Winter sequence cropping kale and oats on winter support land for increased production and reduced Nitrogen leaching

Research trials in Canterbury have established that nitrogen (N) leaching can be reduced compared to a traditional kale only crop, by planting an oat crop immediately after harvesting the kale.

The oats crop in this sequence is a "catch crop", with its purpose being to capture urinary N from the soil, while increasing overall crop yield when compared to a standard kale crop.

This trial compared traditional kale only crop against a kales-oats sequence, both grown continuous on the same winter block, for three years. The sequence of cropping was to go from pasture into kale in the first year, with oats planted during the traditional fallow period, and then repeating the kale and oats sequence for the next two years. Oats were ensiled and fed out the following winter.

Key findings

1. Sequence cropping with a kale/oats combination can reduce N leaching losses by around 25% to 30% compared with the kale only system
2. Total DM yields of 17–22t DM/ha can be achieved from this sequence crop system, compared to 11–15t DM/ha for a kale only system
3. Total production costs of sequential cropping are about 15-22 c/kg DM, similar to a kale only system (16-25 c/kg DM)
4. Sequence cropping can provide all the feed needed for wintering, whereas kale only systems require supplements to be bought in to balance the diet
5. Sequence cropping will only be successful on free-draining soils where machinery can operate soon after kale grazing is completed, where there is irrigation or good rainfall from early December onwards, and where kale is well-utilised during winter grazing so the residues do not interfere with sowing of the oats.

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Why reducing N leaching from winter cropping is important

In Canterbury and Otago/Southland, dairy cows are typically wintered on crops grown on support land. The crops are sown in mid-spring and fed from late May until mid-August. These winter crops provide invaluable dry matter at a time when pasture is in short supply or is being spared for spring growth. The land is then typically left fallow until the crop is re-sown in mid-spring or returned to new pasture.

Winter feeding is costly; especially if the land costs are factored in. Direct winter grazing costs are commonly in the range of $25-$30/cow/week or 16 -25c kg/DM for home grown feed (including the cost of land).

Research has shown that grazing winter crops contributes a large proportion of the total N leached from the total dairy operation. Limiting the amount of N leached can be difficult when crop yields and the N content of the feed is high and winters are wet.

With nutrient loss limits being progressively implemented by regional councils at farm and catchment level, N leaching from winter crop grazing will need to be addressed.

Any restrictions on dairy support land that reduces the yield of crops or decreases the number of cows that can be stocked on that land will result in a decrease in availability of dairy support land and increase the cost of winter feeding.

How can N leaching from winter crops be reduced?

The N 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 – by 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' or catch some of this N before it is leached below the root zone into water draining through the soil profile.

Kale/oats sequence cropping provides the opportunity to increase yield and decrease N leaching. 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 kale grazed in situ, plus oats silage conserved from the previous spring, without adding to production costs;

- Kale only system ranges in cost from 16-25 c/kg DM
- Sequence cropping ranges in cost from 15-22 c/kg DM.

Kale and oat silage complement each other in the diet of pregnant non-lactating dairy cows and can support BCS gains of 0.5+ units over 6–8 weeks, provided intake meets total energy requirements.

Therefore the advantages of sequence cropping are;

- Oat crop can 'mop up' residual urinary N left behind after the kale crop has been grazed
- Reduce N leaching in late winter and spring
- Increase crop yield per unit of land area when compared to a kale only crop
- Cost per kg/DM produced is similar.

How to go about sequence cropping?

A significant implication of using sequence cropping on the same block is that the late grown kale will not reach typical yields. As the late grown kale has less growing time (4 to 6 weeks) depending on when the oat crop is harvested.

To get the best results from sequence cropping follow the instructions of your seed company as well as considering the following points.

1. **Is irrigation required or is the farm summer safe**

   A high-yielding kale crop will only be achieved from this later sowing date if irrigation is available and water supply can be assured right through summer, or summer rainfall is plentiful and reliable (especially in early summer for germination and early establishment of the kale crop).

2. **Assess paddock to be cropped**

   When considering sequence cropping, think about the paddock that will be selected to be cropped.

   - Will the soil conditions after the completion of winter grazing be suitable for vehicle access to prepare the ground for sowing oats? This will vary with season and soil type
   - Paddocks that are flat and free-draining are most suited to the kale–oat sequence system
   - What is the history of the paddock?
     - How often has the paddock been cropped? Sequence cropping can be repeated

successfully for three to four seasons although this will depend on the soil type and soil structure decline.

- Consider disease e.g. club root, and retire paddocks to pasture if this appears.

For more information on paddock selection refer to Southern Wintering Crop Paddock Selection fact sheet on the DairyNZ website (dairynz.co.nz/sws).

3. Keep the focus on the main winter crop – kale

Maximising yield and utilisation of the kale crop is the first priority.

- To have the best chance of achieving yield and utilisation of the kale crop in a sequence cropping system, sowing needs to occur from mid-November to early December. Sowing of late sown kale after 1 January is not recommended.
- Once the kale crop is established, high yield can only be achieved if irrigation is applied through the summer, or summer rainfall is plentiful and reliable.
- To target good kale crop yields and avoid increasing N loss, apply N in two applications early during growth. This ensures the crop gets off to the best start. If N deficiency does appear, apply at rate of 100 kg/ha urea (until the end of February), as long as the soil is not too dry.

4. Sowing the catch crop - oats

Additional yield from the oats (sequence crop) grown is a bonus provided it's grown economically and does not compromise the value of the kale crop.

To produce a uniform seedbed for the following crop, the kale crop residue (mainly un-grazed stem) should be minimised to allow machinery to pass evenly. The kale crop needs to be well utilised (Figure 1), or ploughed well in.

Generally, the later sowing date of kale will mean the crop is less woody at the time of grazing, and cows leave less of it behind.

Oats can be sown at any opportunity after the kale is grazed. The sooner the oats are planted;

- The more excess N is captured by the plant and the less is leached
- The more time to harvest silage/baleage at an optimum growth stage

It is not worth sowing oats after 15 September, as there will not be enough time for the oats to grow before the next kale crop needs to be planted.

The best stage for harvest is when the ears are just showing. At this point the crop is in an active growth stage, but the quality is in rapid decline, so it is important that harvest is not delayed. (Figure 2)

It is important that the oats are wilted before ensiling or baling (Figure 3). Therefore, plan cutting when the weather pattern is promising for an extended dry period.

Figure 1: High utilisation of kale ensures there is a seedbed suitable for direct drilling or minimum cultivation for oat establishment.

Figure 2: Oats Ideal for harvesting.

Figure 3: Wilted oats ready for baling- will already be cut if they are wilted.

Are there alternatives to kale and oats?

Fodder beet

As an alternative to kale fodder beet could be considered, but there are some issues to address;

- Soil conditions
  Are the soil conditions right for establishment? Kale crops are often sown in the same area for two or more years. In contrast, fodder beet is usually rotated onto new land because of soil damage due to intensive grazing and the potential for carryover of beet fragments into the second season.

- Fodder beet yield
  The yield penalty for late sowing of fodder beet is high, as fodder beet is ideally sown mid - September to late October (depending on location). Oats are ideally harvested mid to late November. This increases risks in establishing fodder beet and reduces the duration of the optimum growth period before winter.

Oats

In this set up there is no other feasible option to oats, as;

- Alternative cereals have less yield potential for green chop harvest, because of the time needed between sowing and harvest
- Oats are a safer option compared to annual ryegrass, as they have reliable germination at low soil temperatures and produce more biomass from sowing in early spring
- If the sequence cropping is not continuous, then other cereals are an option, if used as a final crop in the sequence and then new pasture is established in autumn.

What did the research show?

The objective of the research was to quantify the effectiveness of sowing a catch crop in reducing N leaching losses after winter forage grazing of a kale crop.

Research conducted over three years on a Balmoral/ Lismore stony silt loam soil under summer irrigation showed that, compared with a kale-only crop, a sequential cropping can;

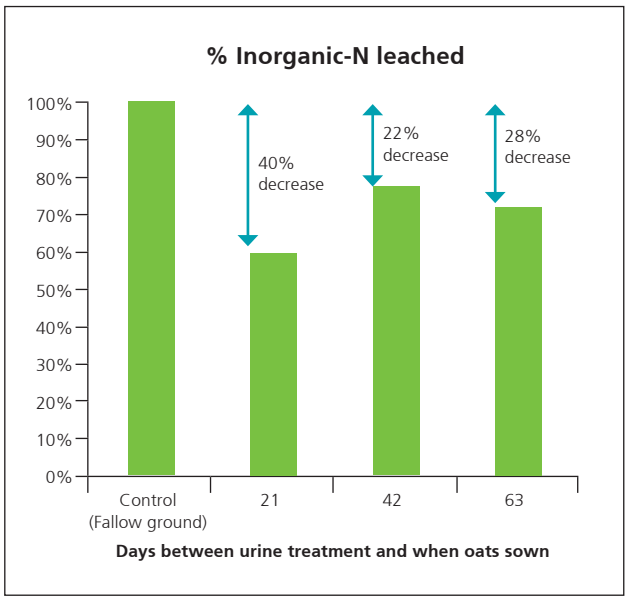
- Reduce N leaching 25%-30%
- Increase crop yield by around 6t DM/ha
- Reduce feed costs by about 3c/kg DM.

What was the impact on N leaching?

Lysimeters treated with urine (replicating urine deposition from cows grazing crops) and then sown with oats showed that the oat crop took up about 10% of the N added in the urine. Translating this to the whole paddock area, we can estimate that the oats may reduce N leaching in the sequence-cropping system by about 25% to 30% compared to a kale only system where land remains in a fallow state for 3–4 months.

Figure 4 shows the difference in N leaching when planting an oat crop between 21, 42 and 63 days after cows have deposited urinary N in early June. The results for 21 days after urine deposition have not been included in management guidelines, as it is unlikely that oats would be planted at this time.

Figure 4: Effect of growing a catch crop (oats) on N leaching from urine applied in early June



What were the Kale and oats crops yield and quality?

Table 1 shows annual yields (t DM/ha) from the kale-only system (where the kale crop was sown in October each year) and the sequence cropping system kale sown in early December followed by oats sown in August/early September). Yields varied substantially over seasons due to climatic impacts. However, the sequential cropping approach consistently yielded more than the kale-only system.

Table 1: Annual yield (t DM/ha) of crops grown in a kale-only, or a sequence cropping system.

	Winter 2012	Winter 2013	Winter 2014
Kale-only	**14.7**	**14.1**	**11.5**
Sequence cropping			
Kale	14.3	12.2	9.5
Oats	7.7	5.3	9.7
Total	22.0	17.5	19.2

Table 2 shows the metabolisable energy (ME) contents of the kale and oat crops averaged over 2 seasons (2012 and 2013). For kale, the ME values are the means of several samples collected throughout the grazing period. For oats, the ME values were measured when the crop was harvested for baleage.

Table 2: ME content (MJ/kg DM) of crops grown in a kale-only, or a sequence cropping system.

Kale-only	**14.7**
Sequence cropping	
Kale	14.3
Oats	7.7

What does it cost to sequence crop?

The kale–oat sequence cropping system yielded 3–7 t DM/ha per year more feed than the kale only system, at a similar cost per unit of DM grown, as shown in table 3.

Standard values for cultivation, sowing and irrigation were taken from the Lincoln University Financial Budget Manual. A cost of 4 c/kg DM has been included for the sequence-crop calculations for harvest and storage of the oats silage. The annual land rental of $1000/ha was split two-thirds for kale and one- third for oats.

Importantly, the kale–oat sequence crop system adopted here provided all the feed needed for cows from the end of May until early to mid-August. Cows were offered 12 kg DM/cow per day of the kale, plus 5kg DM/cow per day of the oats silage, for a total ration providing 153 MJ ME per cow per day.

The supplement used to deliver the same amount of energy from the kale only system was 14kg kale and 3 kg straw per cow per day. In this case, the straw cost $150/t DM or 15 c/kg DM, which has to be added to the cost of winter feeding.

Table 3: Costs of production of crops grown in a kale-only, or a sequence cropping system. Values are averages of three years.

	Mean yield at time of grazing	**Costs**	
Treatment	(t DM/ha)	($/ha)	(c/kg DM)
Kale-only	**13.4 ±1.7***	**$2,790 ± $300**	**21.1 ± 4.2**
Sequence cropping			
Late sown kale	12.0 ± 2.4	$2,300 ± $340	19.8 ± 5.4
Oats	7.6 ± 2.2	$1,340 ± $80	18.6 ±4.7
Total	19.6 ± 2.3	$3,640 ± $315	18.9 ± 3.7

*± one standard deviation

+ To account for the full cost imported feed needs to be added to the early grown kale, this will depend on the type of supplement imported.

Management inputs and timing

Table 4 and Figure 6 summarise the management practices used in the experiment to produce the results discussed above. This schedule will not apply in all cases, but is a useful guide to what needs to be considered.

For detailed crop guidelines refer to seed company recommendations and DairyNZ fact sheets.

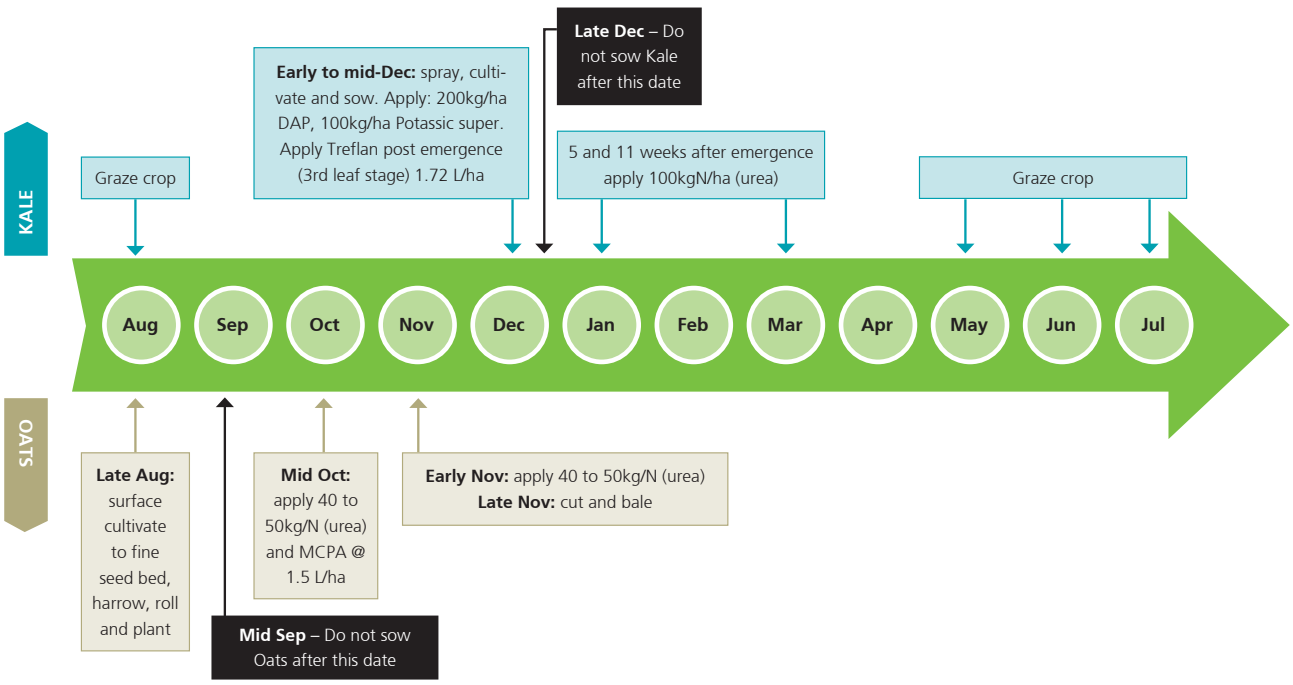
Table 4: Research management activities

	Oats	Kale
Critical requirements	Soil conditions suitable for cultivation/drilling during winter/ early spring. High utilisation of previous kale crop.	Full irrigation or adequate and reliable summer rainfall.
Sowing date	Late August 120 kg seed/ha	Early December 4 kg seed/ha
Cultivars	Nil	200 kg/ha DAP 100 kg/ha potassic super
Nitrogen after sowing	Mid Oct 40-50 kg N/ha (urea) (Early Nov 40-50 kg N/ha only if required)	5 weeks after emergence 100 kg N/ha (urea) 11 weeks after emergence 100 kg N/ha (urea)
Harvest	Late November As green-chop silage	Late May to mid-August Direct grazed
Expected yields[2]	5–7 t DM/ha	10–13 t DM/ha

[1] Assumes good seed-bed conditions at sowing. Seed rates should increase if conditions are less than ideal for germination.

[2] Will be affected by soil type

Figure 6: Research management activities



Check list: Is sequence cropping feasible in your farm system?

Review the below check list when considering sequence cropping

YES / NO	Checklist for deciding if sequence cropping with kale and oats is appropriate
What are your goals with sequence cropping?	
	Do you want to reduce N leaching from winter crops?
	Do you want to increase total annual production over standard kale crop?
Should you try sequence cropping?	
	Do you grow kale as a winter forage crop?
	Do you have the knowledge or can you contract someone to manage the crops?
	Can you grow kale on the same area of land for 2 or more years?
	Does the area you have designated for the crops have reliable irrigation or high and reliable summer rainfall?
	Are the soils free-draining and is the ground level?
	Can the soils bear heavy traffic in August (early September at the latest)? There is potential for soil compaction with cultivation and sowing of oats.
	Can 90+% utilisation of the winter feed crop be achieved? Otherwise crop residues may disrupt the efficiency of cultivation/drilling.

Resources

DairyNZ Fact Sheets
dairynz.co.nz/southernwintering

- Crop Paddock Selection
- Transitioning Cows onto Crops Fact Sheet
- Drying-off Cow Management Fact Sheet

DairyNZ Farmfacts
dairynz.co.nz/publications/farmfacts

- DairyNZ Farmfact: Fodder beet - feeding to dairy cows (1-73)
- DairyNZ Farmfact: Kale - growing a high yielding crop (1-74)
- DairyNZ Farmfact: Winter Crops - Feeding to Dairy Cows (1-75)
- DairyNZ Farmfact: Fodder beet - growing a high yielding crop (1-77)

DairyNZ Information booklets
dairynz.co.nz/publications/environment

- Reducing Nitrogen loss: A guide to good management
- Nutrient management on your Dairy Farm: A farmers guide to understanding how nitrogen and phosphorous cycle through your dairy farm

DairyNZ Information booklets
dairynz.co.nz/publications/feed

- Management practises for forage brassicas

Calculators

- Winter Crop Allocation Calculator (dairynz.co.nz/feedtools)

Articles

- Edwards GR, deRuiter JM, Dalley DE, Pinxterhuis JB, Cameron KC, Bryant RH, Di HJ, Malcolm BJ, Chapman DF (2014) Dry matter intake and body condition score change of dairy cows grazing fodder beet, kale and kale-oat forage systems in winter. Journal of New Zealand Grasslands 76, 81-87.
- Cary P.L, Cameron K.C, Di H.J, Edwards G.R, Chapman D.(2015) Sowing a winter catch crop can reduce nitrogen leaching losses after winter forage grazing (submitted for publication)).

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