August).

The high forage-crop yield, relative to pasture, results in a high stocking density on the crop paddocks over winter, at a time of high rainfall and, consequently, drainage. This, and the low plant growth rate, and therefore nutrient uptake, result in an increased risk of nutrient losses to the environment during this period, particularly nitrogen (N). The Canterbury region of the South Island also has a prevalence of free-draining soils, which increases the risk of nutrients moving through the soil profile into waterways and groundwater.

In response to the National Policy Statement for Freshwater Management (Ministry for the Environment 2014), Environment Canterbury has divided the region into catchments, or zones (Environment Canterbury 2016*b*). The zones are divided into three categories of water quality, including those where water-quality outcomes are met, those that are at risk, and those where water-quality outcomes are not met, i.e. over allocated. Significant reductions to nutrient losses will be required in some zones to meet the environmental outcomes desired by local stakeholders. Consequently, the wintering of dairy cows is under scrutiny, in particular because some practices are identified as having a negative impact on the environment.

Alternative wintering systems where cows are housed off-paddock are available; however, recent studies have questioned the economic viability of such systems in the New Zealand market situation and the environmental benefit is not guaranteed (Newman and Journeaux 2015).

The type of wintering system can influence nutrient loss to the environment. In particular, the grazing of crops in winter has a high risk of nitrate leaching due to high stock densities, and therefore increased N deposition, and the lack of plant growth utilising soil N while the land is fallow (De Klein *et al*. 2010). It is, therefore, important to determine the extent and location of paddock-based wintering and the prevalence of the different wintering systems, to enable an assessment of the current impact and the scope for management options to mitigate N losses. For example, the amount of N deposited onto a paddock during grazing can be influenced by crop choice and management to reduce surplus N intake by cows (Edwards *et al*. 2014; Dalley 2016; Malcolm *et al*. 2016*b*), and a catch crop established as soon as possible after winter grazing has the potential to utilise nutrients deposited over the winter, reducing the risk of nutrient loss to the environment (Malcolm *et al*. 2016*a*).

The aim of the present study was to determine the location, number of cows and duration of wintering, along with the prevalence of different wintering systems used in Canterbury. This enables tracking of change in the future when evaluating the impact of increased research and development efforts in the primary sector in Canterbury, such as, for example, Pastoral 21 and Forages for Reduced Nitrate Leaching (DairyNZ 2016).

Data can be used to identify opportunities for improving nutrient management and for scenario modelling to estimate the impacts of paddock-based wintering and the number of cows that may be displaced should restrictions be imposed in certain areas.

Materials and methods

A survey was chosen as the method to estimate the location, number of cows and the duration of wintering, along with the prevalence of different wintering systems used in Canterbury in the winter of 2015 (June–July).

Survey questions

The survey had five sections. The introductory section collected information on the dairy farm itself, the farm area, the herd size and where the herd was wintered (number of cows remaining on the milking platform or sent to a managed support block or a contract grazier, or combinations of the three).

The second section focussed on wintering practices for cows remaining on the milking platform over winter. First, it was established whether any of the cows were milked through the winter, and, if so, what the predominant diet was and whether they were in an off-paddock facility. Next, it was determined whether there were any non-lactating cows in an off-paddock facility and, if so, what was their predominant diet. Then, information about the number of cows wintered on-paddock on the milking platform during June–July 2015 was collected, along with the predominant crop type(s) and who had prepared the paddock for crop establishment. The same questions were asked of those that had grown crop for transitioning (i.e. to feed before or after winter period). Finally, questions relating to the total area of crop on the milking platform and the types of supplement that had been fed out in combination with the crop were asked. It was intended that the crop-area question was asked of all respondents that had grown crop on the milking platform (for wintering or transitioning). However, an error in survey logic meant that this was asked only of those that had fed crop for both wintering and transitioning on the milking platform.

The third section focussed on wintering on a managed support block, including the number of support blocks and the number of cows that went to each block. For each block, the number of weeks with cows, its area, whether it was owned or leased land and its street address were asked, as well as crop types grown, whether they were irrigated, whether any of the crop was harvested and taken elsewhere, what types of supplement were fed, whether a catch crop was grown and its type, and whether there was a nutrient budget for the block.

The fourth section focussed on graziers and included the relevant questions asked for support blocks. It was established whether the grazier was an arable farmer, a sheep and beef farmer or a specialist grazier.

The final section asked about future wintering plans, namely, whether any changes were planned for wintering in 2016, and, if any, what and why those changes were made and what factors are likely to influence their wintering system in coming years.

Survey participants

The target number of farmers to survey was determined by a sample-size calculator, which estimated that 292 responses (24% of the 1208 dairy farms supplying milk in Canterbury on 22 January 2016) were required to achieve a 95% confidence level with a 5% margin of error. Due to the spatial element to the survey, care was taken to ensure that the survey participants were distributed appropriately across the major zones.

Contacts for the farms were selected using the following method:

(1) Determine the organisation with the largest levy split for the farm.
(2) If the organisation with the largest levy split for the farm did not meet the selection criteria (see below), move to the organisation with the next-largest levy.
(3) If no organisations met the selection criteria, then move to the farm connections, and select the Contract Milker.
(4) If no Contract Milker existed that met the selection criteria, then select the Operations Manager.
(5) If no Operations Manager existed that met the selection criteria, then select the Farm Manager.
(6) If no Farm Manager existed that met the selection criteria, exclude the farm from the data extract.

Selection criteria

The following selection criteria were used for farm contacts:

- the contact had an address within Canterbury;
- the contact had not been surveyed in the past 6 months, nor was allocated to another survey;
- the contact had at least one telephone number;
- the contact had not registered as 'DO NOT SURVEY ME'.

Contacts received

The selection procedure resulted in contact details for 779 contacts, representing 869 farms (i.e. some contacts were associated with multiple farms).

On the basis of experience with a similar survey in Southland, it was decided to conduct the survey by phone.

In total, 238 responses (or 20% of the population) were received from Versus Research on 24 March 2016. This was lower than the initial target of 292; however, the list of contacts had been exhausted and a slightly larger margin of error (5.7%) was considered acceptable.

Data analysis

Address data for the support blocks and graziers were entered into the GPS Visualiser tool (http://www.gpsvisualizer.com/geocoder/, accessed 1 April 2016) to convert the address into latitude and longitude coordinates. Addresses not found by the GPS Visualiser tool were manually checked for spelling and re-entered.

A measure of wintering intensity was calculated by multiplying the number of cows by the number of weeks they were at the location.

Results were summarised by percentage of wintering sites, by percentage of cows, and by wintering intensity (cow.weeks). It was assumed that the length of time cows were wintered on the milking platform was 8.5 weeks (the average time cows went to a grazier). The percentage of cows by location (site or zone) was calculated by summing the wintering intensity (cow.weeks) for the location, then dividing this by the average number of weeks the cows were wintered per category and converting to a percentage of the total for Canterbury. A straight sum of cows could not be used because if a herd spent 4 weeks at a support block and the next 4 weeks at a grazier then this would appear as twice the number of animals compared to a herd that had spent 8 weeks at one location. Data were summarised by type of wintering site and the zone where the site was located. Data were scaled up to the whole of Canterbury by dividing the results by 20% (i.e. size of sample).

Zone intensity per hectare was also calculated (cow.weeks/ha). The area of each zone was calculated by intersecting a zone-boundary GIS layer with Landcare Research's New Zealand Land Resource Inventory (NZLRI) land-use capability (LUC) layer (Landcare Research 2016). The sum of LUC Class 1–6 land (Table 1) was calculated for each zone.

Due to respondents having the option of selecting multiple crop and supplement types, crop and supplement type data were summarised using counts.

Table 1. Description of each New Zealand Land Resource Inventory land-use class (LUC)

LUC class code	Description
1	Land with virtually no limitations for arable use and suitable for cultivated crops, pasture or forestry
2	Land with slight limitations for arable use and suitable for cultivated crops, pasture or forestry
3	Land with moderate limitations for arable use, but suitable for cultivated crops, pasture or forestry
4	Land with moderate limitations for arable use, but suitable for occasional cropping, pasture or forestry
5	High-producing land unsuitable for arable use, but only slight limitations for pastoral or forestry use
6	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest
7	Non-arable land with severe limitations for use under perennial vegetation such as pasture or forest
8	Land with very severe to extreme limitations or hazards that make it unsuitable for cropping, pasture or forestry

Table 2. The distribution of all dairy farms as at 22 January 2016 and the number of farmers surveyed by zone

Survey zone	All farms	Surveyed	%
Kaikoura	24	1	4
Hurunui–Waiau	97	25	26
Waimakariri	113	19	17
Christchurch–West Melton–Banks Peninsula	6	2	33
Selwyn–Waihora	238	42	18
Ashburton	211	50	24
Hinds	196	48	24
Orari–Opihi–Pareora	170	21	12
Waitaki	153	30	20
Total	1208	238	20

Table 3. Comparison of survey farms and 2014/15 Canterbury averages (DairyNZ 2015)

Metric	Survey statistic mean	Survey statistic median	2014–2015 dairy statistics
Average milking-platform area (ha)	284	220	232
Average herd size (cows)	991	791	806
Average stocking rate (cows/ha)	3.5	3.6	3.5

Results

Spatial distribution

The number of farms located in each zone, and the number surveyed, are presented in Table 2. Disproportionately, few farmers were surveyed in the Kaikoura zone, with Waimakariri, Selywn–Waihora and the Orari–Opihi–Pareora zones also below the survey average of 20%. As such, results for the Kaikoura zone should be treated with caution.

Farm and herd size

The farms of the respondents appeared to be larger in area and cow numbers than the Canterbury average reported in the national dairy statistics (DairyNZ 2015), although stocking rates were similar (Table 3). There appeared to be a group of 'very large' farms distorting these averages. It is possible that some survey respondents grouped multiple farms with common ownership together. The survey medians for farm area, herd size and stocking rate were similar to the corresponding averages from the 2014–2015 Dairy statistics (DairyNZ 2015), confirming that it is mainly a few very large farms skewing the averages.

Excluding farms in the Kaikoura and Christchurch–West Melton–Banks Peninsula zones, which had only one or two respondents, there were small but insignificant differences in the farm sizes, herd sizes and stocking rates among the zones.

Wintering and transitioning on the milking platform

There were 49 respondents (21%) that retained cows on the milking platform over the winter. Twelve of these milked cows during the winter, with perennial ryegrass–white clover-based pasture and pasture silage being the most common feed types. Five of the winter-milk farms had an off-paddock facility for lactating cows. This facility was used between 2 and 14 h per day. A further 2 of the 49 respondents had an off-paddock facility for wintering non-lactating cows, with one feeding pasture and cereal silage and the other feeding lifted fodder beet.

Forty-five respondents wintered non-lactating cows on-paddock on the milking platform. Four respondents that milked cows through the winter did not complete this section (including those using an off-paddock facility). The remaining eight respondents that milked cows through the winter also had non-lactating cows wintering on-paddock on the milking platform. Of those that were wintered on-paddock, the predominant feed type was fodder beet (38% of the crops mentioned), followed by pasture (31%) and kale (16%). Nine respondents used more than one feed type. Thirty-eight per cent of the respondents prepared their own land for the winter crop, 38% used a contractor and 24% did not answer because they were feeding pasture.

Seventy-five respondents (32%) grew crop on the milking platform for the purpose of transitioning between feed types. The most common transition crops were fodder beet (68%) and kale (22%). Eight respondents grew more than one type of transition crop. Fourteen per cent of the respondents did not use irrigation; 88% of fodder beet and 78% of kale was irrigated.

There was a large range in area planted to crop on the milking platform for transitioning (and wintering), with one farm growing 240 ha of fodder beet, and some farms growing as little as 1 ha. The median area was 12 ha for fodder beet and 9.5 ha for kale, of the farms that grew these crops on the milking platform. The mean area of the milking platform in crop for wintering or transitioning was 2% (6% for those that grew crops). Land preparation was mainly undertaken by contractors (44%), 33% of the farms prepared land themselves and 21% were not asked because they grew the same crop for wintering and so had already answered the question.

Pasture silage was the most common type of supplement fed with the crop during transitioning (33%), followed by cereal straw (20%), hay (15%), cereal silage (14%), ryegrass straw (11%) and other (7%; e.g. mixed lucerne–pasture silage).

Wintering on support blocks

Support blocks that were managed by the farm business were used by 177 of the 238 respondents (74%). Of this, 37 (16%) had two support blocks and 16 (7%) had three support blocks. The use of support blocks was consistent across zones. The average support block was 173 ha, wintering 719 cows for 9.5 weeks.

The majority of support blocks were owned (58%), with 36% being leased and the remainder a mixture of owned and leased land or unsure of the ownership type (e.g. because the respondent was a farm manager). Sixty-five per cent of support blocks had a nutrient budget. The median area of the support block that was in winter crop was 35%. Most (89%) of the crop grown on the support block was fed on the support block. A catch crop was grown on 21% of support blocks, of which the most common was oats, followed by barley.

Wintering at graziers

Graziers were used by 66 of the 238 respondents (28%), with some using more than one grazier. Cows stayed at graziers for an average of 8.5 weeks. Kale was the most common feed type at graziers (50%), followed by fodder beet (28%). Thirty per cent of graziers used more than one crop type (overall average of 1.3). Pasture silage (32%) and hay (32%) were the most common supplement types at graziers. The majority of graziers (54%) invoiced per kilo of DM, 43% invoiced per cow per week, and the remainder 'other' (e.g. per day) or unsure because the respondent was not involved in business decisions (3%). Arable farmers were the most common type of graziers, followed by specialist graziers and sheep and beef farmers (Table 4).

Combined regional results

The combined results across Canterbury are presented in Tables 4–7. The majority (93%) of cow.weeks were wintered off the milking platform. Few (1%) were wintered in an off-paddock facility. Of the wintering conducted off the milking platform, the majority (68% of cow.weeks) were on a support

Table 4. Types and extent of wintering sites for the Canterbury region
Intensity is defined as the number of cows by the number of weeks they are at the location

Wintering site	Survey		Intensity in Canterbury (cow.weeks)
	Percentage of sites	Percentage by cows	
On milking platform	12	6	593 344
Off-paddock	1	1	79 687
Off-milking platform	88	93	9 199 607
Support block[A]	60	68	6 712 262
Owned[B]	35	42	4 186 434
Leased	21	21	2 118 861
Mixed/unsure	4	4	406 967
Grazier[A]	27	25	2 487 345
Arable[C]	12	13	1 296 708
Specialist grazier	7	7	670 129
Sheep and beef farmer	8	5	453 465
Unsure	1	1	67 043
Total	100	100	9 872 638

[A]Support block and grazier are a breakdown of the off-milking-platform category.
[B]Percentage of the different ownership types for support blocks.
[C]Percentage of the different farmer types for graziers.

block. Graziers conducted ~25% of the wintering (cow.weeks) in the region.

Overall, kale was the most frequently mentioned crop type, followed closely by fodder beet (Table 5). However, fodder beet was the most common crop type grown on the milking platform. Straw was the most common supplement type used, followed by pasture silage.

Over half the wintering in Canterbury was located in the Hinds, Ashburton and Selwyn–Waihora zones (Table 6). These three zones were also the three largest in terms of the number of herds that reside there. Due to its relatively small size in comparison with the other zones, Hinds had the highest zone intensity (cow.weeks/ha). The Ashburton and Selwyn–Waihora zones were the next most intense for wintering.

In terms of the movement of cows, the majority (76%) of the wintering within each zone originated from within the zone (Table 7). The Hinds zone had the greatest percentage of cow.weeks originating from another zone.

Table 5. Frequency of different crop and supplement types across the Canterbury region

Feed type	Platform[A]	Support	Grazier	Total
		Crop		
Kale	28	161	62	251
Fodder beet	79	106	35	220
Cereal	3	8	2	13
Swedes	1	9	2	12
Other	14	26	11	51
		Supplement		
Straw	30	132	6	168
Pasture silage	32	104	7	143
Hay	14	45	7	66
Cereal silage	13	40	2	55
Pasture	–	15	–	15
Other	7	–	–	7

[A]Includes wintering and transitioning.

Future plans

About half of the survey respondents (57%) plan to use the same system for wintering next season, while the remaining 42% were planning on changing, with 1% being unsure. Most of the changes mentioned involved feeding more fodder beet, and keeping more cows on the milking platform. The most frequently stated reason for these changes was the current, low milk price.

Discussion

The results of the survey indicated that, in Canterbury, the majority of cows are wintered off the milking platform, of which owned or leased support blocks were the most common wintering site. Over one-fifth of support blocks used a catch crop, i.e. a crop established as soon as possible after winter grazing to utilise nutrients deposited over the winter, reducing the risk of nutrient loss of these nutrients to the environment. Similarly, the use of arable farmers as graziers represents an opportunity to increase the use of catch crops and other management options that enhance nutrient-use efficiency such as a broader range of crops in the crop rotation and precision management (irrigation and fertiliser management). Consequently, the dairy industry has an opportunity to collaborate with other industries providing winter grazing to influence practice change and reduce its environmental footprint from wintering.

Kale was the most common crop on both support blocks and at graziers, making it the most common crop overall. Fodder beet was the most common crop planted on the milking platform. This may be due to the higher crop DM yield and, therefore, smaller area required. These two crop types were significantly more popular than any other crop type. There are opportunities to reduce the N concentration of kale through N-fertiliser management, without compromising yield (Dalley 2016).

Table 6. The intensity of on-paddock wintering in Canterbury: the distribution of the wintering sites and cows by zones of the surveyed farms; the distribution of Canterbury herds by zone; the intensity of wintering by zone calculated by scaling the survey results up by the response rate; and the productive area and intensity of each zone

Intensity is defined as the number of cows multiplied by the number of weeks they are in the zone during winter. Zone area, area of Class 1 to Class 6 land, defined by New Zealand Land Resource Inventory land-use capability (Table 1)

Zone	Survey		Canterbury		Zone area (km^2)	Zone intensity (cow.weeks/ha)
	Sites (%)	Cows (%)	Herds (%)	Intensity (cow.weeks)		
Kaikoura	1	0	2	9400	728	0.1
Hurunui–Waiau	15	8	8	809 604	4941	1.6
Waimakariri	11	9	9	925 466	1703	5.4
Alpine River	4	6	0	557 969	1783	3.1
Christchurch–West Melton–Banks Peninsula	1	0	0	27 561	1055	0.3
Selwyn–Waihora	24	16	20	1 547 237	2475	6.3
Ashburton	22	19	17	1 897 240	2059	9.2
Hinds	25	21	16	2 079 222	1184	17.6
Orari–Opihi–Pareora	9	8	14	800 912	3326	2.4
Waitaki	13	11	13	1 032 209	6171	1.7
Out of region	1	1	–	106 131	–	–
Total	100	100	100	9 792 951		

Table 7. Origin and destination of cows wintered on-paddock, by percentage of total cow.weeks in the zone (origin) and by the percentage of cow.weeks originating from within the zone (destination)

Intensity was defined as the number of cows multiplied by the number of weeks they were at the location

Zone	Origin of cow.weeks wintered on-paddock by zone			Destination of cow.weeks wintered on-paddock by zone			
	Originated within zone (%)	Originated from another zone (%)	Intensity (cow.weeks)	Remain on milking platform (%)	Travel but remain in zone (%)	Travel to another zone (%)	Intensity (cow.weeks)
Kaikoura	92	8	9400	100	0	0	8628
Hurunui–Waiau	95	5	809 604	9	77	14	895 637
Waimakariri	90	10	925 466	3	90	7	893 626
Alpine River	0	100	557 969	–	–	–	–
Christchurch–West Melton–Banks Peninsula	100	0	27 561	19	21	60	68 166
Selwyn–Waihora	74	26	1 547 237	11	71	18	1 393 288
Ashburton	81	19	1 897 240	7	67	26	2 088 409
Hinds	73	27	2 079 222	6	58	36	2 370 705
Orari–Opihi–Pareora	74	26	800 912	1	69	30	854 992
Waitaki	93	7	1 032 209	1	77	22	1 219 500
Out of Region	0	100	106 131	–	–	–	–
All	76	24	9 792 951	6	70	24	9 792 951

Reducing the N concentration reduces N intake by grazing animals and, therefore, reduces N concentration in the urine at a time when there is risk of N leaching. Fodder beet, which research indicates may leach less N than does kale (Malcolm *et al*. 2016*b*), is already in widespread use, decreasing the potential to further reduce N losses through the adoption of this crop if this research is validated at the farm-system level.

Straw and pasture silage were the most common supplement types used. The supplement-type question was not answered well for graziers (124 responses were given for crops used by graziers, only 22 for supplement), possibly due to the farmer being uncertain about the supplement being used by the grazier. The common use of straw on dairy-owned or -leased support blocks indicated existing integration and relationships between the dairy and arable industries, which could make it easier to work together more in the future to jointly achieve nutrient-management goals.

There was significant variation in the amount of wintering in each zone. This result holds true after accounting for the size of the different zones. Zones that had the most wintering, the Hinds, Ashburton and Selwyn–Waihora zones, also have the highest percentage of lactating herds (milking platforms) in Canterbury. Currently, in the Hinds zone, farmers with nitrate leaching above 20 kg N/ha.year will be required to reduce N loss from baseline (determined over the four seasons from 2009–2010 to 2012–2013) by 36% in a stepped timeframe through to 2035 (Environment Canterbury 2016*a*). Similarly, in Selwyn–Waihora, dairy farmers with N losses above 15 kg N/ha.year will be required to reduce N loss from baseline by 30% and on dairy support by 22% by 2022 (Environment Canterbury 2015). At present, a large proportion of the wintering in these zones originates from another zone (Selwyn–Waihora 26%, Hinds 27%; Table 7). However, a large proportion of the cows in these zones are also wintered outside of zone (Selwyn–Waihora 18%, Hinds 36%). Consequently, regulation minimising the paddock-based wintering of cows not originating from Selwyn–Waihora and Hinds in these zones would be likely to have little impact unless there is capacity to increase wintering elsewhere in the region.

When asked about future plans, it appears there may be an increasing number of dairy farmers taking wintering back onto the milking platform. This may result in an increased N leaching estimate for the milking platform, putting them above their baseline number and, in particular, making it difficult to reach leaching reductions in zones where restrictions are proposed. However, taking land out of the milking platform for winter crop may also force a reduction in dairy-cow numbers. This may have a positive impact on nutrient loss, depending on what stock class the cows are replaced with on the support blocks or at graziers.

Conclusions

This survey has provided the first set of quantitative data on wintering practices in the Canterbury region. A high proportion of cows were wintered on-paddock, off the milking platform, with dairy farmer-owned or -leased support blocks being the most common location. Arable farmers were the most common type of grazier and straw was the most common supplement type, indicating existing collaboration between the arable and dairy industries that could prove beneficial for improving nutrient management. The high use of kale and existing research into kale management to reduce surplus N uptake by kale and surplus N intake by grazing animals represents an opportunity to reduce nutrient loss to the environment. The already widespread use of fodder beet decreases the potential for the adoption of this crop to reduce nitrate leaching, should current research be validated. The present survey has provided base data that can be used to assess practice change if repeated in the future.

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References

DairyNZ (2015) 'New Zealand dairy statistics 2014–15.' (DairyNZ: Hamilton, New Zealand) Available at http://www.dairynz.co.nz/media/3136117/new-zealand-dairy-statistics-2014-15.pdf [Verified 13 April 2016]

DairyNZ (2016) 'Key research projects.' (DairyNZ: Hamilton, New Zealand) Available at http://www.dairynz.co.nz/about-us/research/key-projects/ [Verified 8 July 2016]

Dalley DE (2010) 'Achieving wintering targets: critical success factors for different wintering systems in Southland and Otago.' Proceedings of the South Island Dairy Event. Available at http://side.org.nz/wp-content/uploads/2014/05/5.3-ACHIEVING-WINTERING-TARGETS-%E2%80%93-CRITICAL.pdf [Verified 8 July 2016]

Dalley DE (2016) 'The foibles of fodder beet and other forage crops: animal and environmental considerations for successfully feeding forage crops.' Proceedings of the South Island Dairy Event. (Eds GR Edwards, RH Bryant) (Lincoln University: Christchurch) Available at http://side.org.nz/wp-content/uploads/2016/06/1.1-The-Foibles-of-Fodder-Beet-and-Other-Forage-Crops.pdf [Verified 8 July 2016]

De Klein CAM, Monaghan RM, Ledgard SF, Shepherd M (2010) Systems perspective on the effectiveness of measures to mitigate environmental impacts of N losses from pastoral dairy farming. In 'Proceedings of the 4th Australasian dairy science symposium', pp. 14–28.

Edwards GR, De Ruiter JM, Dalley DE, Pinxterhuis JB, Cameron KC, Bryant RH, Di HJ, Malcolm BJ, Chapman DF (2014) Urinary nitrogen concentration of cows grazing fodder beet, kale and kale-oat forage systems in winter. In 'Proceedings of the 5th Australasian dairy science symposium', (Ed. J Jacobs) pp. 144–147. (Department of Primary Industries, State Government Victoria: Melbourne)

Environment Canterbury (2015) 'Appendix B proposed variation 1. Inclusive of recommended amendments.' (Environment Canterbury: Christchurch, New Zealand) Available at http://ecan.govt.nz/publications/Plans/v1-report-hearing-commissioners-appendix-b.pdf [Verified 6 April 2016]

Environment Canterbury (2016*a*) 'Appendix B proposed plan change 2. Inclusive of recommended Aamendments.' (Environment Canterbury: Christchurch, New Zealand) Available at http://ecan.govt.nz/publications/general/Recommendations%20on%20Proposed%20Plan%20Change%202%20(plan%20provisions%20and%20map%20volume).pdf [Verified 6 April 2016]

Environment Canterbury (2016*b*) 'Canterbury regional policy statement.' Available at http://ecan.govt.nz/get-involved/canterburywater/about-strategy/key-documents/Pages/cwms.aspx [Verified 8 July 2016]

Landcare Research (2016) 'NZLRI land use capability.' Available at https://lris.scinfo.org.nz/layer/76-nzlri-land-use-capability/ [Verified 8 July 2016]

Malcolm B, Teixeira E, Johnstone P, Chakwizira E, Maley S, Dellow S (2016*a*) 'Validating crop sequences for improving N use efficiency following winter grazing of forages.' Milestone no. 67668. Contract no. 32051. Job code: P/442056/07. SPTS No. 13168. (Plant & Food Research: Lincoln, New Zealand)

Malcolm BJ, Cameron KC, Edwards GR, Di HJ, de Ruiter JM, Dalley DE (2016*b*) Nitrate leaching losses from lysimeters simulating winter grazing of fodder beet by dairy cows. *New Zealand Journal of Agricultural Research* **59**, 194–203. doi:10.1080/00288233.2016.1150307

Ministry for the Environment (2014) 'National policy statement for freshwater management.' (Ministry for the Environment) Available at http://www.mfe.govt.nz/fresh-water/freshwater-management-nps [Verified 8 July 2016]

Newman M, Journeaux P (2015) The economic and nutrient loss impacts of constructing and running cow housing facilities: a case study of five South Island freestall barns. In 'Proceedings of the Australian Agricultural Resource Economics Society conference'. Available at http://purl.umn.edu/202561 [Verified 8 July 2016]