

# THE FOIBLES OF FODDER BEET AND OTHER FORAGE CROPS – ANIMAL AND ENVIRONMENTAL CONSIDERATIONS FOR SUCCESSFULLY FEEDING FORAGE CROPS

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## Summary

All forage crops require controlled transitioning for successful feeding management and to minimise the nutritional risks.

### *Fodder beet*

- Yield estimates in the area of the paddock to be offered during transition increase the accuracy of feed allocation and help minimise the risk of acidosis.
- Offer fodder beet after pasture or supplement and so that all animals in the mob can access the crop at the same time.
- Even when cows are introduced to fodder beet by increasing the allocation 1 kg DM/cow every second day, some animals will experience liver dysfunction.
- Adaptation requires at least 14 days, and up to 28-30 days if targeting ad libitum intake.
- Do not feed more than 5 kg DM fodder beet/cow/day to lactating cows (25-30% of the diet depending on total dry matter intake).
- The low nitrogen (crude protein) content of fodder beet has environmental benefits – lower urinary N excretion – but if fed as a high proportion (>70%) of the diet, may result in cows not consuming recommended nitrogen intakes.
- Estimated N leaching losses from fodder beet crops in Canterbury are lower than kale.

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## **Swedes**

- All cultivars of swedes can cause liver damage. The severity is influenced by multiple factors including temperature, cultivar, reproductive development, amount of leaf, feeding management.
- Do not feed HT® swedes on the milking platform in late August/early September when many of the factors that lead to ill-health can rapidly combine, causing brassica toxicity.
- Do not feed swede crops in their reproductive growth phase, i.e. when the stem elongates, new growth appears and the swede plant develops flowers and a seed head.
- Be cautious when grazing animals on swede crops in autumn, before the first frosts.
- Be cautious at any time during the season when grazing a swede crop with a high leaf to bulb ratio as cows may preferentially graze leaf.
- Observe the physical characteristics of the crop being fed, monitor the health of cows and limit the allocation if ill-health is observed.

## **Kale**

- Frosting increases the risk of bloat on kale.
- Use crop calculators to manage the amount and timing of nitrogen fertiliser inputs to achieve realistic yields and minimise the crude protein content of the crop.
- Low urinary N concentrations can be achieved with good N fertiliser management.
- Following kale crops with a winter sown catch crop e.g. oats, can reduce nitrate leaching by up to 40% in free draining Canterbury soils.

## **Introduction**

Dairy farming in Southland and Otago has grown in the past 25 years to 837,113 cows on 1,402 farms producing 17% of New Zealand's milksolids in 2014-15 (2014-15 NZ Dairy Statistics). The use of forage crops continues to be an important aspect of farming in southern regions, especially during the cool winter months when pasture growth is negligible. However, increasingly, farmers are looking to crops, especially fodder beet, to fill feed gaps during lactation. At the same time the use of fodder crops is coming under increasing scrutiny from regulators looking to meet their obligations under the National Policy Statement for Fresh Water Management (2011). Research has demonstrated that grazing forage crops has inherent risks, with regards nitrate leaching (Shepherd et al. 2012; Smith & Monaghan 2012) and sediment, phosphorus and e-coli losses through runoff, if not well managed. Therefore, the agricultural industries need to develop strategies to minimise the environmental impacts while capitalising on the productivity and profitability gains these feeds provide.

This paper outlines recent research investigating the integration of fodder crops into dairy systems and discusses animal health and environmental challenges that need to be considered.

## **Fodder beet**

Fodder beet is a high yielding root crop that has been adopted by farmers in the past 10 years. Initially, it was used as a winter alternative to swedes and kale; but, more recently as a feed for lactating cows and young stock and to overcome weed and disease issues with brassica's.

### ***Transitioning***

Requirements for transitioning cows onto fodder beet during lactation, and for wintering, have been well documented in recent years (Gibbs and Saldias 2014; Gibbs et al. 2015). The key consideration when transitioning cows onto fodder beet is adaptation of the rumen microbes to the sugar rich content of the bulb **and** the targeted level of intake to prevent acidosis and other non-acidosis related disease (e.g., liver dysfunction, chronic inflammation, deferred ketosis). This differs from brassica species, where the main objective of transitioning is to adjust the rumen microbes to changes in feed quality and anti-nutritional compounds. If cows are offered too much fodder beet too quickly, it will result in rumen acidosis and, if severe enough, death. Strict allocation of fodder beet on a DM basis over a period of at least 14 days is essential. Allocation should start at 1-2 kg fodder beet DM and increase by no more than 1 kg DM every second day for 14-21 days – i.e., up to a maximum of 9-10 kg DM/cow. Supplement/pasture inputs need to provide the additional energy to meet cow requirements, so start at 8 kg DM on day 1 and drop to 4 kg DM by day 14; then 2-4 kg at day 21 and thereafter. If ad libitum intake is the target, from day 21 the break line is then increased a little each day until the cows leave fodder beet behind (Gibbs et al. 2015).

**Even if cows have been consuming fodder beet during lactation they still require additional transitioning up to their winter allocation, using the 1 kg DM every second day approach** (e.g., if feeding 4 kg DM during lactation and through the drying off period then on day 1 of winter transitioning offer 5 kg DM, day 3 offer 6 kg DM, day 5 offer 7 kg DM etc).

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The highly digestible nature of fodder beet means it should be treated more carefully than grain during any dietary change (i.e., increased slowly to higher level of intake). Pasture and/or silage/baleage should be used as the supplement part of the ration in the early days of transitioning when the supplement forms a larger part of the diet. Hay and straw can be included in the transitioning diet if being offered throughout the feeding period.

For rising 1 year old calves, start them on 0.5 kg DM/day and then increase by 0.5kg DM every second or third day for 14 days. A low DM variety should be offered to younger animals because the roots are softer. Calves should be offered good quality pasture silage/baleage as their supplement to increase nitrogen intake.

Transitioning cows onto fodder beet during lactation comes with more challenges than transitioning non-lactating cows where the total daily DM intake is lower and the primary objective is to get all cows eating fodder beet consistently before increasing the allocation. **During lactation, it is recommended that 14 days is allowed to get cows up to an allocation of 5 kg DM/day** (Gibbs et al. 2015). During lactation, it is also important to offer sufficient total feed to support lactation, which prevents the use of a feed restriction to get reluctant eaters onto the fodder beet. Fodder beet is also a smaller proportion of the diet so individual animals have more opportunity to meet their daily nutrient requirements from the other feeds being offered and, therefore, avoid the fodder beet. Individual cows not eating fodder beet create a higher allocation for those who are eating, placing the good eaters at risk of acidosis early in the transitioning period and the slow adapters at greater risk of acidosis as the amount offered increases. Observing the herd regularly during the transition period (not just in the first 5-10 minutes of crop allocation) is important to ensure all cows are eating the crop at low allocations. Non-eaters may initially take an interest in the crop and even graze the leaves when the break is opened up or beets are fed on the grass paddock, but will soon move off onto pasture or supplement, leaving a higher allocation for the remaining animals. If you have only observed the cows for the first 5-10 minutes you will not notice this behaviour and will therefore continue to increase the allocation to those eating beets, now at a rate higher than the recommended 1 kg DM increase every second day. Where possible it would be an advantage to transition naïve cows separately from those that have eaten fodder beet previously.

The key to good results during transition is to ensure all cows have equal access to the crop, whether it is grazed or spread in the pasture paddock from the silage wagon and that they have sufficient time to try it. This means at least 1 m of face width on the crop. Allocations lower than this will result in younger and timid animals being bullied off the crop.

Monitoring of cows transitioning from kale to swedes in Southland and onto kale and fodder beet in Canterbury has highlighted that, even in well-managed herds, some animals will experience metabolic challenges during the transitioning process. In Southland, changes were recorded for most of the metabolites that indicate liver and kidney function (Table 1), in

response to the transition from kale to swedes, indicating potential liver stress or damage. On days 4 and 7, 6 and 8%, of the monitor cows had higher than normal concentrations of AST. Additionally, increased concentrations were recorded for GGT and GLDH for day 7 and 14. NEFA concentrations peaked on day 4 which may indicate a decrease in feed intake during the initial transitioning process. Although, the concentration of some metabolites were above the normal range between days 4 and 14, they had decreased to within normal range by day 28, indicating that these animals had become acclimatized to the change in diet.

**Table 1.** Blood metabolites and the disease or disorder they are used to diagnose

<b>Metabolite</b>	<b>Name</b>	<b>Indicates</b>
AST	Aspartate Aminotransferase	Damaged tissue especially liver, kidney, pancreas, heart and muscle tissue
GGT	Gamma glutamyl transferase	Diseases of the bile duct and some liver disease
GLDH	Glutamate dehydrogenase	Liver damage
BHBA	Beta-hydroxybutyrate	Sub clinical ketosis
NEFA	Non-esterified fatty acids	Negative energy balance
TP	Total Protein	Liver disease or acute infection
Albumin	Albumin	Kidney or liver disease

Similar increases in blood metabolites were observed in cows transitioning onto kale or fodder beet in Canterbury; however, in these cows many of the metabolites did not decline with time on the crop. There were differences between the crops in the timing and extent of change in individual metabolites. For cows transitioning onto kale, reduced concentrations of blood albumin and total protein and greatly increased concentrations of AST and GGT were evident on day three and BHBA from day seven and all remained elevated throughout the feeding period. When fodder beet was introduced Albumin and total protein declined and blood AST, GGT and total protein did increase, but the changes were not evident until day 14. BHBA

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increased steadily from day 7 to 28 and remained elevated throughout the feeding period. GLDH peaked on day 7 and had returned to pre-feeding levels by day 28.

It is not known at this stage whether the differences in blood metabolites between crops is due to specific factors within the crops or differences in the transitioning regimes between the two feeds (i.e., fodder beet allocation was increased at a slower rate during transitioning than kale). At this stage we do not know the longer term consequences on production and reproduction of these metabolic challenges during crop feeding.

### ***Why all the fuss about acidosis?***

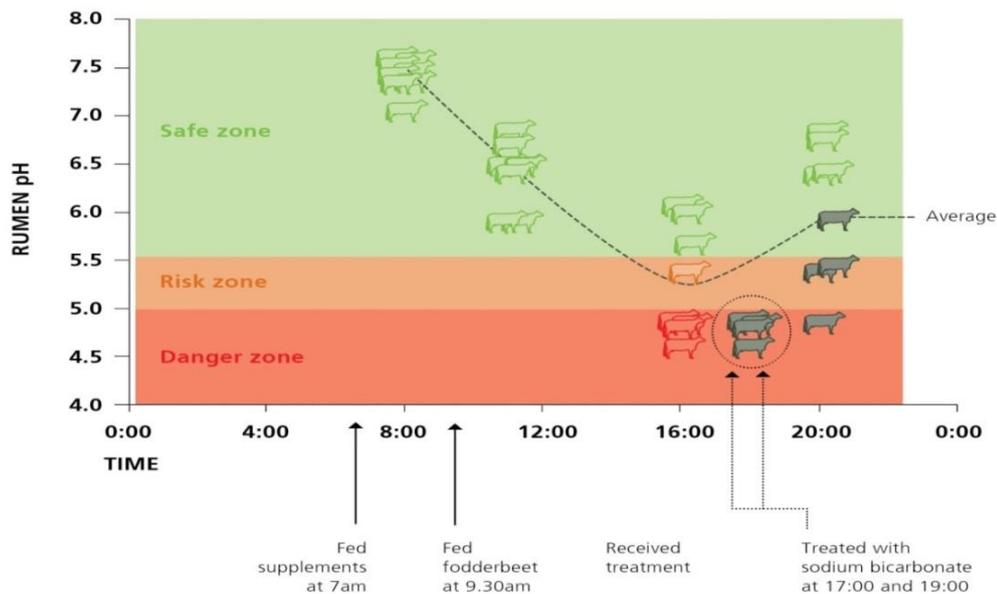
Ruminal acidosis reflects a decrease in rumen pH and develops in animals that have ingested too much of feeds rich in fermentable carbohydrates or sugars that they are not accustomed to (Owens et al. 1998). When large amounts of starch or sugar are added to the diet, the rumen bacteria that produce lactic acid grow faster than other bacterial species in the rumen (Russell and Hino 1985). Lactic acid is an acid 10 times stronger than volatile fatty acids (the acids formed during normal rumen fermentation). Increased lactic acid swamps the buffering ability of saliva and the rumen pH declines further. This low pH stops volatile fatty acid production as the bacteria that digest fibre don't work well at low pH. Rumen contractions reduce and the cows ruminate (chew their cud) less. Acidosis is also known to damage the rumen papillae (small finger like projections in the rumen through which nutrients are absorbed) further reducing the ability of the animal to absorb nutrients.

Cows with mild clinical acidosis will exhibit scouring, will be off their feed and hanging back from the rest of the herd. In more severe cases the disease may progress to include metabolic acidosis, depression, dehydration, bloating and milk fever like symptoms. Severe acidosis may result in cows going down, coma and death within 8-10 hours.

In lactating animals, sub-clinical acidosis is usually of greater economic importance than the clinical disease and can often affect a significant proportion of the herd. The implications of sub-clinical acidosis on non-lactating cow performance are less well researched but one area it will impact will be body condition score gain. Cows with clinical acidosis will go off their feed and with sub-clinical acidosis digestion of nutrients will be reduced so fewer nutrients will be available for body condition score gain. Detecting sub-clinical acidosis in non-lactating cows is challenging as the best diagnostics appear to be VFA, lactic acid and ammonia concentrations, and rumen pH, none of which are easy to measure.

There has been little research on the cause and nature of acidosis induced by fodder beet feeding, but research at DairyNZ in 2015 showed significant differences in the diurnal pattern of rumen pH in cattle offered fodder beet either during lactation or the dry period (Figure 1). In eight non-lactating cows, where rumen pH was being monitored, the pH of three remained in

the safe zone, one fell into the risk zone and four dropped into the danger zone. Sodium bicarbonate supplementation was provided to increase buffering in the rumen of those animals where rumen pH fell into the danger zone. Magnesium oxide (MgO; e.g. causmag) can also be used to treat cows with acidosis. While it is not a buffer, the alkaline pH of MgO in solution assists in increasing the rumen pH. It is likely that a failure to produce enough buffering through salivation, production of lactic acid in the rumen and production of large amounts of weak volatile fatty acids all contribute to the decline in rumen pH when fodder beet is consumed.



**Figure 1.** Diurnal variation in rumen pH in eight non lactating dairy cows offered a diet of 80% fodder beet and 20% cereal straw.

### ***Feeding fodder beet to lactating cows***

Recent research conducted at DairyNZ indicates that in late lactation, offering above 30% of the diet (5.4 kg DM/cow/day) as fodder beet resulted in an increased incidence of acidosis in lactating cows fully transitioned to fodder beet. In the same study a significant reduction in two amino acids (arginine and citrulline) was observed (Pacheco et al. 2016, in press) when fodder

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beet was included at higher levels. The long-term impact of these changes requires further examination to ensure it is not having a negative effect on other metabolic processes. Until this work is completed farmers should err on the side of caution with regards fodder beet allocation to lactating cows. The impact of fodder beet allocation on calcium, phosphorus, protein and fibre intake, relative to requirements from the DairyNZ research is provided in Table 2.

**Table 2.** Dry matter, crude protein, fibre and mineral intake of lactating dairy cattle offered increasing proportions of fodder beet in late lactation.

% Fodder beet	DMI		Fodder beet DMI	CP	NDF	Ca		Mg		P	
	kg/cow	Pasture DMI kg/cow				% DM	% DM	g/cow/day	% DM	g/cow/day	% DM
0	18	18	0	19.1	45	142	0.79	45	0.25	61	0.34
20	18	14.4	3.6	17.0	39	137	0.76	52	0.29	54	0.30
30	18	12.6	5.4	15.9	36	134	0.75	55	0.31	51	0.28
40	18	10.8	7.2	14.9	33	131	0.73	59	0.33	47	0.26
Lactating cow requirements				16-18	>30		0.6-0.8		0.28		0.3-0.35

### ***Non-negotiables when feeding fodder beet***

1. Know the area of the paddock and the length of the feeding face.
2. Accurately measure the yield and work out the square metres required, especially in the area where cows will be transitioned.
3. Have dry matter tests done – DM% varies from paddock to paddock, farm to farm, year to year and between varieties.
4. Do not put hungry cows onto the crop.
5. Offer supplement at least 3 hours before the fodder beet is offered.
6. Do not use a time based approach on the crop when transitioning – cows can consume 3-4 kg DM/hour (i.e. 1 kg /15-20 minutes) when the break is first opened up.
7. Don't forget to readjust the breaks if cows are removed.
8. Transition onto the crop over at least 14-21 days, increasing the allowance by no more than 1 kg DM every second day for cows and 0.5 kg DM every 2-3 days for rising 1 year olds.
9. Pay attention to detail when setting up break fences.
10. Have good power on the fences and always have a catch fence close to the break fence to minimise the impact of breakouts.

### ***Practical factors to consider making transitioning easier***

1. Develop a grazing plan for the paddock before you start cultivation (see Crop Paddock Selection Tool and Wintering in Southland and South Otago – a land management guide to good environmental practice <http://www.dairynz.co.nz/environment/land-and-nutrient/land-management-guides/>).
2. Have a grass paddock adjacent to the fodder beet paddock and run cows on and off the crop during the early stages of the transition period.
3. Leave a headland of 6 m and plant in Italian ryegrass or a multi graze cereal crop, e.g. oats for supplement making during the season and to provide feed and space during transitioning.
4. Harvest the fodder beet to make a headland before starting to graze and use the harvested fodder beet fed with supplement through the silage wagon on a pasture paddock for the first few days of the transition process.
5. Do not mix experienced and naïve animals together during transitioning. Naïve cows take time to familiarise themselves with the crop.

### ***Brassica feeding practices that DO NOT work with fodder beet, especially during transitioning***

1. Offering a higher allocation and using a time based approach to transition cows is not recommended; cows can consume 3-4 kg fodder beet per hour if the feed is available.
2. Leaving animals who have not adapted on the crop and continuing to increase the allowance; the crop they don't eat will be available for other cows to eat, increasing their allocation at a rate faster than recommended.
3. Leaving residual crop in the previous days' breaks for cows to eat later; good eaters will increase their intake too quickly.
4. Moving the fence an extra metre or so on a cold, wet day to fill the cows up: some cows will increase their allocation too quickly.

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## **Brassica's – kale and swedes**

Kale and swedes are still major contributors to the winter feed supply in the South Island. In a survey of wintering practices in Southland in 2015, farmers reported that for winter 2014, kale and swedes were the most commonly used crops, with fodder beet third. For crops planted on the milking platform, swedes were the most popular choice. Since winter 2014, there has been a trend towards increasing area being planted in fodder beet. However kale and swedes remain important crops in sustainable cropping rotations for the region. A similar survey conducted in Canterbury in 2016 reported kale and then fodder beet as the most commonly mentioned crops grown on support blocks. Fodder beet was the most common crop grown on the milking platform in Canterbury. Issues associated with feeding brassica's are well summarised by Nicol et al. (2003). Recent Pastoral 21 research in Canterbury has reported similar BCS gains in herds of cows offered either fodder beet or kale at 2 stages of maturity, providing similar energy allocations are offered (Edwards et al. 2014).

### ***Learnings following the swede toxicity outbreak in winter 2014***

Brassicacins contain glucosinolates (GSL) and S-methyl-L-cysteine sulphoxide (a compound in brassicas that can cause haemolysis of red blood cells resulting in 'red water'). GSL concentrations increase as the plant reaches maturity, so flower-heads and seed tend to have the highest concentrations within the plant (Velasco et al. 2008).

Many GSL are pre-toxins and break down to actively toxic products when plant tissue is damaged. There are five major breakdown product groups: thiocyanates, isothiocyanates, oxazolindione-2-thiones, nitriles and epinitriles. These products, often with bitter and unpalatable tastes, have evolved as protective mechanisms against disease, insect and herbivore attack (Bekeart et al. 2012) and when ingested by cows may result in a spectrum of brassica-associated diseases with a wide range of possible clinical signs (Nichol et al. 2003). Derivatives of GSL are modified into toxins that can interfere with thyroid function or damage the liver and kidneys (Bones & Rossiter, 2006).

The proportions of compounds present in the rumen are influenced by a number of factors, including the rumen conditions. These conditions and differences in stability, longevity and toxicity mean it is very difficult to identify specific toxins that cause liver and kidney damage. It is also extremely difficult to identify a specific toxin's parent GSL, further complicating the investigation of potential toxicity events.

Therefore, it's not surprising that toxicity data of individual GSL in ruminants are very sparse. Instead, the total amount of GSL in the diet is most commonly used to determine the level of risk of brassica toxicity.

During the winter of 2014, Southland and South Otago dairy farmers encountered unusual patterns of illness and deaths of cattle grazing on swede crops across the region. Sporadic reports and cases of dead or sick animals were first received by veterinarians from mid-July. DairyNZ, in collaboration with a number of other organisations, responded by developing a research plan and extension activities to:

- provide advice and support to affected farmers to assist them through the remainder of the 2014/15 season
- understand the cause of the animal health problems and identify management strategies to reduce toxicity risks associated with feeding swede crops.

The analysis of blood samples collected from affected and unaffected herds indicated there was subclinical disease with all swede varieties, irrespective of whether or not ill health was observed. This result was deduced from the concentration of the enzyme  $\gamma$ -glutamyl transferase (GGT), which is an indicator of liver damage. When damage occurs, GGT is secreted at higher amounts from the bile duct linings. As GGT concentrations in blood were elevated in cows fed swedes (50% of all animals tested were above 37 IU/l), this provided support that the disease outbreak was due to toxins causing liver damage.

An important result from a farmer survey was a statistically significant ( $P < 0.001$ ) association between disease and consumption of the HT® swede variety when cows were fed swedes on the milking platform during calving or in early lactation. The number of weeks spent on crop did not appear to be a major contributing factor to the disease incidence. There were, however, marginal associations between disease and the proportion of swede in the total diet.

Climatic conditions were also thought to have influenced growth and maturity of swedes, with autumn through spring 2014 being much warmer than normal, at times and in places by as much as 1.5°C. The pattern of monthly rainfall totals also differed from the ten year average, with more rain than normal occurring in April, May, and July. Farmers reported visual differences in their crops compared with other seasons, with stems elongated and plants in the reproductive phase (bolted; Figure 2).

Analyses of swede plant samples indicated significant differences in GSL concentrations between different plant parts and between HT® and non-HT® swede varieties (Figure 3), with

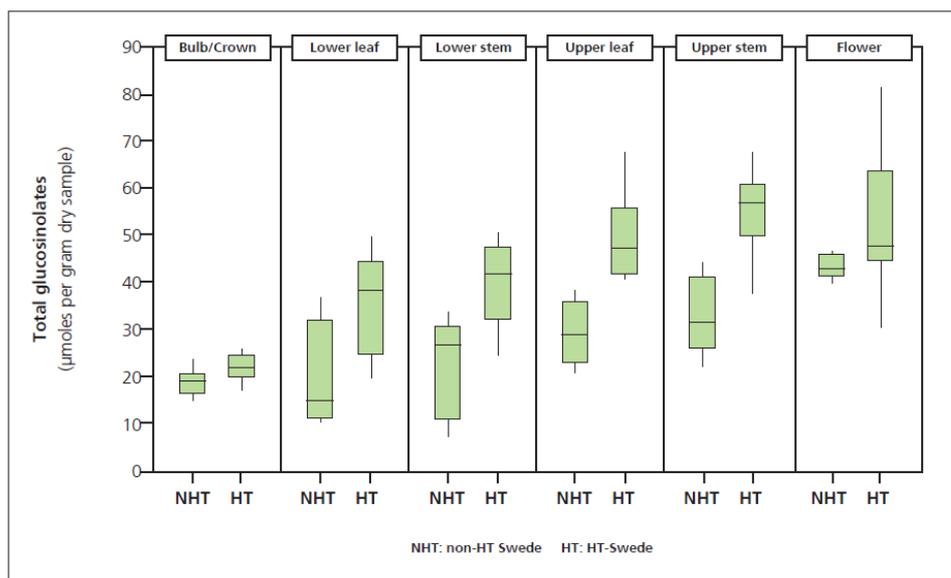
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significant interactions between plant part and variety. For all plant parts, except bulb/crown, the average glucosinolate concentration was greater in HT® than non-HT® swedes. In non-HT® swedes the bulb/crown and lower leaf GSL concentrations were similar, but there was a steady increase in GSL concentration moving up the plant from lower stem, upper leaf, and upper stem to the flower. In HT® swedes, there was an increase from bulb/crown, but upper leaf, upper stem and flower were similar for GSL concentrations.



**Figure 2.** Comparison of swede physical appearance: mid September 2014 and late August 2015



**Figure 3.** Concentration of total glucosinolates in swede plant parts collected from HT® and non HT® swede varieties on commercial dairy farms in spring 2014

The common practice of feeding swedes during calving and early lactation was likely to be a major contributory factor to this disease outbreak as it increased the risk of feeding crop with higher concentrations of glucosinolates. Over the last 10-20 years, swede use has changed from being a solely wintering crop to one now used by many farmers to fill the early lactation feed deficit on the milking platform. As swede crops for both scenarios are sown at the same time, cows will be exposed to a more mature crop during calving and early lactation, and thus their glucosinolate intake will be higher. In 2014 this effect was, most likely, exacerbated by crops reaching maturity more quickly due to the unusually warm winter with fewer frosts.

#### *In summary*

- The event was multifactorial in nature, involving animal, plant, farm, climatic and farm management practices, which, in winter 2014 in Southland and South Otago, culminated in the ‘perfect storm’ rather than this being a new disease caused by HT® swedes.
- Blood analyses provided evidence that some liver damage had occurred in many apparently healthy cattle grazing swedes (both HT® and non-HT®).
- There was a statistically significant ( $P < 0.001$ ) association between disease occurrence and the consumption of HT® swedes by cattle that were heavily pregnant or in early lactation.

#### *Recommendations*

- Be cautious when grazing animals on swede crops in autumn before the first frosts, as they may eat more leaves than bulbs as the bulbs are hard and difficult to eat.
- Be cautious, at any time during the season, when grazing animals on swede crops with a high leaf to bulb ratio as cows may preferentially graze leaf.
- Observe the physical characteristics of the crop being fed, monitor the health of cows and adjust their feed management if ill-health is observed – see Advice for feeding swedes.
- Simplify winter feeding systems to minimise the transitioning requirements for animals as they change feeds (i.e. pasture to crop; crop to crop; crop to pasture) - see Advisory #12.
- Use farm management practices (e.g. mob age structure, feeding frequency, and break dimensions) that reduce the potential for individual cows to graze proportionately more leaf.

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- Do not feed HT® swedes on the milking platform in late August/early September (i.e. late pregnancy, early lactation). This period is when many of the factors that lead to ill-health and potential cow death (warmer temperatures, new leaf growth, bolting) can rapidly combine.
- Do not feed swede crops in their reproductive growth phase, which can be recognised when the stem of the swede elongates, new growth appears and the swede plant develops flowers and a seed head.

## **Environmental impact of forage crops**

Nitrate leaching losses in grazed systems occurs primarily beneath animal urine patches (Cameron et al. 2013) and, as such, winter forage grazing can contribute a disproportionately large fraction of whole-farm N leaching losses (Chrystal et al. 2012) because of the high stocking rates at the time of the year i.e. winter, when minimal amounts of N are taken up by vegetation and soils are regularly draining. Simulation modelling by Monaghan et al. (2007) and Chrystal et al. (2012) using the Overseer nutrient budgets model (Wheeler et al. 2003), indicated that winter forage crop systems in southern New Zealand could leach 55-60 kg N/ha per year. Furthermore, in-paddock measurements of leaching losses from these systems show N losses can range from 52 to 173 kg N/ha/year (Shepherd et al. 2012; Smith et al. 2012; Monaghan et al. 2013). Research in the Pastoral 21 and Forages for reduced nitrate leaching programmes in Canterbury and South Otago has investigated crop sequences and grazing management options to reduce the environmental impact of crop based wintering.

### ***Sequence cropping (catch crops) to reduce nitrate leaching***

Sequence cropping provides the opportunity to increase yield and decrease N leaching (compared to a traditional kale crop). This can be achieved by exploiting the traditional fallow period to establish a quick growing cereal, which can be harvested for silage and ‘catch’ residual urinary N. Sequence-cropping can increase total annual feed grown per unit land area, from grazed kale, plus oats silage conserved from the previous spring.

The nitrate leaching risk from winter support land comes mostly from the N in the urine that is deposited on the soil while the cows are grazing crops. If the land lies fallow for three months after grazing before the next crop is sown, then there are no plants growing on the soil to take up the N until late October – during which time much of the urinary N will likely be leached in drainage water. The idea of sowing oats as soon as possible after the winter crop grazing is to ‘mop up’ some of this N before it is leached below the effective rooting zone for plants in water draining through the soil profile. However, the N in the oats can contribute to leached N by contributing to the urinary N load when fed in winter. Importantly, sequence-

cropping ensures that N is recycled on the same area of land, and not distributed to other areas of the farm that may be at risk of high N loss.

Therefore the advantage of sequence cropping is that the oat crop can ‘mop up’ residual urinary N left behind after the kale crop has been grazed, and reduce nitrate leaching in late winter and spring and increasing crop yield per unit of land area when compared to a kale only crop. Establishing a catch crop within 60 days of winter grazing of kale in Canterbury resulted in a significant reduction in nitrate leaching (Figure 4; <http://www.dairynz.co.nz/about-us/research/key-projects/pastoral-21/> ). Total DM yields of 17–22 t DM/ha were achieved from this sequence crop system, compared to 11–15 t DM/ha for the kale only system. The sequence crop system provided all the feed needed for wintering, whereas kale only systems require supplements to be bought in from other land sources to compliment the diet.

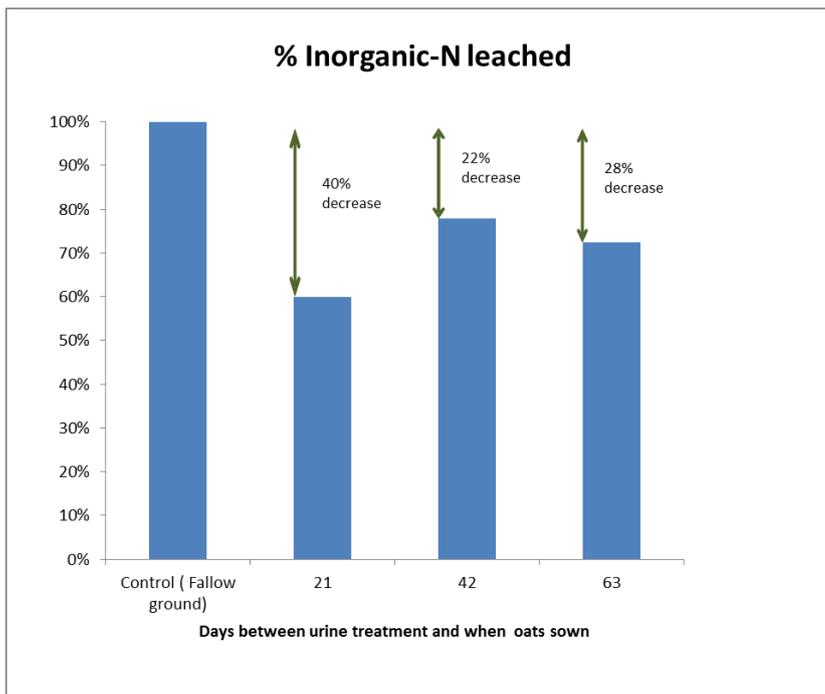
In many regions current crop establishment options and soil conditions following grazing will make it challenging to establish an oats crop within the timeframes tested in Canterbury, however future research will investigate alternative crop establishment methods, crop types and paddock grazing options to enhance the opportunity to use catch crops in other regions.

Successful sequence cropping depends on:

- soil type and soil condition allowing machinery to pass for cultivation and sowing of the oats in the period from mid-June to mid-September
- the availability of irrigation or reliable summer rainfall for the crop or pasture from sowing in early December onwards
- high utilisation of the winter crop during grazing, leaving minimal crop residue to interfere with sowing of the oats.

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**Figure 4.** Effect of growing a catch crop (oats) on nitrate leaching from urine applied in early June

### ***Critical source area management to reduce sediment and phosphorus loss***

Critical source areas (CSAs) are those parts of the landscape, such as swales and gullies, where overland flow and seepage converges to form small channels of running water, which may then flow to streams and rivers. The P21 Telford project research quantified the potential reductions in phosphorus and sediment loss from CSA protection during winter crop grazing (<http://www.dairynz.co.nz/about-us/research/key-projects/pastoral-21/>). Strategic grazing and careful management of CSAs can reduce losses of sediment and phosphorus by 80-90%. The reduction is achieved by minimising stock movements and thus soil treading damage in the CSA. This means any rainfall and runoff that occurs is more likely to infiltrate the soil, minimising the amount of runoff and losses of sediment and P. Strategic grazing will not greatly reduce nitrogen losses observed from grazed winter forage crops, which are largely due to the urine patches left behind following crop grazing.

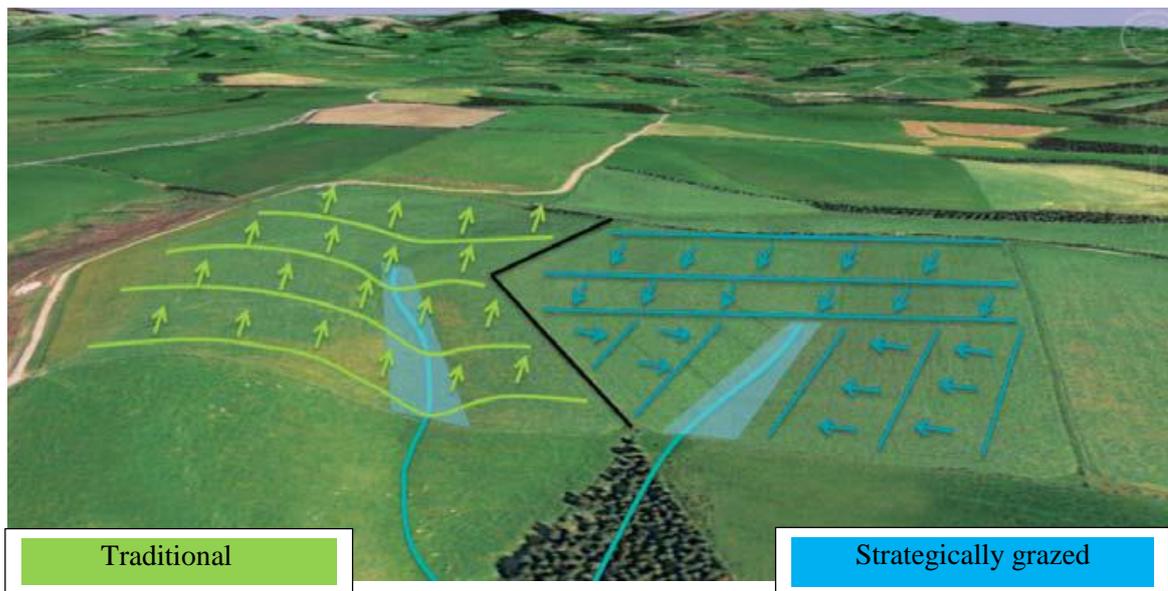
Management tips to reduce surface run off in a CSA:

- When selecting future winter forage crop paddocks, if possible, avoid paddocks with large CSAs that will be difficult to manage.
- Work out a grazing strategy before putting up fences, thinking about the location of stock water sources. i.e. do you need portable water troughs?
- Use a winter crop calculator to work out feed requirements to achieve BCS targets at calving (<http://www.dairynz.co.nz/feed/feed-management-tools/more-feed-tools/>).

- Set up baleage in paddocks ahead of winter.
- Leaving CSAs uncultivated and not planted in crop will make it easier to fence them off and reduce the amount of soil treading damage by stock. The pasture will also provide an additional filter for any runoff that occurs.
- Fence off CSAs to provide as much of a buffer area as possible. This type of buffer strip should be at least 10 m wide and as long as possible (will depend on landscape).
- Ensure cows begin grazing the least risky parts of the paddock first to minimise the period of runoff risk. This usually means that cows should enter at the top of paddock catchments/gullies, and graze their way downhill (Figure 5).
- Back-fence as much as possible – this will help minimise soil pugging and compaction damage, and thus reduce the volumes of surface runoff generated.
- The CSA should be the last break grazed in the paddock (if it needs to be grazed at all). Changing the break layouts to graze into the CSA from each side will allow this to happen (Figure 5).
- On-off graze any crop left in the CSA, ideally at a time when soil moisture content is not too high.
- Additional information – Wintering in Southland and South Otago. A land management guide to good environmental practice (<http://www.dairynz.co.nz/environment/land-and-nutrient/land-management-guides/>).

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**Figure 5.** Grazing direction comparison of two paddocks, one set up to minimise sediment and phosphorus loss by protecting the critical source area during grazing.

## Conclusions

Brassica's and fodder beet are important sources of high quality feed for non-lactating and lactating cows. Nutritional differences to pasture e.g. high sugar content and the presence of anti-nutritional factors e.g. glucosinolates in some crops mean that careful transition onto crops is essential for good animal performance. Fodder beet offers opportunities to reduce nitrogen intake and subsequently urinary N excretion however diets too low in nitrogen can have negative effects on animal performance. Maximising the production and environmental benefits that crops offer, especially fodder beet, while minimising any negative impacts on the dairy production system remains a priority for the dairy industry.

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