Catch crops for production and environmental benefits
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The fallow period after winter grazing of kale or fodder beet crops creates a potential risk for nitrogen leaching. This risk can be significantly reduced when a catch crop is established directly after grazing in winter.

5 Prudent use of dry cow antibiotics - what does this mean?

International calls for “prudent” or “judicious” use of antibiotics for food production animals have implications for how we manage mastitis in New Zealand dairy herds. Use of antibiotics at dry off is coming under increasing scrutiny and will change how we dry cows off in future.

9 Principles from Pastoral 21: Optimising dairy system strategies to meet nutrient limits

The New Zealand Government released its National Policy Statement on Freshwater Quality in 2011 to trigger Regional Council planning processes aimed at improving long-term water quality throughout the country. It is now clear that dairy farmers in many regions will need to reduce the amount of nitrogen leached from their farm systems to comply with regional nutrient limits.

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Catch crops, often referred to as cover crops, are by no means a new phenomenon in the response to reducing nitrogen (N) leaching risks. In arable cropping systems, catch crops are often established in autumn and are very effective at reducing N leaching losses during the following winter period\(^1,2\). Using this concept to ‘mop-up’ N after winter forage crop grazing is a novel approach that has only recently generated interest in New Zealand, particularly in the South Island.

**The challenge**

Winter forage kale and fodder beet are important single-graze crops in livestock production systems. However, given the high-yielding nature of these winter crops, animal stocking densities are typically high, resulting in a large number of urine patches within a relatively small area of land\(^3\). Urine is the main source of N leaching in grazed systems, particularly when there is no forage growing to use it. Therefore the potential for N leaching losses after crop grazing is high\(^4,5\). Furthermore, ground often remains fallow for three to five months after grazing. During the fallow period, urinary N is converted into nitrate, which is especially susceptible to leaching loss.

The question is – “can a catch crop be successfully established during the winter-spring fallow period to reduce N leaching, and also produce additional forage biomass?”

**Key findings**

- A winter-sown cereal catch crop can reduce soil mineral nitrogen and reduce nitrogen eaching by 22–40%.
- Additional forage production is an extra benefit of catch crop establishment in winter.
- The reduction of N leaching risks by growing catch crops varies from year to year depending on weather conditions, particularly during catch crop establishment.
- Oat catch crops could be successfully established by direct-drilling after kale grazing. However, cultivation may be necessary after fodder beet grazing because of greater soil compaction from animal treading.
Reducing N leaching

Research has demonstrated that growing catch crops after winter forage grazing has significant environmental benefits. A Pastoral 21 (P21) programme experiment at Lincoln University indicated that on a stony soil a catch crop of oats sown between 21 and 63 days after urine deposition in early winter could reduce the amount of N leaching loss by 22–40% compared with no catch crop\(^6\) (Figure 1).

In general, the earlier the crop was established after grazing, the greater the potential to reduce N leaching.

On other deeper Canterbury soils, reductions in N leaching are also likely. Data generated from the Forages for Reduced Nitrate Leaching (FRNL) programme indicates that oats sown in either July or August substantially reduced the amount of N remaining in the soil profile, by up to 86% compared with that in fallow plots\(^7\) (Figure 2).

![Figure 1: Relative effect of delaying the sowing of oats, following simulated winter forage grazing in 2014, on mineral - N leaching after applying urine to lysimeters\(^6\) (P. Carey pers comms). Based on these findings, earlier sowing of catch crops is recommended.](image1.png)

![Figure 2: Change in soil mineral nitrogen (kg N/ha between 0–120 cm depth) under an oat catch crop sown in either July or August on Templeton silt loam\(^7\). Fertiliser rates of either 0 or 400 kg N/ha represent non-urine and urine patch areas of a paddock, respectively, applied on 1 July as urea. Vertical bars represent the least significant difference (LSD) at the 5% level.](image2.png)
Although this is not a direct measure of N leaching outcomes, and the effect is perhaps overemphasised by the apparent high rates of mineralisation in the fallow treatment during November, it demonstrates the ability of a winter-sown oat crop to ‘mop-up’ residual soil N.

Similar work in the North Island (Central Plateau) also indicates that deep-rooted chicory, sown in spring after winter grazing of a kale-swede mixed forage, could reduce the amount of soil mineral N at a 60–90 cm depth by 35% compared with ryegrass, by the following autumn.

It is important to recognise that N leaching is strongly dependent on crop management and the timing and amount of rainfall. Therefore, the reduction in N leaching loss from a catch crop will vary with sowing time and also from year to year. Weather, particularly rainfall and temperature, influences how much N moves through the soil profile and how much, and how quickly, N is used by the catch crop.

Table 1: Average cost of production of crops grown in a kale-only or in a sequence cropping system on a stony Canterbury soil, over three years. Data sourced from DairyNZ website article[^5].

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean yield at time of grazing</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t DM/ha)</td>
<td>($/ha)</td>
</tr>
<tr>
<td>Kale-only</td>
<td>13.4 ± 1.7*</td>
<td>$2,789 ± $302</td>
</tr>
</tbody>
</table>

**Sequence cropping**

| Late-sown kale     | 12.0 ± 2.4                   | $2,299 ± $341  | 19.8 ± 5.4    |
| Oats               | 7.6 ± 2.2                    | $1,338 ± $82   | 18.6 ± 4.7    |
| Late-sown kale + oats | 19.6 ± 2.3              | $3,637 ± $316  | 18.9 ± 3.7    |

*± One standard deviation

*To account for the full cost, imported feed must be added to the early-grown kale scenario; the exact cost will depend on the type of supplement imported.

**Biomass production potential**

Establishing an oat crop after winter grazing can offer additional annual biomass production, and, in turn, higher farm productivity. For example, an oat crop grown in sequence with kale in Canterbury can yield 3–7 t DM/ha per year more feed than a kale-only system, at a similar cost of production per kg DM[^5].

An estimated cost analysis of a kale-oat cropping sequence compared with one of kale-only is provided in Table 1. In this example, the kale-oat sequence crop system provided all the feed needed for dry cows from the end of May until early to mid-August for approximately $0.19/kg DM.

On deeper soils, the production potential of an oat crop is likely to be greater than those grown on stony soils, because of higher soil water-holding capacity. Yields of 6–12 t DM/ha in large field plots have been reported on Templeton silt loam soil when grown through until ‘green-chop’ maturity stage (50% ear emergence). Importantly, it is evident from this work (and in current FRNL experiments) that most of the biomass is accumulated during October and November.

Therefore, not harvesting before ‘green-chop’ can result in significant yields. However, delaying harvest beyond ‘green-chop’ will compromise quality in terms of the amount of metabolisable energy per unit of DM.

It is important that the use of catch crops be analysed in the context of each system. For example, in dryland systems, where subsequent spring crops rely heavily on stored water from winter rains, catch crops may not be a suitable option because they can deplete valuable soil water through transpiration in early spring.

**Method of catch crop establishment**

There can be practical challenges to sowing a catch crop in the middle of winter, particularly in the South Island. In particular, it is unclear what are the most appropriate methods for successfully establishing catch crops to ensure sufficient soil-to-seed contact without restricting emergence. This will undoubtedly be dependent on soil conditions both at the time of grazing and at sowing. Recent on-farm research in FRNL has investigated three different approaches to sowing catch crops following grazing of either kale or fodder beet, on a free-draining soil:

1. Broadcast (after surface grubbing), then maxi-till
2. Tillage (grub, power-harrow, roll), then drill
3. No tillage (direct-drill).

Preliminary emergence and yield data from this work indicate that the method of establishment is important when establishing oats, particularly after grazed fodder beet. As a result of heavy treading and the formation of a hard surface crust under fodder beet grazing, tillage was necessary for two reasons:

1. To enable the drill coulters to penetrate the soil surface and ensure seed was placed at the appropriate soil depth, and
2. To allow seedlings to emerge without undue surface resistance.

Direct-drilling, after kale grazing, was shown to be a viable option, with good emergence and DM yields that were not too dissimilar to the tillage treatment. Although broadcasting oat seed after grazing seems an attractive low cost option from an operational point of view, some form of surface working is likely necessary to achieve sufficient soil-to-seed contact and a good catch crop establishment.

Overall, yields ranged from 7–10 t DM/ha. For oat seed broadcast two–three days before fodder beet grazing on a 4 m x 20 m strip (‘proof-of-concept’) results were particularly poor, with <1% of plants successfully establishing. This was also attributed to the compacted soil.
On soils that are heavier or more prone to surface capping, successful catch crop establishment relies on good management of the fallow soil after grazing to ensure optimum conditions for germination. For example, as conditions allow, immediately grubbing/ripping recently grazed land will facilitate drainage and evaporation of subsequent rain events, and soils will dry out more quickly. This might allow machinery access earlier for catch crop sowing than what might have otherwise been possible.

Conclusions
Growing a catch crop of oats after winter forage grazing can offer significant yield benefits, as well as reduce N leaching losses. The degree of benefit is largely dependent on management for achieving high catch crop yields (e.g. early sowing and establishment method) and on seasonal weather, particularly timing and amounts of rainfall.

The majority of the biomass accumulation in catch crops is during October and November. Therefore, delaying harvesting by only two–three weeks around the ‘green-chop’ maturity stage (early ear emergence) can have significant yield advantages. This will be governed by the requirements for timing of the following crop.

It is important to consider the most appropriate method for establishing the crop, which will depend on the surface conditions at the time of grazing and at sowing. Fodder beet grazing can result in heavily compacted soils and therefore some form of cultivation may be necessary.

Fast facts
- Growing catch crop oats after winter forage grazing can reduce risks of N leaching.
- Catch crop oats provide additional feed at a similar cost/kg DM as the kale.
- Oat yields at ‘green-chop’ silage maturity stage can range between 5 and 12 t DM/ha.

Acknowledgement
Forages for Reduced Nitrate Leaching is a DairyNZ-led collaborative research programme across the primary sector delivering science for better farming and environmental outcomes. The aim is to reduce nitrate leaching through research into diverse pasture species and crops for dairy, arable and sheep and beef farms. The main funder is the Ministry of Business, Innovation and Employment, with co-funding from research partners DairyNZ, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Landcare Research.