MARCH 2016

Issue 29

Technical Series ONLINE

Lessons from swedes disease outbreak

Dawn Dalley and Sue Petch, DairyNZ

In the winter of 2014, dairy farmers across Southland and South Otago encountered high incidences of illness and death in cattle grazing on swede crops. DairyNZ Senior Scientist Dawn Dalley and project manager Sue Petch explain the findings of DairyNZ's investigation into the event.

Key Findings

- ***High concentrations of glucosinolates (GSL; a family of compounds found in brassicas) can cause brassica toxicity. Leaves and flowers of swedes have higher GSL concentrations relative to the bulb and crown***
- ***All cultivars of swedes can cause liver damage in cattle. The severity of toxicity is influenced by multiple factors***
- ***The higher disease incidence reported from Southland during calving and early lactation in 2014 was largely caused by feeding swede crops that were reproductive ('bolting'). HT® swedes, shown to have higher concentrations of GSL, exacerbated the problem.***
- ***Air temperatures in winter and spring of 2014 were warmer than normal for Southland and South Otago; this probably increased the proportion of leaf in swede crops and caused crops to bolt earlier than normal. Thus, cows fed these crops were affected by brassica toxicity***

Brassicas known to cause toxicity

Brassica crops, which includes turnips, swedes, rape and kale, are a valuable source of supplementary forage for dairy cows in pasture grazing systems, particularly as winter feed in cooler regions of New Zealand[1]. Swedes, in particular, have been fed to cattle in Southland and South Otago for more than 50 years[2].

Brassicas 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[3].

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, oxazolindine-2-thiones, nitriles and epinitriles. These products, often with bitter and unpalatable tastes, have evolved as protective mechanisms against disease, insect and herbivore attack[4] and when ingested by cows may result in a spectrum of brassica-associated diseases with a wide range of possible clinical signs[5]. Derivatives of GSL are modified into toxins that can interfere with thyroid function or damage the liver and kidneys[6].

The proportions of derivatives 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.

Reports of sick cattle spark investigation

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

Researchers initially suspected brassica toxicity was the cause of the problems given that clinical signs closely matched descriptions in the veterinary literature. This formed the basis of the research hypotheses to be tested, these being:

- The unusual patterns of illness and death in cattle grazing on swede crops was due to liver damage caused by toxic compounds formed as breakdown products following the consumption and digestion of glucosinolates
- Concentrations of glucosinolates were higher in the reproductive parts of the swede
- The Herbicide Tolerant® (HT®) swede variety could be a contributing factor

The activities then fell into three main phases:

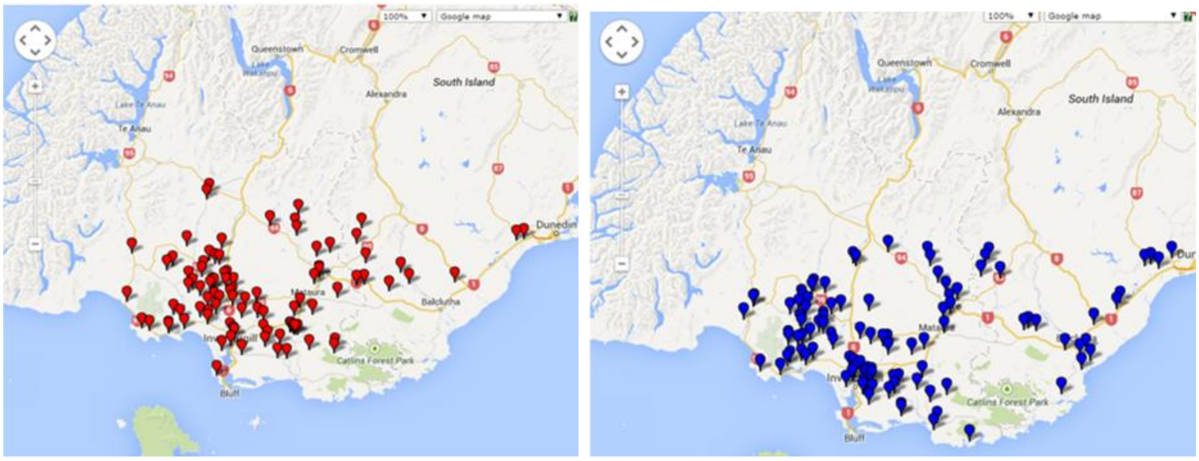
- Phase 1: Collection of animal and plant samples at the time of the event and an initial survey to assess the extent of the problem

- Phase 2: Review of scientific literature, follow-up surveys of illness in animals and management practices on farms, and the analysis of the animal and swede samples collected during the event

- Phase 3: Extension initiatives occurred throughout the project as new information became available, providing timely dissemination of findings and recommendations for farmers and rural professionals

Phase 1 was conducted with urgency to collect plant and animal samples, from affected and non-affected farms, before the crop was consumed or cows removed. A range of swede varieties was included. The extent of the problem was determined by a rapid survey of approximately 2600 farmers in Southland and South Otago; farmers were asked if adverse effects and deaths had occurred with animals grazing swedes on their farm. The incidence of disease reported was spread across the region (Figure 1).

Figure 1: Spot maps created from a rapid survey of approximately 2600 farmers, asked if they had adverse effects and deaths occur with animals grazing swede crops. Left: farms where cases of animal health issues were reported. Right: farms where no animal health issues were reported.



The second phase then began. This comprised an extensive review of the scientific literature, an in-depth farmer survey, analyses of animal and plant samples, the collation and analyses of all subsequent data, and the preparation of preliminary reports to generate advice for farmers.

The review of the scientific literature was undertaken to:

- Ensure the working team were up to date with basic knowledge and potential issues associated with grazing brassica crops and, in particular, swedes

- Identify potential causes of the ill health and deaths and to help guide the development of the in-depth survey

The in-depth survey, restricted to farmers that had fed swede crops during the winter and/or spring of 2014, was designed to address known and potential casual factors of brassica toxicity, which include:

- Factors, from the literature, reported to influence the glucosinolate concentrations in swedes

- Management factors that could cause adverse impacts when feeding swedes to cattle

- Potential issues raised by farmers, rural professionals and other parties

Analysis of the animal samples was straight-forward, using the commercially available testing service offered by Gribbles, Invermay. Analysis of the swede materials was more challenging, as there were no agreed laboratory protocols for testing GSL in swede material. Additionally, there were no accredited laboratories undertaking glucosinolate testing in New Zealand. DairyNZ considered that an important outcome of the study was to have a validated method for testing individual glucosinolate and S-methyl-L-cysteine sulphoxide concentrations by an accredited commercial laboratory in New Zealand available for plant breeders and/or farmers to assess the potential toxicity of a swede crop. The method that was developed is currently going through the ISO 17025 accreditation process.

Throughout the project, advice on best-practice crop and animal management were issued to help manage the risks associated with feeding swede crops to dairy cows during the remainder of the 2014/15 season and in future. New information was released to farmers and their advisors (veterinarians and other rural professionals), and the media, as it became available.

Results of the investigation

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 γ-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.

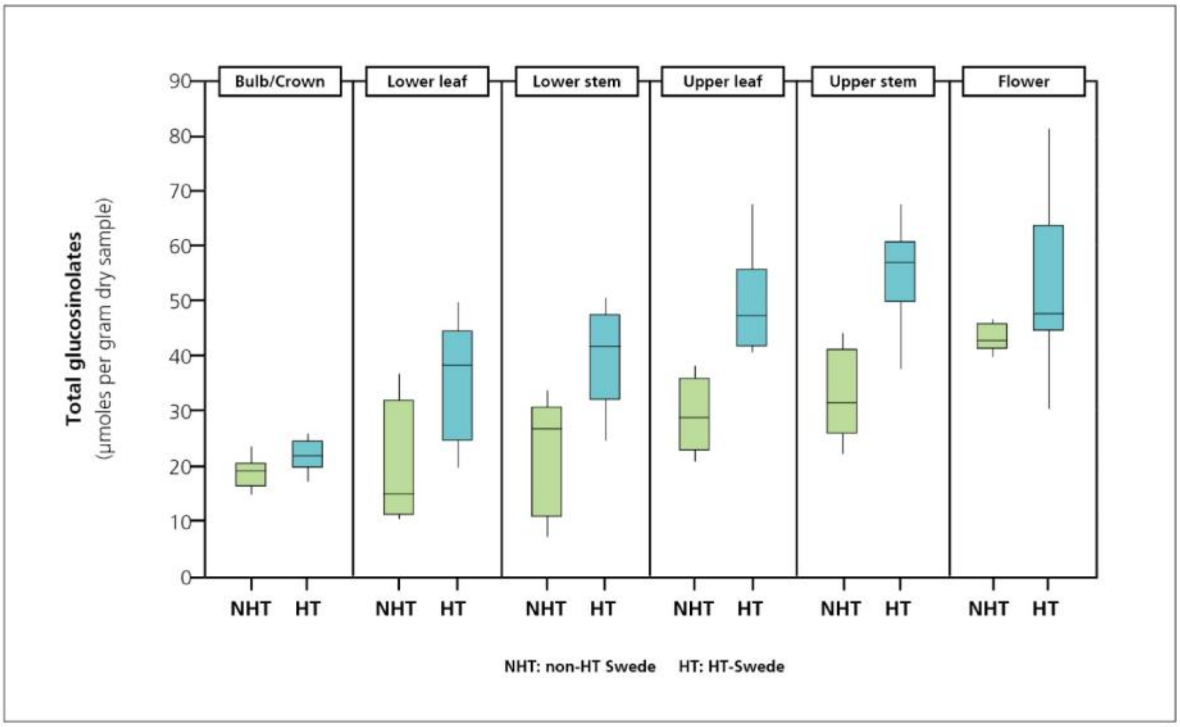
An important result from the farmer survey was a statistically significant ($P < 0.001$) association between disease and consumption of the HT® swede variety when cows were fed swedes on the milking platform during calving or in early lactation. The number of weeks spent on crop did not appear to be 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[7]. The pattern of monthly rainfall totals also differed from the ten year average, with more rain than normal occurring in April, May, and July[7]. Farmers reported visual differences in their crops compared with other seasons, with stems elongated and plants in the reproductive phase (bolted; Figure 2).

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

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 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 3. Concentration of total glucosinolates in swede plant parts collected from Herbicide Tolerant (HT®) and non HT® swede varieties



The, now common, practice of feeding swedes during calving and early lactation was, in our opinion, 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

DairyNZ recommendations to farmers

- 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-heath and potential cow death (warmer temperatures, new leaf growth, bolting) can rapidly combine and result in signs of brassica toxicity
- Do not feed swede crops in their reproductive growth phase, recognisable as when the stem of the swede 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, 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. Refer to DairyNZ Advisory #11 for more information around feeding management
- Follow PGG Wrightson Seeds advice regarding HT® swedes and their use

These recommendations are based on the following factors:

- Warmer weather will stimulate swedes to enter the reproductive phase
- HT® swedes have a higher concentration of total GSL in the plant parts where re-growth occurs. This may occur with other leafy swede varieties
- Cows that are under metabolic stress, due to late pregnancy and early lactation, are less able to cope with toxins arising from high concentrations of total GSL in their diet

Managing risk in the future

- 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) (DairyNZ Advisory #12).
- Use farm management practices (e.g. mob age structure, feeding frequency, and break dimensions) that reduce the potential for any individual animal behaviour to deviate from herd behaviour (i. e. dominant cows grazing proportionately more leaf)

References

1. Westwood, C. T., and H. Mulcock. 2012. Nutritional evaluation of five forage brassica. Proceedings of the New Zealand Grassland Association 74: 31-38.

2. Halford R. E. 1970. Grass wintering and its implications in Southland. Proceedings of the New Zealand Grassland Association 32: 42-48.

3. Velasco, P., P. Soengas, M. Vukar, and M. Elena Cartea. 2008. Comparison of glucosinolate profiles in leaf and seed tissues of different brassica napus crops. Journal of the American Society of Horticultural Science 133(4): 551-558.

4. Bekaert, M., P. P. Edger, C. M. Hudson, J. C. Pires, and G. C. Conant. 2012. Metabolic and evolutionary costs of herbivory defense: systems biology of glucosinolate synthesis. New Phytologist 196(2): 596-605.

5. Nichol, W., C. Westwood, A. J. Dumbleton, and J. Amyes. 2003. Brassica Wintering for Dairy Cows: Overcoming the Challenges. South Island Dairy Event, p.154-172.

6. Bones, A. M., and J. T. Rossiter. 2006. The enzymatic and chemically induced decomposition of glucosinolates. Phytochemistry 67: 1053-1076.

7. Dalley, D.E., G. Verkerk, R. Kyte, C. McBeth, S. Petch, B. Kuhn-Sherlock, C. Leach, A. Irwin, N. Harding, C. Morley, and T. Ryan. 2015. Swede associated toxicity in dairy cattle during winter 2014. An overview of activities supported by DairyNZ. Report for New Zealand Dairy farmers. Pp. 84. http://www.dairynz.co.nz/farm/adverse-events/southland-swedes/?_cldee=ZGF3bi5kYWxsZXlAZGFpcnluei5jby5ueg%3d%3d&urlid=0 (accessed 12 Jan 16).