Fodder beet – friend or foe?

The rise of fodder beet popularity has seen the crop's sown area in New Zealand increase from about 100 ha in 2006 to 15,000 ha in 2014[1], and 75,000 ha in 2016 (PGGW, pers. comm.).

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More than 80% of cows in Southland and Canterbury consumed fodder beet at some period during the 2015-16 season (unpublished data), and it is grown in all major dairy regions in New Zealand. Although fodder beet has been fed to overseas dairy cows for decades[2,3,4,5], it normally comprises just a small proportion of the diet.

Initial fodder beet use in New Zealand was for over-wintering non-lactating cows, especially in the South Island, with relatively recent widespread feeding of fodder beet to lactating cows[6]. Fodder beet for non-lactating cows is traditionally grazed in situ, supplemented most commonly with either barley straw[1], pasture silage[7] or hay. In situ grazing of fodder beet by lactating cows is more likely to occur during autumn, with lifted fodder beet bulbs more common during spring feeding periods and to non-lactating cows in off-paddock facilities during winter.

The Forages for Reduced Nitrate Leaching Programme (FRNL) identified fodder beet as a high nutritive value, low N forage crop with potential to mitigate the impact of excessive dietary N typical of New Zealand ryegrass pasture (3-5 g/100g DM).

Key findings

- Fodder beet is low in nitrogen (N), so can reduce urinary N excretion and therefore risk of N leaching loss from urine patches.
- The recommended maximum percentage of DM intake from fodder beet is 40% (lactating) and 70% (non-lactating), due to risk of acidosis.
- Even at these rates, some cows may still experience adverse health because of individual variations in diet selection and susceptibility to acidosis.
- High levels of fodder beet in the diet also increases risk of N and amino acid deficiencies, and can impact milk composition.
- Maximising production and environmental benefits of fodder beet, while minimising any negative impacts, requires careful management.

This is particularly so in late lactation and winter when the risks of nitrate leaching[8] and nitrous oxide emissions[9] in subsequent months is high.

As the proportion of fodder beet in the diet, and total diet composition, differs from overseas experiences, it is important to investigate fodder beet's role in animal performance, N excretion and animal health to inform best practice management for pasture-based systems.

The following information is the FRNL programme's results to date.

Nitrogen balance and rumen function

Two metabolism stall experiments measured the N balance, with lactating and non-lactating cows offered increasing proportions of the diet as fodder beet, with the remainder comprising either pasture (lactating) or barley straw and pasture silage (non-lactating).

The lactating cow experiment explored the impact of substituting 0, 20, 40 and 60% of ryegrass with fodder beet for cows fed ad libitum in late lactation. It became apparent that a diet of 60% fodder beet was detrimental to cow health, as 50% of cows developed acidosis despite implementing recommended transition management.

Based on this early finding, the fodder beet allocation was reduced to, on average, 23 and 45% of DM intake during the trial. Substitution of ryegrass with fodder beet did not affect feed DM intakes (Table 1) or milk yield (10.7kg/cow/d), microbial synthesis (129 g of N/d) or fractional outflow rates of digesta (0.16/h; 11.2 L/h).

Feeding 23 or 45% fodder beet in late lactation reduced nitrogen intake by 12 and 31%, respectively, with associated reductions in urinary N excretion of 25 and 45% respectively. However, acidosis risk increased when fodder beet was above 40% of the diet DM.

The interest in reducing N intake to reduce N excretion to the environment must also consider the overall N economy of the ruminant. Non-lactating cows offered 85% fodder beet and 15% barley straw excreted more N (22 g/cow/day) than they consumed, indicating that at 7.1% crude protein (CP), the diet was N deficient.

This N deficiency was mitigated by offering 70% fodder beet and 30% pasture silage (0.3 g N/cow/day gain; 10.9% diet CP). Rumen microbial growth was especially low in cows fed the straw compared with the silage diet (Table 1) and ammonia was undetectable in the rumen of cows fed the straw diet over much of the day. In addition, the proportions of the amino acids arginine, citrulline and ornithine decreased, while the proportion of glycine increased, when 23 or 45% fodder beet was included in the diet[10].

While researchers could not identify the underlying causes of the amino acid concentration changes, the results show that feeding fodder beet changes the cow's N economy, with potential impacts on cow health and production. The causes of the changes and the long-term consequences require further investigation if significant proportions of fodder beet are going to be sustainable as an alternative feed to help mitigate N loss to the environment.

Contrary to expectations, there was a greater proportion of large particulate DM (unable to pass a sieve with a 2 mm aperture) in cows fed fodder beet, than pasture alone. Saliva added during chewing helps buffer the rumen environment and maintain a stable rumen pH. The particle size results suggest changes in chewing behaviour with fodder beet diets which may be an important factor contributing to acidosis in some cows and not others. More research is required to investigate the intake rate and rumination patterns of cows consuming fodder beet.

In both the lactating and non-lactating cow experiments there were clear variations between individuals in their tolerance of

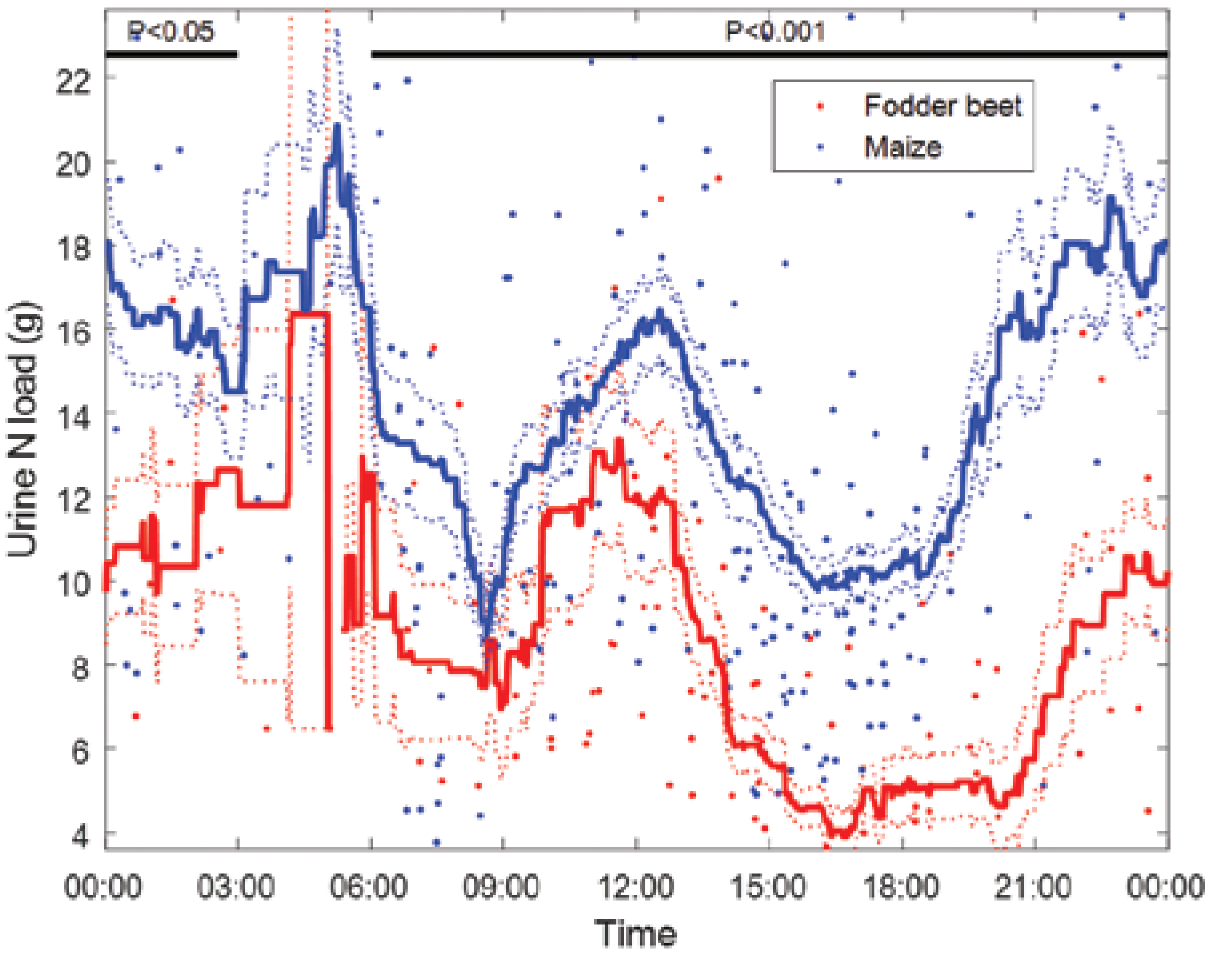
Table 1: Intake and nitrogen dynamics in lactating cows fed pasture, pasture with 23% fodder beet (23%FB) and pasture with 45% fodder beet (45%FB); and non-lactating cows fed fodder beet with 15% cereal straw (FB+Straw) or fodder beet with 30% pasture silage (FB+Silage) diets over a six-day period.

Chemical	Lactating				Non-lactating		
	Control	23%FB	45%FB	Significance	85%FB+Straw	70%FB+Silage	Significance
DMI	15.2	15.3	14.0	NS	6.4	8.3	NS
Water intake (l/cow/day)	29.4	16.8	12.3	***	4.0	17.0	***
N intake (g/cow/day)	460	407	317	***	74	144	***
Faecal N (g/cow/day)	148	139	131	NS	44	56	**
Milk N (g/cow/day)	57	64	67	NS	-	-	-
Urine N (g/cow/day)	205	155	112	***	52	87	**
Microbial N/kg DOMI (g)	15.5	13.7	12.2	**	6.6	15.8	***
Blood urea N at 7 am (mmol/l)	7.3	5.7	4.4	***	1.7	2.8	***

Table 2: Intake, milk production and composition and blood, urine, milk and faecal nitrogen concentrations of lactating cows grazing pasture and supplemented with either maize silage (control), 25% fodder beet (FB25) or 40% fodder beet (FB40) in autumn.

	Maize	FB25	FB40	Significance
Pasture intake (kg DM/day)	12.7	12.8	10.6	P<0.05
Maize silage intake (kg DM/day)	4	-	-	P<0.05
Fodder beet intake (kg DM/day)	-	4	5.7	P<0.05
Estimated ME intake MJ/day)	195	206	196	-
Estimated N intake (g/d)	520	530	460	-
Milk yield (L)	11.5	11.2	10.7	NS
Milk solids yield (kg)	1.02	1.10	0.98	P<0.001
Milk fat (%)	5.44	5.37	5.10	P<0.05
Milk protein (%)	3.99	4.31	4.34	P<0.05
Urinary N (%)	0.33	0.32	0.26	P<0.05
Faecal N (%)	2.4	2.6	2.5	P<0.1
Milk urea N (mmol/l)	4.8	5.2	3.9	P<0.1
Blood urea N (mmol/l)	5.2	5.2	3.9	P<0.001

Figure 1: The dynamic temporal changes in urine N load per urination event for non-lactating dairy cows offered pasture plus maize silage (Blue) or fodder beet plus pasture silage (Red). Solid lines denote a three-hour smoothing average and dotted lines denote SEM (standard error of the mean).



high proportions of fodder beet. Based on current research, 40% (lactating) and 70% (non-lactating) are the recommended upper limits of fodder beet in the diet to mitigate the risk of acidosis. However, even at these levels, variations between individuals in diet selection and susceptibility to acidosis are likely to have an adverse effect on some cows' health.

Milk production and composition, and nitrogen excretion

International research found cows fed pasture silage and concentrates did not produce more milk when supplemented with up to 4 kg DM/cow/day of fodder beet. However, increases in the milk fat and milk protein content resulted in significant increases in milk solids production[3,4].

FRNL researchers offered 25% (4 kg DM; FB25) or 40% (6 kg DM; FB40) fodder beet to cows in late lactation, grazing perennial ryegrass-based pastures, and compared this to cows offered pasture plus 4 kg DM maize silage/day (Maize).

Refusals were observed when cows were offered 6 kg DM fodder beet, such that the average intake was 5.7 kg DM/day (Table 2). Milk yield did not differ between the treatments, though the FB25 cows produced significantly more milk solids.

Although FB40 significantly increased milk protein content, milksolids was not affected as milk fat content was reduced. These cows also had an increased proportion of short chain fatty acids in their milk. Although clinical acidosis was not observed after the 18-day adaptation period, behavioural observations of FB40 cows suggested this allocation was at the upper limit of fodder beet intake and that some cows may have been experiencing subclinical acidosis.

Urinary, milk and blood N concentrations did not differ between the Maize and FB25 diets but were reduced in the FB40 cows. The reduction in urinary N concentration with the FB40 was associated with a lower N intake compared with the Maize and FB25 treatments.

Diurnal variation in urinary N excretion

To investigate the impact of fodder beet feeding on urinary N excretion, a 28-day early winter grazing study was conducted with non-lactating cows offered either pasture (8kg DM) plus maize silage (4kg DM) (Control) or fodder beet (8kg DM) plus pasture silage (4 kg DM) (FB).

The amount of urine-N excreted per urination was significantly lower from cows consuming the fodder beet diet, compared to the control (8.3 vs. 13.3 g N per event). This was largely due to differences in feed N intake (203 vs 339 gN/day), which led to a lower daily urine-N excretion by the fodder beet cows relative to Control (90 vs. 173 g N/cow/day, respectively). Diurnal trends in urinary N concentration and load differed between treatments (Figure 1) and cows consuming fodder beet had more, smaller urination events per day compared with the Control.

Conclusions

With a long shelf life, either in the ground or harvested, high yield potential, high digestibility and low nitrogen (N) content in the bulb, fodder beet offers many advantages. However, although fodder beet can reduce nitrogen intake and subsequently urinary N excretion, diets too low in nitrogen can have negative effects on animal performance.

The high sugar content requires careful transitioning onto fodder beet for good animal health outcomes. Changes in rumen fermentation influence milk composition, requiring caution with the amount offered to lactating dairy cows. Maximising the production and environmental benefits that fodder beet offers, while minimising any negative impacts on animal health, remains a research priority for the dairy industry.

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