September 2011

Technical Series

Issue 5

ISSN 2230-2409

DairyNZ

0800 4 DairyNZ (0800) 4 324 7969 dairynz.co.nz

Reproductive failure – do cows need more feed to get in calf?

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Summary

- Cow fertility has declined significantly over the last two decades for many reasons
- Nutrition is important for getting cows in calf. This does not mean you will get more cows in calf by feeding supplements during the breeding season
- Achieving body condition score (BCS) targets at calving is the most important nutritional influence on getting cows in calf. Late lactation and dry cow nutrition are, therefore, very important
- Transition cow management to reduce liver inflammation in early lactation may be important in reducing uterine infections
- Supplements are unlikely to improve fertility when grazing residuals are 1,500-1,600 kg DM/ha or greater
- Starch (grain) or sugar (molasses)-based supplements in early lactation have inconsistent effects on post-calving anoestrus and some reports suggest these supplements will reduce embryo survival following insemination
- High protein intake does not reduce conception rates in pasture-based systems.

Background

Getting lactating cows in calf has never been easy. It has become even harder over the last 25 years.

- **USA:** inter-calving interval increased by 1 month and services per conception increased 33%[1]
- **Ireland:** services per conception increased by 14%[2]
- **UK:** calving rate to first insemination declined from 56% to 40%[3]
- **New Zealand:** 6-week re-calving rate declined from 70% to 50%[4].

These studies indicate a reduction in conception rate and an increase in embryo mortality over the last 25 years, while longer post-calving anoestrous intervals and reduced expression of oestrus have also contributed to the decline[1,5].

During the same period, milk production/cow has increased and cows now tend to lose more BCS in early lactation. Because of this, many people have associated failure to get cows in calf with negative energy balance in early lactation and assume that feeding cows more pasture (higher post-grazing residuals) or feeding particular supplements in early lactation will improve reproduction. DairyNZ staff recently reviewed the scientific literature on the effect of nutrition on fertility for pasture-based cows. The following is a summary of their findings.

Reproductive failure – influence of genetics

Comparisons between New Zealand cows and those of North American ancestry offered the same diet proved a strong effect of cow genetics in reproductive failure. Supplements do not correct the poor reproductive performance of the North American cow. New Zealand cows cycle later[6] after calving but have higher conception rates and, as a result, higher pregnancy rates than North American cows. Although North American cows lose more BCS in early lactation[6,7] the difference in BCS does not explain the increased reproductive failure. Detailed experiments at DairyNZ have discovered that there are important differences between these strains in the:

a. length of their reproductive cycle

b. concentration of important hormones circulating in blood

c. expression of key genes in the uterus that enable the embryo to grow and survive.

It is unlikely that these genetic effects can be overcome by nutrition. However, there is significant research effort into discovering genetic markers that will allow the rapid selection of bulls for improved fertility in the future.

Reproductive failure – influence of nutrition

Many nutritional factors have been suggested as contributing to the decline in fertility in New Zealand.

Body condition score: Body condition score at calving is, arguably, the most important nutritional factor associated with getting cows pregnant. Cows that are fatter at calving, cycle earlier and tend to be fatter at mating[8]. However, cows that are too fat lose excessive condition after calving and are less likely to conceive. For this reason, it is recommended that mature cows calve at BCS 5.0; this ensures they cycle early, lose no more than 1.0 BCS unit between calving and mating, and are greater than BCS 4.0 at mating[8]. Younger cows (heifers and second calvers) tend to be healthier and less prone to disease (mastitis and endometritis)[8,9] if they calve a little fatter than mature cows (BCS 5.5).

It is important, therefore, to pay attention to nutrition during late lactation, at drying off time and in the dry period to ensure that cows reach recommended BCS targets.

Transition period: Nutrition during the transition between dry/pregnant and lactation influences liver health after calving. This may affect the incidence of uterine infection and, in particular, subclinical endometritis and these effects may be present for more than six weeks post-calving[10].

Subclinical endometritis is an inflammation of the lining of the uterus (endometrium) more than 21 days post-calving, but with no obvious signs that the cow is not well (i.e. no uterine discharge, near normal milk production, eating and ruminating normally, etc). New Zealand data indicate that subclinical endometritis can affect 30 to 40% of cows, even in well managed herds, and can reduce reproductive performance. The worst affected cows (up to 20% of the herd) will have a 20% lower conception rate to first service (from 54% to less than 35%)[9,10] and conception is delayed by more than 20 days[10]. There is some evidence that this endometritis may be associated with transition cow nutrition[9], but this is not certain.

Cows are healthier in early lactation if they achieve a BCS of 5.0 a month pre-calving and are partially restricted in the weeks before calving[11,12,13,14]. Best practice management of the transition cow is not to feed her as much as she can eat before calving, as has been recommended in the past[15]. Springers should consume 80% of their energy requirements each day during the 2 to 3 weeks before calving (i.e. they should be offered approximately 90% of their energy requirements to account for wastage). These recommendations are also appropriate for heifers[11].

NOTE: this is not appropriate management for cows that have not achieved a BCS of 5.0.

Intake: Many believe that cows fed only pasture cannot eat enough to meet demand and that supplements will, therefore, improve energy balance[16]. It is true that cows cannot eat sufficient DM in early lactation to meet energy requirements for milk production; they will be in negative energy balance and will, therefore, lose BCS.

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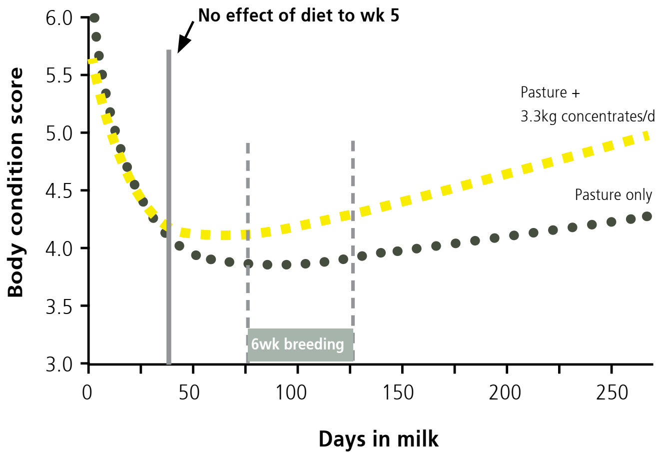
This is primarily controlled by genetics, and feed amount or feed type have little effect on BCS loss in the first 4 to 5 weeks of lactation[7,8] (Figure 1).

Although a negative energy balance during mating will reduce the likelihood of a cow getting in calf, the effect on fertility is not as great as many think. DairyNZ data[17] indicate a reduction of 4% in 6-week in-calf rate if cows lose 2.0 BCS units between calving and mating compared with cows that lose 1.0 unit. Furthermore, in a large study in which cows had a 40 to 50% restriction for the first two weeks of mating, cows had a 6-7% lower pregnancy rate to first service and 6-week in-calf rate[18]. Although such a decline in fertility is important, this was a very severe restriction. Results indicate that a poor feeding level in early lactation is not the main reason for poor fertility and that supplementation per se will not greatly improve in-calf rates.

Supplementation can influence BCS from week six of lactation onwards (Figure 1), but the effect is small[7]; results from New Zealand studies suggest that feeding cows 290 kg of a maize grain-based concentrate (i.e. 13 MJ ME/kg DM) increased cow BCS by 0.25 units[7] at the start of mating and cows gained more condition through mating (0.1 BCS units over 42 days[7]) than if they were offered pasture alone (Figure 1). This difference in BCS and in BCS change, however, would only be expected to increase the 6-week in-calf rate by 1%[17].

Collectively, results suggest that low DM intake in early lactation is not the major cause of reproductive failure in New Zealand. If cows are grazing to residuals of 1,500-1,600 kg DM/ha, offering supplements will not improve reproduction. If cows are grazing to residuals below 1,500 kg DM, providing cows with energy supplements will very likely improve milk production and reproduction.

Figure 1. Effect of supplementing cows with 3.5 kg/d of a concentrate feed throughout lactation on BCS gain compared with cows grazing fresh pasture[7].



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Supplementing with starch/sugar in early lactation: Although there is evidence that increasing the amount of starch (e.g. cereal grain) or sugar (e.g. molasses) in the cow's diet in early lactation results in a shorter period of anoestrus[19,20], the effect is inconsistent. A large amount of data indicates no benefit of supplementation with starch or sugar on post-calving anoestrus[21,22,23,24] when cows are grazing to residuals of 1,500-1,600 kg DM/ha. In addition, DairyNZ data[25] indicate that supplementing cows with starch in early lactation increases the production of fat in the liver, a factor believed to reduce cow health[26] and possibly reduce conception rate[9]. There is also evidence that supplementation with starch (e.g. grain), or sugar-based (e.g. molasses) feeds can reduce embryo survival following insemination[27].

Too much protein in pasture: Although there is evidence internationally that too much rumen degradable protein reduces conception rates, evidence from pasture-fed cows and heifers[28,29,30] do not agree. In these studies, higher crude protein pastures or higher blood urea nitrogen concentrations did not reduce fertility. These studies included blood and milk urea nitrogen concentrations three to four times higher than would be regarded as problematic in the United States. The reason for this inconsistency is unclear, but available data suggest that dietary protein is not a major factor effecting reproductive failure in New Zealand.

Conclusions

There are many reasons why cows do not get in calf. However, nutrition of the cow during breeding tends to be over-emphasised.

Late lactation and dry cow nutrition to achieve a BCS of 5.0 at calving in mature cows and BCS 5.5 for heifers and second calvers is arguably the most important nutrition-related influence on fertility in the New Zealand system. There is also evidence that level of feeding pre-calving and its effect on liver health may affect reproduction.

Other feeds are not better than pasture in early lactation. Therefore, if grazing residuals are 1,500-1,600 kg DM/ha or greater, supplementation will not improve reproduction.

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Grazing management guidelines for optimal pasture growth and quality

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DairyNZ recommendations for perennial ryegrass pastures are to:

- Graze between the two and three leaf stage – at the three leaf stage if short of feed and at the two leaf stage if there is plenty of feed and you do not want to make silage. If continually grazing at the two leaf stage, re-assess your stocking rate and/or nitrogen fertiliser decision rules
- Graze to consistent, even post-grazing residuals of 3.5-4 cm height (1,500-1,600 kg DM/ha using the RPM winter formula) to maximise pasture yield and quality, and milk production. Lower residuals will reduce pasture regrowth (except in winter). Higher residuals result in areas in the paddock with more than 5 cm of residual pasture (2,000 kg DM/ha) and reduced pasture quality in subsequent rotations.

Background

The ability to graze cows year round provides a low cost, competitive edge to New Zealand dairy farming. To maximise sustainable profit, farmers must balance requirements of the cows with those of pasture plants. The pasture plants used are relatively forgiving of mismanagement. However, mismanagement affects pasture yield and quality, and therefore energy utilisation/ha. This article aims to clarify optimal grazing management for the plant and for the cow.

When should pasture be grazed?

Perennial ryegrass plants consist of a number of tillers connected at the base. Each vegetative tiller is able to maintain about three live leaves; as the fourth leaf emerges, the oldest leaf dies.

After grazing, regrowth of well-utilised pasture follows the stages presented in Figure 1. Immediately after grazing, growth of roots and new tillers stops, and the plants begin to use stored energy reserves (water soluble carbohydrates; WSC) to grow a new leaf[1]. Once tillers have grown between a half and one full new leaf, roots begin to grow and the plant begins storing WSC reserves. Around the two leaf stage, growth of new tillers begin. Between the two and three leaf stages, WSC reserves are replenished to pre-grazing levels. This is an indication that the plant is ready for grazing again.

Due to the above factors, pasture regrowth immediately after grazing is slow, accumulating approximately 15% of total pasture yield between grazing and the one leaf stage (Figure 2). Growth between the one and two, and two and three leaf stages is more rapid, accounting for between 35-40% and 45-50% of total pasture yield, respectively. This has implications for rotation length.

Rotation lengths affect pasture growth and quality

Grazing perennial ryegrass pastures close to the three leaf stage maximises pasture regrowth and quality. Pastures should not be grazed before the two leaf stage as:

1. The phase of rapid growth will be shortened, reducing total pasture accumulation
2. The failure of tillers to replenish the necessary WSC reserves will reduce the ability of plants to tiller and survive stress periods (e.g. summer)[1].

The only time that pastures should be grazed before the two leaf stage is when you can't see any bare ground through the pasture (i.e. canopy closure) or when you are trying to reduce pasture growth rates to manage a surplus in low stocked systems. However, this should not be done repeatedly or the plant will die. If pastures are consistently at canopy closure before the two leaf stage, re-assess the nitrogen fertiliser policy (nitrogen grows bigger leaves) or post-grazing residuals (high residuals result in canopy closure earlier in the regrowth cycle).

Perennial ryegrass pastures should not be grazed after the three leaf stage[1], except when cover is being managed to transfer feed into early spring or summer deficit periods. After the three leaf stage, older leaves begin to die, reducing pasture quality. Grazing pastures beyond this point can also result in reduced tillering[2] and increased stem formation due to decreased light penetration.

Leaf appearance rates depend mainly on temperature and moisture availability, with leaves taking longer to appear when it is cooler or when soil water is limited. Table 1 presents approximate leaf appearance rates for different regions based on average temperatures and soil water availability of at least 40%. To determine the minimum rotation length (i.e. two leaf stage) multiply the time taken for a leaf to grow by two, and for the maximum rotation length multiply the time taken by three. This can be used as a guide but it is important to determine the leaf stage of your own pastures.

To determine the leaf stage of a perennial ryegrass pasture, collect 10 ryegrass tillers across the paddock. Ryegrass tillers are usually red/purple at the base (may have to peel back dead leaves to see). Compare each of the tillers with those in Figure 1; if they are all between the two and three leaf stages then the paddock is ready to be grazed. For more information contact the DairyNZ Information Service on 0800 4 DairyNZ (0800 4 324 7969).

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Table 1. Approximate regional leaf appearance rates based on average monthly temperatures[3].

NOTE: this is just a guideline – actual rates will vary with temperature and soil moisture.

	Spring	Summer	Autumn	Winter
Northland				
Average temperature	13-16°C	18-20°C	14-20°C	10-13°C
Time taken for one leaf to fully grow	9-11 days	8-10 days	8-12 days	11-15 days
North Waikato				
Average temperature	11-16°C	16-20°C	12-20°C	9-12°C
Time taken for one leaf to fully grow	9-13 days	8-11 days	8-14 days	12-16 days
South Waikato				
Average temperature	9-16°C	16-19°C	10-18°C	7-10°C
Time taken for one leaf to fully grow	9-16 days	9-11 days	10-17 days	15-21 days
Bay of Plenty				
Average temperature	10-16°C	16-20°C	11-20°C	7-12°C
Time taken for one leaf to fully grow	9-15 days	8-11 days	8-16 days	12-21 days
Taranaki				
Average temperature	10-16°C	14-18°C	10-18°C	8-10°C
Time taken for one leaf to fully grow	9-15 days	10-12 days	10-17 days	15-18 days
Lower North Island				
Average temperature	10-16°C	14-20°C	10-18°C	8-10°C
Time taken for one leaf to fully grow	9-15 days	8-12 days	10-17 days	15-18 days
Top of South Island/Westland				
Average temperature	10-16°C	14-18°C	10-18°C	7-9°C
Time taken for one leaf to fully grow	9-15 days	10-12 days	10-17 days	16-21 days
Canterbury/North Otago				
Average temperature	7-14°C	13-18°C	6-16°C	2-8°C
Time taken for one leaf to fully grow	10-21 days	10-13 days	11-28 days	18-72 days
Southland/South Otago				
Average temperature	7-13°C	13-18°C	6-15°C	2-8°C
Time taken for one leaf to fully grow	11-21 days	10-13 days	12-28 days	18-72 days

**Assuming that available soil moisture is at a minimum of 40%, if it is less than 40% the time taken for a leaf to fully grow will increase dramatically.*

Recommendations for other pasture grasses are slightly different. Tall fescue pastures should be grazed between the two and four leaf stages, with herbage quality declining after the two leaf stage[4]. Prairie grass and cocksfoot pastures are best grazed between the three and four leaf stages[5].

Post-grazing residuals affect pasture growth and quality

DairyNZ recommends a consistent, even, post-grazing residual for ryegrass/white clover pastures (1,500-1,600 kg DM/ha using the winter formula for the rising plate meter (RPM) or 7-8 clicks on the RPM or 3.5 to 4 cm height). This recommendation maximises utilisation of high quality pasture/ha, while not unduly penalising cow production.

In a DairyNZ study[6], residuals of 1,500 to 2,300 kg DM/ha did not affect pasture regrowth (Figure 3). However, the pasture was cut with lawnmowers to a consistent, even height. In reality, it is very difficult to obtain consistent, even residuals under grazing when the average residual is more than 1,600 kg DM/ha (8 clicks RPM or 4 cm height) because areas of the paddock will have longer clumps of pasture. Because of the additional grass within the clumps, the amount of light reaching the base of the pasture is reduced[7]. After two to three rotations of higher residuals, tillers produce stem to push their growing point towards the light, as tillers will die if they do not get enough light. The increased stem production reduces pasture quality and potentially milk production[8,9]. In addition, growing points above ground level are more likely to be grazed by cows, resulting in tiller death and reducing pasture growth and persistence. To avoid this the aim is to treat pasture as a crop and harvest what has grown since the last grazing, leaving consistent and even residuals (clumps grazed into) between 3.5 – 4 cm height (1,500 and 1,600 kg DM).

Grazing below 3.5 cm or 1,500 kg DM/ha is discouraged in most situations as it reduces pasture regrowth. This is because the plant's WSC energy reserves stored in the 4 to 5 cm of plant above the ground (i.e. the plant stubble) are reduced. For example, reducing residuals from 1,500 to 1,100 kg DM/ha reduced the stubble WSC reserves by half, which restricted regrowth[6]. This is commonly seen in dry summers, when cows often graze lower than 3.5 cm because of a feed shortage. In those situations, pasture recovery is slower than expected when the autumn rains arrive. If residuals are below 3.5 cm, supplements can be used to bring residuals back to the target to ensure high pasture regrowth[10].

The exception to this rule is during winter, when pastures can be grazed as low as 2.5 cm or 1,200 kg DM/ha without reducing pasture regrowth[11,12]. This is because stubble WSC reserves are higher due to slower plant growth and less energy use at night due to the colder temperatures. Care must be taken in wet conditions to avoid pugging.

Figure 1. The leaf stages of well-utilised perennial ryegrass pasture as it regrows.

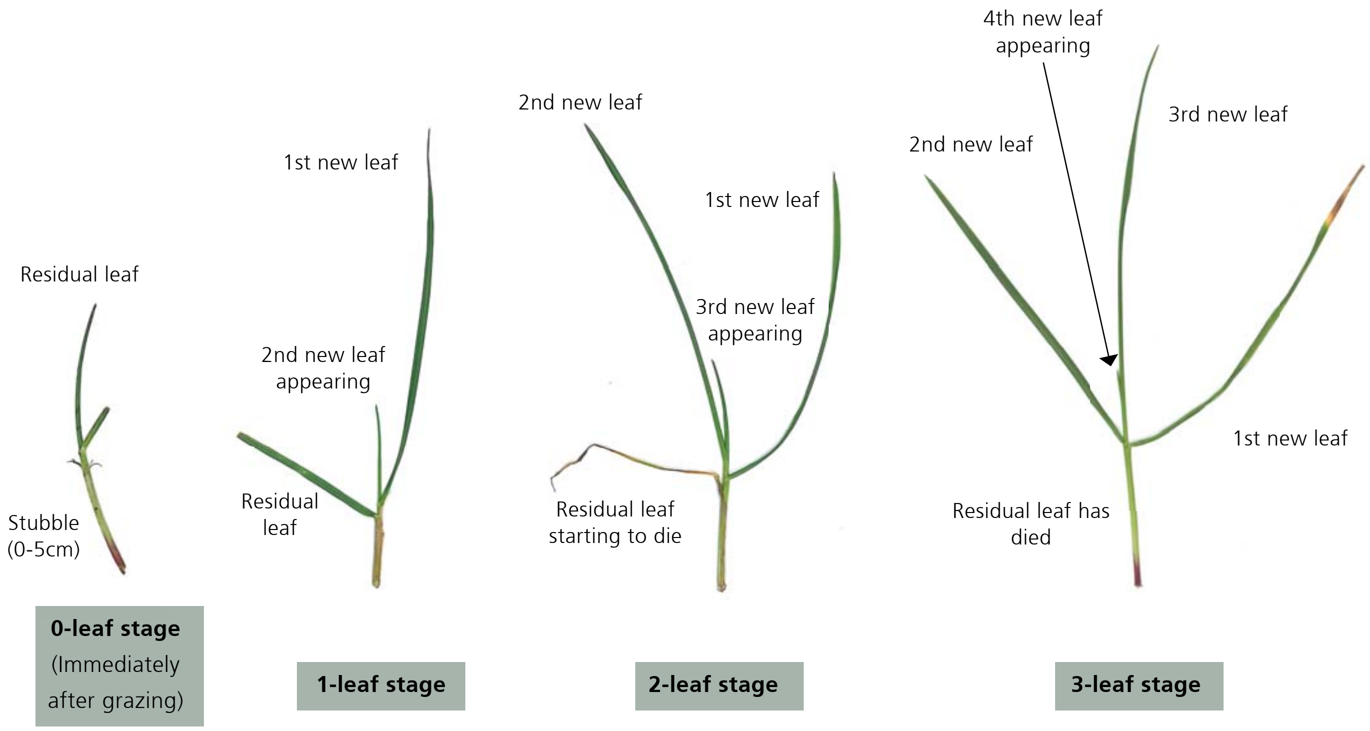

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Figure 2. The curve of pasture regrowth, with the approximate proportion of total growth that accumulates between each leaf stage[13].

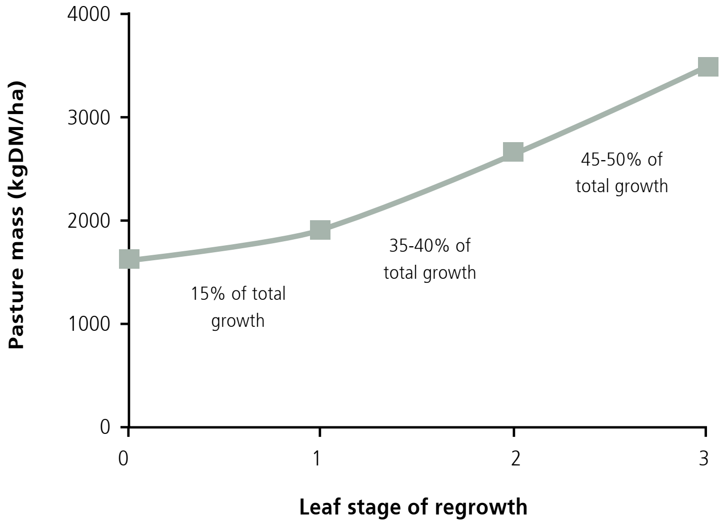
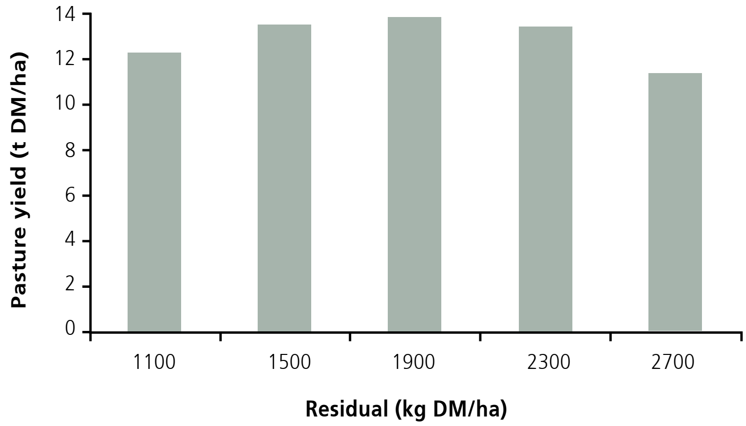


Figure 3. Total yield from ryegrass pastures cut to different residuals between September and April[6].



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Pasture silage – maximising the return on your investment

Kevin Macdonald, DairyNZ Senior Scientist Farm Systems; Phillipa Hedley, DairyNZ Developer; Productivity, John Roche, Principal Scientist Animal Science.

Summary

- Pasture cut for silage must be of high quality. It doesn't improve in quality after it has been turned into silage. To achieve high quality silage:
  - areas identified for silage must be closed early (preferably before balance date)
  - grazing residuals should be 1,500 kg DM or less in these paddocks
  - heavily pugged paddocks should be rolled to avoid soil contamination of the silage
- Harvesting, compacting and covering of the stack must be done quickly to reduce spoilage
- Inoculants may improve the fermentation process, but will not turn poor quality grass into good silage. All inoculants do not work the same. Ask to see the research results that show the inoculants improves silage quality and/or animal production
- Attention to detail is required when feeding out to minimise losses both at the stack and in the paddock/ feed pad.

Background

Pasture silage is a major source of supplementary feed on New Zealand dairy farms. Its importance is twofold:

1. It facilitates the removal of pasture surplus to the herd's immediate needs, enabling the provision of higher quality pasture in late spring/early summer, and
2. It provides a good quality feed supplement for summer/ autumn milk production and autumn body condition score (BCS) gain.

Making high quality pasture silage should not be difficult, but it must be viewed as an investment in supplementary feed rather than a "necessary evil" to manage pasture. The objective in making silage is to preserve as many of the original nutrients as possible. In practice, however,

- The silage is often not made at the optimal time. This reduces the pasture quality advantage and the value of the silage as a supplementary feed
- Poor attention is often paid to the silage making process. This increases fermentation losses[1] and reduces the value of the silage as a supplementary feed.

The important points in making high quality silage will be discussed.

What is silage?

When grass is cut and left in a heap, it rots! Silage making is the process of "pickling" pasture to reduce the pH (acidity) to a level that stops microbial activity (stops the feed "rotting"). This is achieved through compacting the pasture and covering with plastic to exclude air, while microorganisms "burn" the sugars in the grass to produce lactic and acetic acid. When enough of these acids are produced, no further breakdown of the pasture occurs. The micro-organisms can be either naturally present in the grass or added in the form of inoculants[2].

A high pH in silage indicates inefficient fermentation, possibly resulting from:

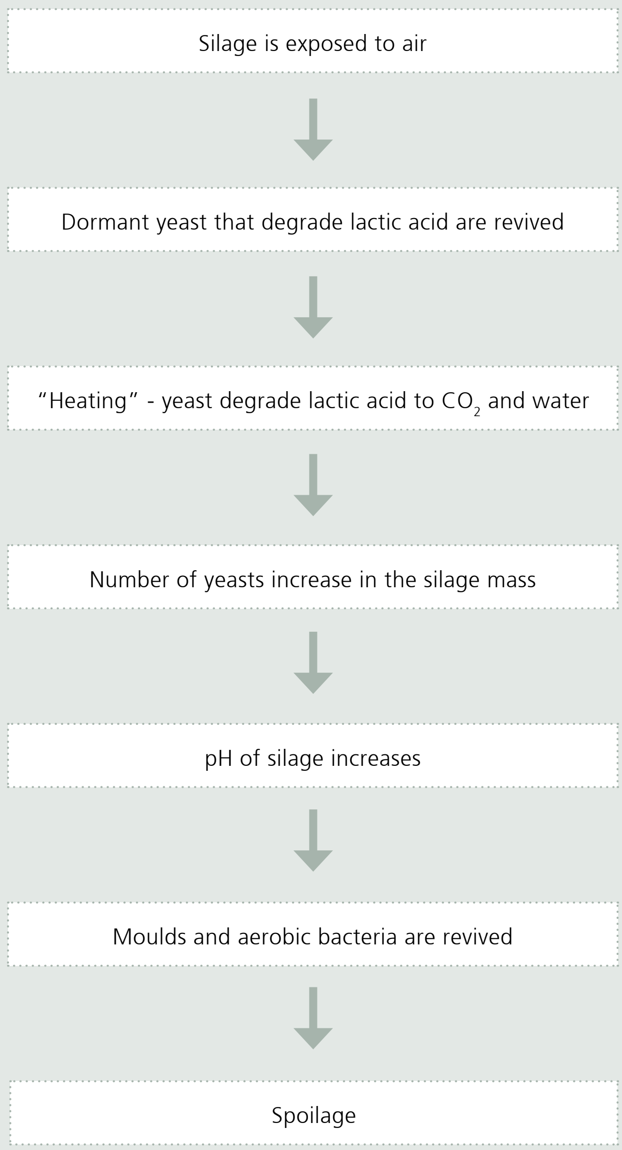
- low pasture sugar content
- high pasture N content
- excessive soil contamination
- not compacting the stack sufficiently
- not covering the stack quickly and thoroughly
- not using sufficient tyres to hold down the plastic
- not checking for damage to the plastic regularly
- not controlling vermin, cats, birds that damage the plastic covering.

If the silage is exposed to air (e.g. torn plastic), a chain reaction occurs that reduces silage quality (Figure 1). Yeasts that cannot grow without air become active once more and break down the acids in the silage ("heating"). This causes the pH to rise, allowing the bacteria that were suppressed at low pH to grow once more. These bacteria use the energy and protein in the pasture, causing massive spoilage. These silages can also have a high concentration of butyric acid, which reduces palatability and dry matter intake and, if fed in early lactation, increases the risk of ketosis.

Most silage analyses provide you with indicators of how well the pasture was fermented. Key things to take note of include:

- **Dry matter (DM%)**: pasture that has a DM% below 25% is more difficult to ensile well and will lose nutrients through effluent loss. Pasture with a DM% above 35% is more difficult to compact (especially if not precision chopped) and generally takes longer for the pH to drop.
- **pH:** this is an indicator of how well the fermentation process has gone. A high pH (>4.5) generally indicates that air was not excluded properly.
- **Ammonia-N (NH_3-N):** this is an indicator of how much protein has been broken down by bacteria. In well preserved silage, NH_3-N should be less than 10%.
- **Lactic acid (% DM or % total acid):** is an indicator of how successful the fermentation was, how successful your choice of inoculant was, and how palatable the silage will be. In pasture silage, total acids can be 2-10% DM. Ideally silages will be 5-7% total acid of which more than 50% is lactic acid.
- **Butyric acid (% DM or % total acid):** this is an indicator of secondary fermentation and soil contamination. Air has either not been excluded from the stack or the plastic has become ripped. The pasture ensiled was contaminated with soil (pugged paddock not rolled), providing clostridial bacteria that convert sugars to butyric acid. Butyric acid should be less than 1% DM.

Figure 1. Sequence of events that occur when air enters the silage stack[3].



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Why is silage quality important?

Silage is used to feed both lactating and dry cows during times of pasture deficit or to increase BCS gain while building pasture cover in the autumn. Therefore, it must be of the highest possible quality. DairyNZ data suggest that increasing silage quality by 2.3 MJ ME/kg DM increases milksolids production by 13, 17 and 41% in spring, summer and autumn, respectively[4]. As is recommended for all feeds, the value of silage as a supplement must be based on its quality (i.e. its ME energy content). Quality is all about energy, the wrong acids reduce palatability.

Should I be making my silage in bales or in a stack/pit?

Pasture silage can be made either in a field stack, a pit/concrete bunker (on top of the ground) or as bales. Provided the quality of the material going into the silage is the same and proper attention is paid to covering the pasture and ensuring no air enters the stack after covering, pasture silage quality should be the same from either stack/pit or baled silage. The decision to make bales or stack/pit silage is generally dependent on the farm system, the method of feeding silage and the infrastructure available for silage storage.

- **Baled silage** allows flexibility – the ability to remove small crops of pasture when desired and the ability to store and feed it in multiple locations. This method generally suits situations when there is only small surplus and to reduce the risk of creating a deficit the paddocks are only shut for up to a week longer than the grazing rotation. As the pasture crop is often lighter, silage quality can be greater and regrowth recovery is generally faster. If the baled pasture is not chopped further, utilisation of the silage can be greater when fed in the paddock. A disadvantage is the cost and need to dispose of large quantities of plastic wrap.
- **Stack/pit silage** can also be fed in multiple locations on the farm, and is cheaper than baled silage provided the yield of pasture ensiled is greater than 30 t DM/ha or the silage is added to an existing pit.
- **Pit/bunker silage** does not offer flexibility in storage, but, when properly used, reduces wastage relative to stack silage. Pit silage is easier to compact and, therefore, expel air. The disadvantage, however, is the need for greater capital investment.

The stack/pit must be filled, compacted and covered quickly to exclude air and allow the 'pickling' process to start. Any delay in this process will compromise the quality of the silage. If making silage is going to take more than one day, do not leave a stack or pit uncovered at night. A plastic cover should be pulled over the stack/pit each night and weighed down on the edges with tyres. This will reduce respiration losses and prevent spoilage[5].

Are there advantages to precision chopping?

Modern mowers, balers and forage harvesters facilitate chopping pasture to 3-5 cm (i.e. precision chopped). Precision chopping pasture for silage provides an advantage in stack compaction and, therefore, silage quality, provided other factors important in silage making are followed (e.g. high quality, clean pasture at 25-35% DM). It is particularly useful when the pasture is greater than 30% DM. There is significant evidence in sheep and dairy cattle that DM intake of precision chopped silage is greater than "flail chopped" silage[5]. However, there is only limited evidence that this greater intake results in greater animal production.

Making high quality silage in practice

Rubbish in, rubbish out.

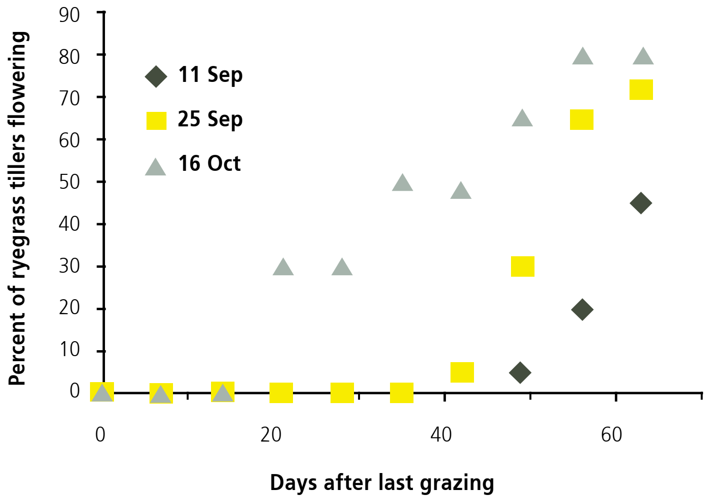
The pasture you put into a stack cannot improve in quality. Therefore, it is important to ensure that the pasture to be ensiled is as high quality as possible.

The drive for higher silage yields/ha to reduce the cost/t DM of making pit or stack silage has often been used as an excuse for ensiling "overgrown" pasture (i.e. pasture that has been growing for too long since its last grazing). New Zealand data indicate that pasture quality does not decline between 10 to 40 days after grazing in early spring[7,8].

Wrenn and Mudford[9] reported that with later closure of the paddock, pasture quality declined earlier due to increased seed head emergence. Therefore, they recommended earlier rather than later closure. Their data from both Waikato and Taranaki indicate that silage can be made six to seven weeks after closing without major loss in quality when the final grazing was in the two weeks before balance date. When the silage area was closed two to four weeks after balance date, there was a significant drop in pasture quality within three weeks of closing because of seed head emergence (Figure 2).

In addition to the closing date effect on silage quality, Wrenn and Mudford[9] also noted an effect of post-grazing residuals before closing. Their data indicated that for every extra 100 kg DM/ha increase in grazing residual in the grazing before closing for silage, pasture should be closed for 1.4 days less. Therefore, if post-grazing residuals were 1,500 kg DM/ha (3.5- 4.0 cm) in a proposed silage paddock in early September, the optimum closure period is six weeks. If, in comparison, there is a residual of 1,800 kg DM/ha, the pasture should be cut after five weeks to optimise yield and quality. If the decision to make silage is delayed, such that paddocks are not closed until early October, and the post-grazing residual is 1,800 kg DM/ha, pasture quality will start to decline after 15 days and the resultant silage quality will be poor.

Figure 2. Effect of date of last grazing before making silage, on the percentage of ryegrass plants with seed heads before silage making. The earlier the pasture is closed for silage, the longer the period of closure before significant loss of quality from seed heads[9].



These results mean that you can have your cake and eat it too (i.e. have high yields of silage of high quality), as long as the silage is made early (approximately four to five weeks after balance date - when pasture growth exceeds herd demand). Earlier than this and the risk of underfeeding the herd is increased; later than this and pasture will be "heading" during silage making, with quality of pasture to be ensiled declining as rotation length increases. In addition, a dry November-December period will reduce pasture recovery.

Planning for a surplus

Failing to plan, is planning to fail! Although pasture silage is the conservation of "surplus pasture" during peak pasture growth, maximising yield of high quality pasture silage requires that this surplus is expected and its removal planned months in advance.

This is particularly important when pit or stack silage is being made. If pasture silage is only planned when pre-grazing mass exceeds the desired amount for the milking herd and then closed for a period to maximise yield before harvesting, the silage is often made 50-60 days after balance date; quality of the material being ensiled in such situations is generally poor (ME<10.5 MJ/kg DM and crude protein <15%)[7]. Alternatively, if harvested immediately on recognising the surplus, yield/ha is low and the cost of the silage may be expensive relative to other supplements.

To ensure that silage is made at the correct time to maximise yield and quality:

- The area available for silage must be calculated
- The contractor must be booked to ensure availability when required
- Decisions have to be made about additives.

Area to close for silage

The amount of farm area that can be taken out for silage on an average year is equal to:

$$\frac{100 \times (\text{Pasture growth rate} - (\text{Stocking rate} \times \text{Cow pasture intake}))}{\text{Pasture growth rate}}$$

For example, if peak growth rate is 75 kg DM/ha/day, stocking rate is three cows/ha and cows are expected to eat 17 kg DM/day, the area available for silage on an average year is:

$$\frac{100 \times (75 - (3 \times 17))}{75} = 32\%$$

In comparison, if peak growth rate is 60 kg DM/ha/day and stocking rate is three cows/ha, only 15% of the farm area can be closed for silage. In reality, you want to close less than what is theoretically possible, allowing some additional pasture for the herd in case growth rates are not as high as average, but being prepared to remove additional areas strategically as baleage.

Planning the surplus: Ideally, the silage area should be scheduled into the winter/spring grazing plan (e.g. spring rotation planner) so that it is grazed in the month before balance date (See Figure 3). Doing this recognises that there will be a surplus of pasture at the end of the second round. However, by doing it in this way, the silage ground will be closed and fertilised one to two weeks before balance date, ensuring that silage can be made four to five weeks after balance date.

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Apply 40-50 kg N/ha to three-quarters of the silage ground and 30 kg N/ha to the remaining quarter. This allows you to utilise this quarter of the silage area for grazing if you need to. On some farms harvesting on some paddocks may be an issue due to contour, therefore, planning is even more important to ensure that surplus feed occurs in the paddocks that are harvestable.

To inoculate or not

When a crop is ensiled, the bacteria naturally present turn sugars into acids. To aid this process, inoculants are applied to increase the population of "desirable" bacteria, thereby ensuring a more rapid reduction in pH and speeding up the 'pickling' process.

However, this is not always the case. Inoculants are not all the same. They differ in their effectiveness and other factors (i.e. pasture quality, weather, management) influence their effectiveness. Inoculants will not help preserve silage where poor silage making processes are followed.

There are many different types of inoculants on the market. The most effective inoculants will be those that reduce pH quickly, produce the most lactic acid relative to acetic acid, and increase the time taken for the silage temperature to rise when the stack is opened. If in doubt about what inoculants to choose, ask for the research supporting the claims for the product. If none is available, choose an alternative for which this information is available.

If the data on these characteristics are not available for an inoculant, you should not presume that it will improve your silage quality.

Minimising losses

Field losses can be minimised by ensuring the paddocks chosen for silage are the largest paddocks, to minimise machinery turning, rectangular shaped, to avoid more corner losses than necessary, and that water troughs and other obstacles (e.g. electricity pylons) can be easily avoided. Cows and older heifers can be used to graze the headland areas to minimise field losses, but do not allow these in long enough to start grazing the regrowth. Even in the best conditions these losses will be 5-10% of the pasture available[10].

Losses in the stack can be minimised by:

- Reducing the length of time that the cut material is exposed to air
- Ensuring the stack is well packed (tractor tyre grip marks) and covered with plastic promptly
- Ensuring that the entire stack is covered in tyres (tyre to tyre touching) to hold the cover in place.

Even with perfect diligence, 5-10% of DM will be lost during ensiling. If not careful, losses can be greater than 25%.

Feeding out losses can be controlled by allowing the silage sufficient time to ferment and by ensuring the correct shape of stack/pit for herd size. Depending on the inoculants used, the stack should not be opened for three to four weeks after closing. When open, the face should be cleaned daily to ensure the material at the front is not exposed to air for longer than 24 hours and movement of the silage within the stack should be minimised (preferably through use of a block cutter/shear grab). Wastage at feeding out can be reduced by ensuring that cows have good access to the feed but that they cannot trample it into the ground. Thus it is best to feed it in troughs or on a feed pad.

Figure 3. Schematic of grazing rotation before balance date

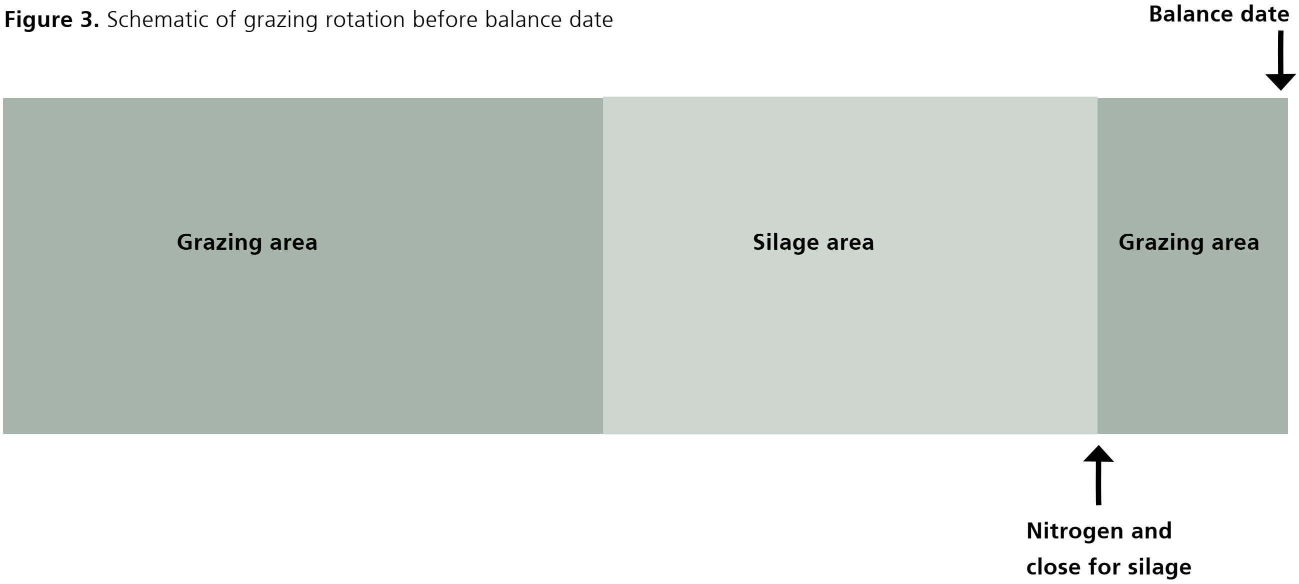
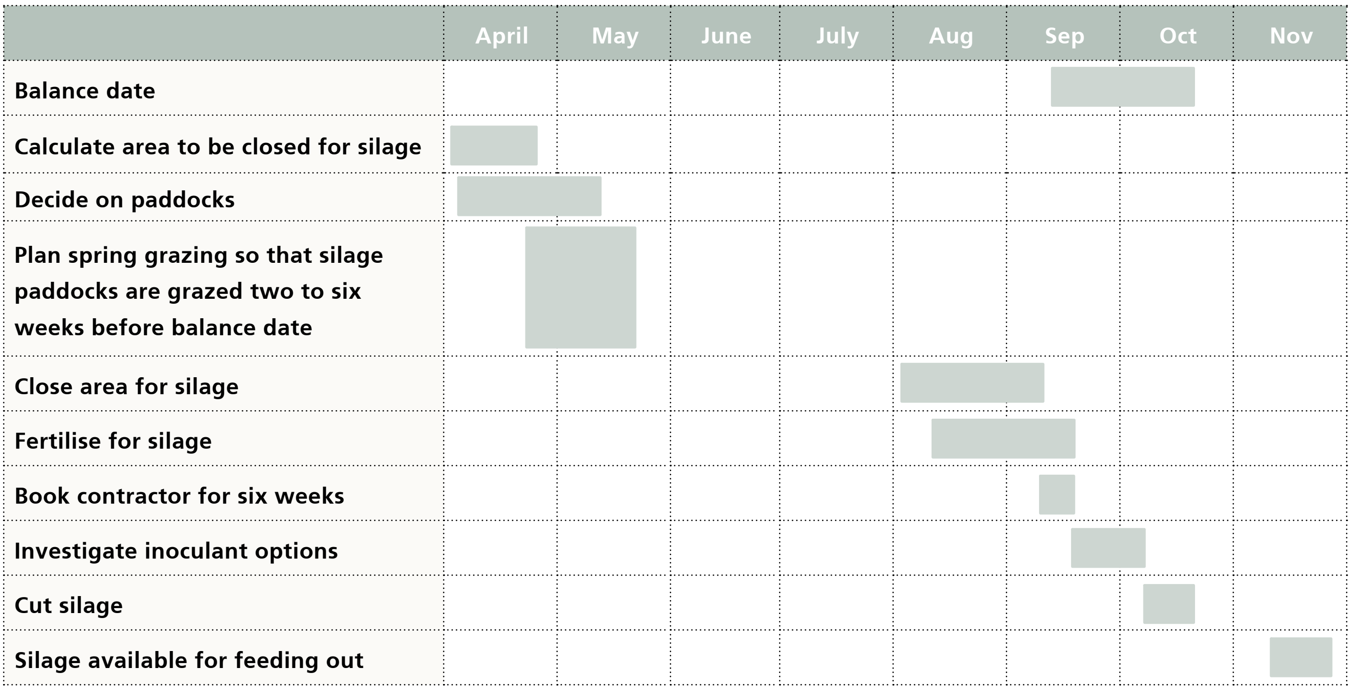


Figure 4. A hypothetical timeline of the silage making process. Note area and paddock choice decisions are made six months before the silage is made.



Conclusions

Pasture quality cannot be improved by ensiling. It is, therefore, important to ensure the highest quality pasture possible is ensiled, it is well compacted, covered with plastic quickly, and the plastic is covered in tyres (touching). Planning silage must begin six months before the event (see Figure 4)

Even doing this perfectly, 5-10% DM will be lost during fermentation. Anything less than perfect management will increase fermentation losses. Some inoculants can be used to improve the fermentation of the silage and the stability of the face when feeding out. However, not all inoculants are equal and inoculants will not improve silage quality if poor quality pasture is ensiled or without proper diligence to managing the stack appropriately.

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The place of summer crops in dairy farm systems

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The practice of growing summer crops such as maize and turnips is common on North Island dairy farms. Recently biennial (chicory) and perennial (plantain) crops have become popular. Farmers considering growing a summer crop need to have a clear understanding of the crop's purpose on their farm.

Summary

- Growing summer crops to increase the supply of feed in the system alone is unlikely to increase whole farm profitability
- Reasons other than increasing feed supply, such as renewing pasture, more effective use of effluent areas, managing spring surplus pasture and protecting pasture from over-grazing in the summer may justify growing summer crops on farm
- If pasture renewal is a key reason for growing a summer crop, selection of the right crop to achieve pasture renewal target dates is most important
- Whenever a paddock is sprayed out the farm is exposed to increased risk of a feed deficit until the new crop or pasture is established
- Management practices must ensure that the crop has the best chance of success as high yield and utilisation are important, regardless of the reason for growing the crop.

Increasing the feed supply

Numerous farm systems studies have found that growing summer crops to increase the supply of feed in the system alone is unlikely to increase whole farm profitability[1,2,3]. These studies found that, at typical crop yields achieved by farmers, the increase in utilisable dry matter grown from summer crops was insufficient to cover the costs of growing the crop, replace the dry matter that would have been grown by pasture and show a profit. This point is simply demonstrated in Table 1 where the relative crop yield (gross yield less the pasture that would have been grown) divided by the costs of growing the crop is calculated. The cost per kg DM can be compared to other feed options such as purchased feed.

Table 1: Yield and costs of growing maize and turnips on dairy farms.

	Turnips	Maize
Crop yield (kg DM/ha)	12,000	20,000
Less pasture yield foregone (kg DM/ha)	6150	7165
Extra yield (kg DM/ha)	5850	12,835
Crop costs ($/ha)	1420	3640
New pasture costs ($/ha)	800	800
Total costs ($/ha)	2220	4440
Cost/kg DM	38c	35c

Reasons other than increasing the supply of feed may justify the place of a summer crop in a dairy farm system. These include:

- Pasture renewal
- Reducing over-grazing of pasture
- More effective use of effluent
- Managing surplus pasture.

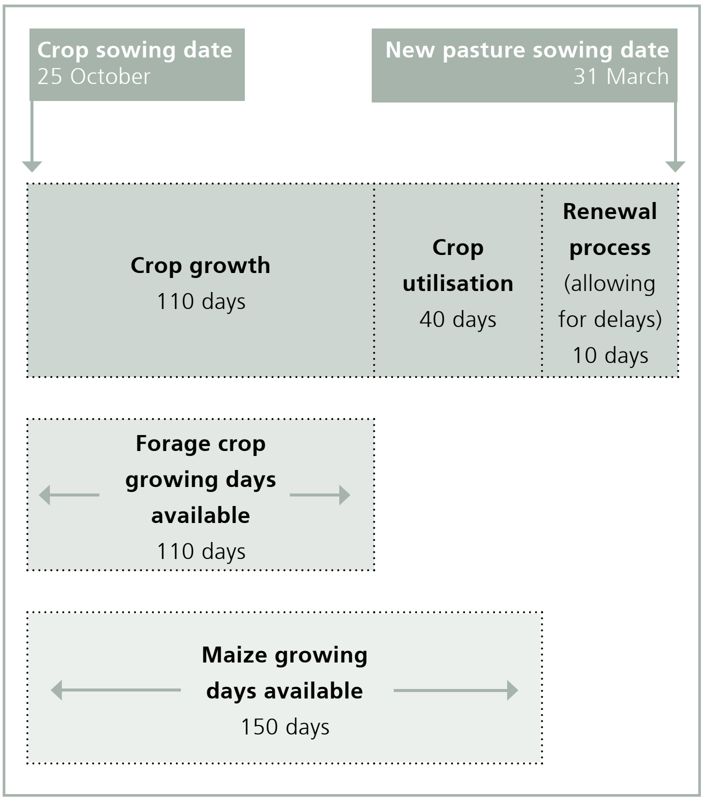
Pasture renewal

The incorporation of a crop sequence in the pasture renewal process is likely to improve the pasture renewal outcome[4]. Crops provide an opportunity to break weed and insect cycles[5]. Weeds that are hard to remove, such as summer grasses, are normally sprayed in summer and autumn. Growing crops prior to establishing new pasture has been shown to be beneficial when introducing novel endophyte grasses[6].

If renewing pasture is the primary reason for growing a crop then the choice of crop is most important. The crop type must complement the pasture renewal process not hinder it. Two things are important when considering the type of summer crop to plant:

1. The most effective break in weed and pest cycles. For example, in situations where Black Beetle is a problem brassica and maize crops, are likely to be most suitable. Where summer grasses such as yellow bristle grass are a problem, multiple sprayings of herbicide are required, and a perennial crop such as chicory is likely to be the best option
2. Timing. The crop must fit with the target date for new pasture sowing. For areas north of Taupo, the recommended date is March 31 and for the lower north island around March 20. Work back from this date in planning a crop allowing time for new pasture preparation and crop utilisation (for forages). Estimate the date to sow the crop. The date from sowing to when the crop will be fed or harvested gives the number of growing days available for the crop. Match the growing days available to the crop requirements. (Figure 1)

Figure 1 Timelines required to achieve the target sowing date for new pasture.



It is important that the crop choice does not compromise the pasture renewal outcome. While it is tempting to maximise crop yield and extend the crop harvest or utilisation date the resulting delay in sowing date of new pasture for 1-2t DM/ha gain of crop, risks compromising a 120t DM/ha crop of pasture (15t DM/ha/yr for 8 years). In the case of maize, hybrid choice is very important[7] and shorter maturing varieties are likely to fit the pasture renewal process better despite the compromise in crop yield.

(cont'd p20)

(cont'd from p19)

Utilising effluent areas

The nutrient enrichment of land receiving effluent can be a potential risk because of nutrient leaching and metabolic disorders resulting from excessive potassium (K). Periodically growing crops on these areas will remove excessive K[8] and allow K to be redistributed around the farm by grazing cows.

Table 2 The effect of crop type and yield on the removal of nutrients from the soil[8,9]

		Nutrients (kg/ha)			
	Yield (t DM/ha)	N	P	K	S
Maize silage	18	234	41	216	23
Turnip crop	10	210	37	300	33
Chicory*	13	365		530	

Reducing over-grazing of pasture in the summer

Repeated grazing of pasture below 3.5 cm in height in the summer months is likely to be a contributing factor to the lack of persistence of ryegrass[10]. Removing cows from paddocks when they are likely to graze below 4 cm height is one way to avoid over-grazing[11]. Forage crops such as turnips have a useful role to play as the cows can be 'held' off pasture without damaging future pasture yield.

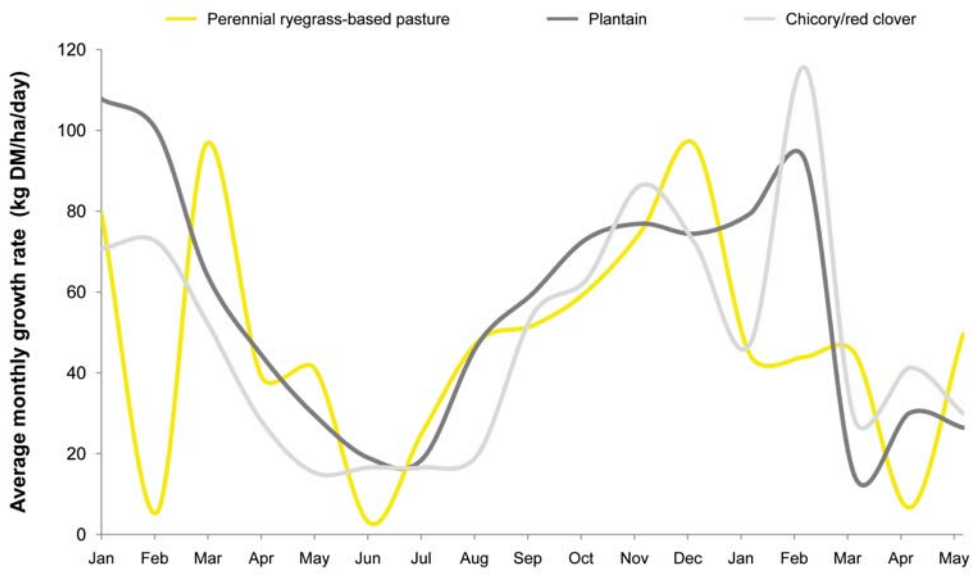
Managing surplus pasture

Crops are a useful alternative to silage and hay for managing surplus pasture (normally in the late spring). Some farmers prefer to take paddocks out of the grazing rotation for crop preparation, increasing the stocking rate on the remaining area and allowing pasture quality to be more effectively managed on the rest of the farm. For a farm stocked at three cows/ha removing 10% of the farm to grow crops will increase feed, demand on the remainder by 11% (e.g from 45kg DM/ha to 50kg DM/ha).

Biennial and perennial forage crops

Chicory and plantain are becoming popular as alternatives to turnips. Like most things there are pros and cons to consider. They can provide a mass of high quality feed at a time when pasture growth is limiting the feed supply, but their growth patterns are different to ryegrass/white clover pastures (Figure 2). They also offer more flexibility than turnips because timing of grazing can be altered to match pasture availability. Both species are less susceptible to insect damage compared with turnips and under good management they will survive for two or more years. This means, unlike turnips, a new crop does not have to be established each year and, therefore, there are fewer occasions for a crop failure to occur. The main disadvantages of chicory and plantain are that they are slow winter growers and will not survive treading damage (especially chicory). Careful feed planning is required to factor this loss of winter feed supply.

Figure 2. Average monthly growth rates of established perennial ryegrass-based pastures compared with plantain and chicory/red clover in the Waikato between January 2009 and May 2010[1]



DairyNZ, 2011[13]

Managing risk

The integration of crops into the dairy system changes the risk profile of the farm business. Summer crops mitigate (to some extent) the risk of summer dry conditions by providing a mass of high quality feed at a time when pasture growth is likely to be limiting. However, the farm is exposed to other risks as soon as a paddock is sprayed out. These include having crop areas out of production during an unexpected decline in pasture growth resulting in under feeding cows at a critical time (peak milk and mating). Delays, due to weather or contractor scheduling, may result in yield losses or target dates for the establishment of new pasture in the autumn being missed. Poor yields represent the greatest financial risk to the business when growing crops. Some of these risks can be mitigated through good planning and best practice establishment and management.

Grow a good crop

Yield is very important, regardless of the reasons for growing a crop. Poor crops will have a negative impact on farm profitability. Good practice crop establishment and management are important and short cuts can be costly. Excellent guides, prepared as a result of Sustainable Farming Fund projects, are available - *Management Practices for Forage Brassicas, Pioneer's Maize Silage 2010/11, PGG Wrightsons Brassica guide, DairyNZ Farmfact: Turnips - Growing a high yeilding crop (1-62)* and *DairyNZ Farmfact: Chicory establishment and management (1-72).*

How much crop to grow?

The area required for forage crops can be calculated as follows:

100 ha farm milking 300 cows

Offering 6 kg DM/cow/day of crop for 40 days

Total crop offered 6 *40*300 = 74 t DM

At a crop yield of 10 t DM/ha = 7.4 ha of crop required.

The impact of having this crop area out of pasture production should be tested with a feed budget for the period from spraying out the crop area in the spring until the paddock returns to the rotation as new pasture in the autumn.

Summer crops have a number of roles on dairy farms and farmers need to have a clear understanding of these roles, which of these are the highest priority and select crops that meet these priorities best.

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DairyNZ trial

Herbicide application and direct drilling improves establishment and yield of chicory and plantain

Chris Glassey, DairyNZ Farm Systems Specialist; Cameron Clark, DairyNZ Scientist and Chris Roach, DairyNZ Senior Research Technician

Summary

- Spraying out existing pasture and direct drilling (spray and drill) improved the establishment and yield of spring sown chicory and plantain crops compared with broadcasting seed without spraying existing pastures
- While spraying and direct drilling costs approximately NZ$240/ha more than not spraying and broadcasting seed, a yield advantage of 2.1 t DM/ha for chicory and 2.3 t DM/ha for plantain means that the extra feed is supplied at 11 and 10 cents/kg DM for chicory and plantain, respectively.

Waikato farmers reported they were broadcasting chicory seed directly onto pasture in spring to establish a crop. To test this, four establishment methods (see Table 1 and Figure 1), for chicory and plantain crops sown into non-cultivated ryegrass pastures in spring were compared for 201 days from sowing. Treatments were spraying or not spraying, before drilling or broadcasting seed.

Existing annual ryegrass pasture was sprayed in early November with 4L/ha glyphosate before sowing of seed six days later. Either SUPERSTRIKE® coated Chicory (cultivar 'Choice') at 6 kg/ha or plantain (Ceres Tonic) at 8 kg/ha was used. The same drill was used for either drilling or broadcasting. "Slugout" slug bait (10 kg/ha) was also broadcast at sowing.

This was a plot trial (140 m^2 plots), grazed by dairy cows. Each treatment had five replicates.

Plantain was first grazed, after 61 days, when it had reached six fully developed leaves, while chicory was first grazed after 54 days at seven leaves. Subsequent grazings were determined when plantain reached a mean height of 25 cm and chicory 20 cm. Residual grazing height was 3 cm. Five grazings resulted for all chicory treatments and the two broadcast plantain treatments, with six grazings for the two drilled plantain treatments.

Results

Seventy and 115% more plants were present at the first grazing for spray and drilled (SD) chicory and plantain respectively, compared with unsprayed and broadcast (UB) treatments.

Growth of chicory and plantain was greater for SD in the period from sowing to March (Figure 1a & 1b).

From April onwards growth was similar between treatments.

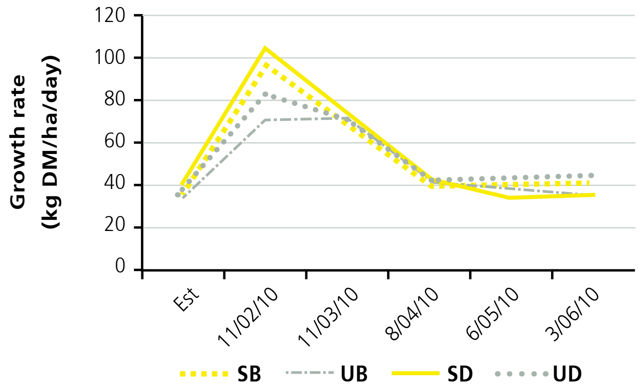
Overall, plantain crops yielded 1.2 t DM/ha more than chicory. 92% of this being weeds. Chicory provided higher forage quality (11.7 v 10.9 MJME/kg DM) compared with plantain.

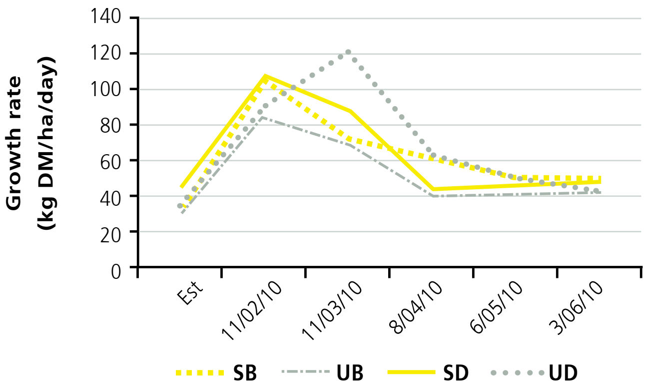
While SD incurs additional costs compared with UB, it provides additional feed through higher plant populations of forage herbs, increased growth rates and reduced weed establishment. Use spray and drill to establish herbs for maximum yield, shorten time to first grazing, and reduce the risk of poor establishment.

Table 1. Total dry matter grown between November 2009 and June 2010 of chicory and plantain crops established by four different methods.

	Establishment method			
	SD seed direct drilled after spraying	**SB** seed broadcast after spraying	**UD** seed direct drilled into unsprayed pasture	**UB** seed broadcast over unsprayed pasture
Chicory DM accumulation (t DM/ha)	11.2	10.0	10.0	9.1
Plantain DM accumulation (t DM/ha)	11.8	11.3	12.3	9.5

Figures 1a and 1b. Average growth rates between grazings for chicory and plantain crops established by four different methods. Establishment (Est) = growth from sowing until first grazing.





DairyNZ trial

Chicory and plantain: two summer cropping options

Julia Lee, DairyNZ Scientist

Limited information is available regarding best management practices to optimise herbage yield and nutritive value of modern chicory and plantain cultivars within a dairy farming context. A DairyNZ funded research programme aims to define grazing management practices for optimal herbage growth and nutritive value, and determine the dairy cow response to increased proportions of the crops in the diet. Preliminary data from the first year of a two year plot trial are reported here. The plots are cut, not grazed, which allows more treatments to be tested. To ensure that results are similar under dairy cow grazing, promising treatments will be evaluated over two years at Massey University starting in 2011/2012.

Trial design

Plots of chicory (cv. Choice; 6.7 kg/ha) or plantain (cv. Tonic; 10 kg/ha) SUPERSTRIKE® treated seed were sown to achieve a similar plant density in mid-October 2010 following a double spray/full cultivation establishment regime.

Treatments for each species were:

Chicory:

- Cutting heights of 15, 25, 35 or 55 cm extended leaf length
- Residual heights of 3-5 or 6-8 cm.

Plantain:

- Cutting heights of 15, 25, 35 or 45 cm extended leaf length
- Residual heights of 3-5 or 6-8 cm.

However, chicory plots were not cut during the winter to ensure maximal plant survival.

Between December and May plots received irrigation and four applications of 39 kg nitrogen/ha + 20 kg phosphorus/ha.

Measurements included herbage yield at each harvest, seasonal nutritive value, seasonal plant density, and changes in root water-soluble carbohydrate (WSC) and nitrogen reserves throughout a regrowth cycle.

Preliminary findings from year one

- Cutting height (i.e. rotation length) affects yield and plant survival more than residual height
- Total herbage yield for chicory was greatest when harvested at 35 or 55 cm (Figure 1)
- Total herbage yield for plantain was greatest when harvested at 45 cm (Figure 2)
- Plantain plant density remained relatively stable at 300 plants/m^2, except in plots harvested at 45 cm where density declined to 270 plants/m^2 by March
- Chicory plant density halved between November and May irrespective of treatment (200 to 100 plants/m^2)
- Summer energy content of chicory was greater than plantain (12.0 v.s. 10.9 MJ ME/kg DM)
- During summer, plantain fibre content was greatest in plots harvested at 35 or 45 cm.

Key messages

Chicory

Production of high quality feed appears to be maximised when swards are grazed between 35 and 55 cm during the first year.

Plantain

While grazing swards at 45 cm appears to maximise total herbage yield, it increases the fibre content and reduces plant survival. Additional data are required to fully understand the impact of this.

Figure 1. Total herbage yield (December to May) from chicory cut at heights of 15, 25, 35 and 55 cm extended leaf length.

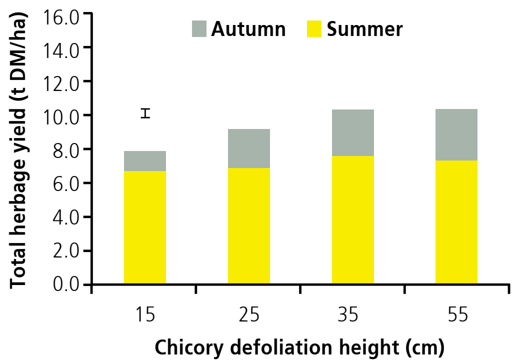
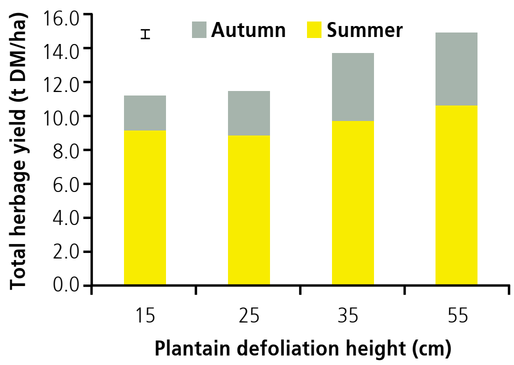


Figure 2. Total herbage yield (December to May) from plantain cut at heights of 15, 25, 35 and 45 cm extended leaf length.



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Focus on international research

The following is a brief summary of some key science papers recently published

Gilmore and others (2011). An evaluation of the effect of altering nutrition and nutritional strategies in early lactation on reproductive performance and estrous behavior of high-yielding Holstein-Friesian dairy cows.
Journal of Dairy Science 93:3880-3890.

Various feed types, fed in different ways, for the first seven weeks of lactation did not significantly change reproductive performance in dairy cows, although there was a tendency for the high starch diet to shorten the time to first ovulation. Irrespective of feeding, intensity of oestrus increased as the number of cows in the sexually active group increased. Further, cows with a stronger expression of oestrus were more likely to get pregnant than those with a weak display of oestrus.

DairyNZ comment: DairyNZ research also indicates a reduction in time to first heat with starch supplementation. However, the effect is not consistent across studies. Cows with stronger heats are more likely to get pregnant because the timing of AB is likely to be more accurate and a strong display of oestrus indicates a fully functioning reproductive system. It is important to put the sexually active cows drafted out for AB back in with the herd as soon as possible after insemination.

Bionaz and Loor (2011). Gene networks driving bovine mammary protein synthesis during the lactation cycle.
Bioinformatics and Biology Insights 5:83-98.

The production of milk fat is strongly regulated by nutrition. Milk protein regulation, however, was thought to be largely regulated by genetics. This study highlighted that milk protein also appears to be regulated by nutrition, through insulin receptors on mammary milk secreting cells. Once insulin binds to its receptor, glucose and amino acids enter the mammary cell. Once inside, the glucose and amino acids are used to make milk protein.

DairyNZ comment: Results indicate that both milk fat and protein production are influenced by insulin concentrations in blood, with high insulin concentrations reducing milk fat and increasing milk protein production. Insulin is released in response to feeding starch or sugar-based feeds and this is why milk protein % increases and milk fat% decreases when grain is fed compared with palm kernel.

Prado and others (2011). Vaccination of dairy cows with recombinant *Streptococcus uberis* adhesion molecule induces antibodies that reduce adherence to and internalization of *S. uberis* into bovine mammary epithelial cells.
Veterinary Immunology and Immunopathology 141:201-208.

Cows were either vaccinated against the *S. uberis* adhesion molecule (SUAM) or left unvaccinated. SUAM enables bacteria to stick to udder cells and then travel into the cell so that milking doesn't remove the bacteria. When cows were vaccinated, *S. uberis* were less able to stick to udder cells and were less able to get into udder cells.

DairyNZ comment: This research is still in early stages, but may be an important step in the development of a vaccine for *S. uberis* mastitis.

Legrand and others (2011). Using water to cool cattle: Behavioral and physiological changes associated with voluntary use of cow showers.
Journal of Dairy Science 94: 3376-3386.

This study examined the voluntary use of water by dairy cows to cool themselves in summer. Cows with access to an overhead shower spent an average of three hours per day under the shower. There was considerable variability in shower use by individuals, ranging from 0 to 8 hours per day. Some of this variability was attributed to the weather; shower use increased by 0.3 h for every 1°C increase in ambient temperature. Respiration rate and skin temperature did not differ between cows that did or did not have access to a shower, but body temperature of cows provided with access to a shower was 0.2°C lower in the evening than control cows. Cows with access to a shower spent half as much time near the water trough than control animals, and this pattern became more pronounced as the temperature-humidity index increased.

DairyNZ comment: Results indicate that dairy cows, if given the opportunity, will make use of a shower to reduce heat load. However, use of this resource may vary between individual animals which, is an important consideration in the design of sprinkler systems used for summer cooling. Lactating or larger animals are likely to gain greater benefit from use of showers as they have a higher heat load.