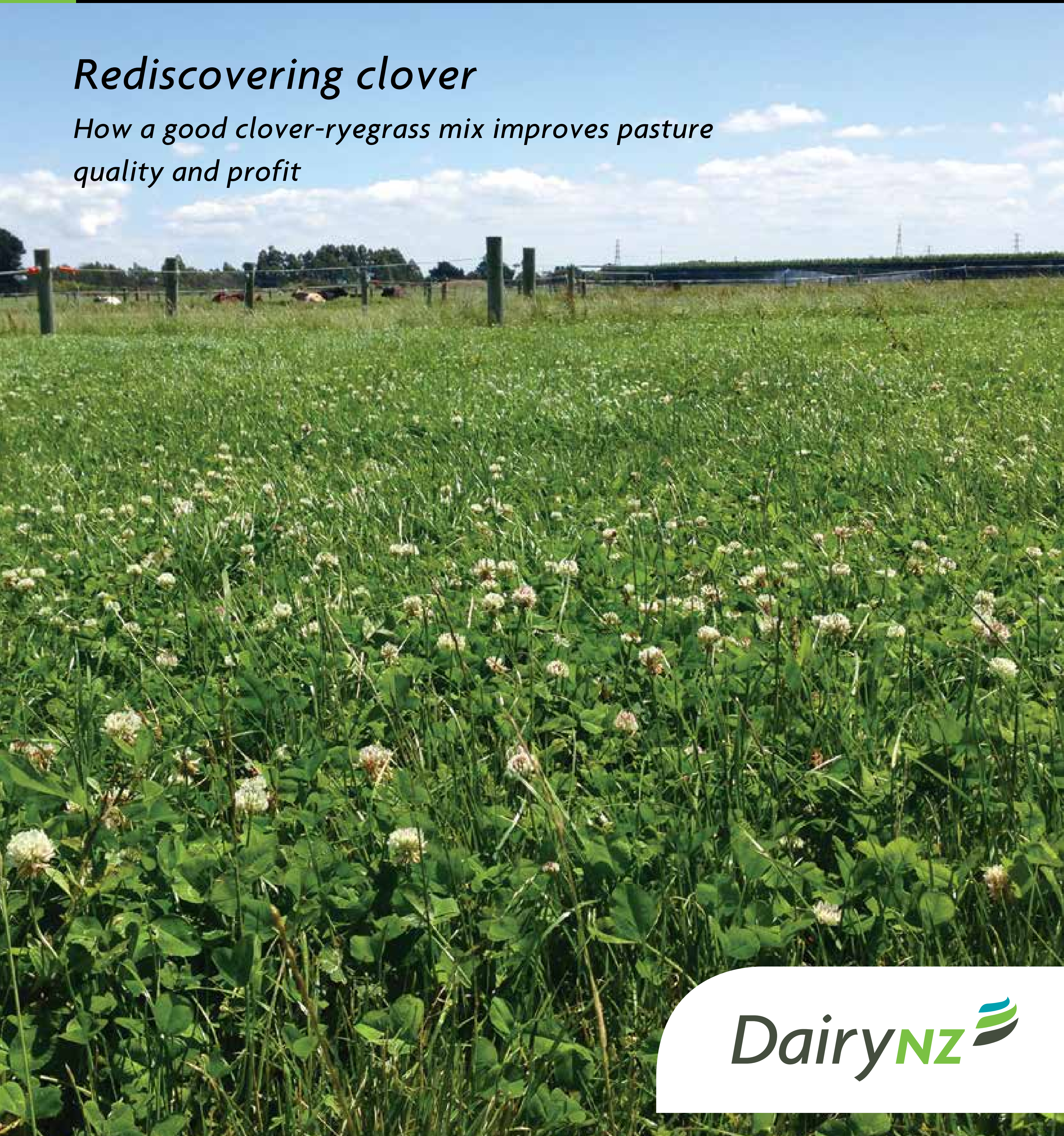
September 2016

Issue 31

Technical Series

IN BRIEF



Rediscovering clover

How a good clover-ryegrass mix improves pasture quality and profit

DairyNZ

BIOCONTROL OF PESTS | SPRING GRAZING MANAGEMENT | MAXIMISING SILAGE RETURNS

Contents

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ISSN 2230-2395
DNZ04-031

Good clover-ryegrass mix – vital for a productive pasture

The importance of having a good mix of clover and ryegrass to produce better feed quality and yield has been somewhat forgotten and most farms don't grow enough clover. With more emphasis on a 'pasture first' approach for restoring profitable margins on farms, clover's vital role has taken on renewed significance. DairyNZ principal scientist, feed and farm systems, David Chapman, DairyNZ scientist, Laura Rossi and Doug Edmeades of AgKnowledge Ltd, explain the core elements of productive pastures.

David Chapman, DairyNZ

Key points

- The core elements of productive pastures are best met by mixtures of ryegrass and white clover.
- When clover comprises between 10 and 40 percent of total dry matter (DM) in summer, there are gains in DM of between 1.4 and 3.4 t DM/ha per year.
- Yield gains come mostly in summer, when extra feed grown has high economic value.
- White clover generally requires higher levels of soil nutrients than ryegrass – especially phosphorus, potassium, sulphur and sometimes magnesium and molybdenum.
- Excessive focus on nitrogen (N) fertiliser and failure to meet the soil nutrient requirements of white clover in recent years have inhibited clover growth and compromised pasture productivity.

Putting pasture first for profitability

The recent re-focus on using pasture first, and using it efficiently for animal feeding is critical for restoring profitability margins in the industry. 'Pasture First' is essentially matching feed demand to feed supply to maximise pasture eaten. The best results are achieved when this is implemented on a productive pasture base and supported by good decision-making based on monitoring information. The first step is calculating current pasture eaten on your farm and comparing this with other farms in your region. You will then know the pasture growing potential in your area, and whether there is a 'gap' between potential and your current estimate for your farm.

Closing the gap: What makes up a 'good' pasture?

A 'good' pasture is one that meets the nutritional requirements of cows over as much of the annual cycle as possible, year-on-year. To achieve this, there are four primary requirements:

1. Growth rates are close to the potential set by the climate and soils of the farm. Both the total amount of pasture grown for the year, and the time of year when the pasture produces feed, are important.
2. The feed produced is of adequate nutritional value for cows to perform to expected levels. The key factor here is the metabolisable energy (ME) density of the feed, which is mainly governed by the pasture's green leaf content.
3. Animals can sustain high rates of intake from pasture, so that they can achieve high production without compromising ability to graze pastures back to target residuals. This also relates to the bulk density of green leaf available in the pre-graze pasture.
4. The pasture enables the farm system to meet limits required by regional environmental plans (e.g. for freshwater quality). Ideally, pastures should require low to moderate inputs of N fertiliser to reach maximum yield, and/or not accumulate excess N in herbage so that animals are not eating and excreting large surpluses of N[1].

Growth rate is controlled mainly by environment, but also by management. Points 2 and 3 are mainly about management. If these primary requirements are met, then it is likely that one further, secondary, requirement will also be met:

5. The pasture contains a high proportion of the sown species and a low content of weeds that restrict the biological efficiency of the pasture. An abundance of weeds is generally a signal of terminal pasture decline.

Closing the gap requires ongoing measuring and monitoring of pastures. Here are some fundamentals (see *Farm Facts*[2]):

- Growth rates and residuals come from feed wedges.
- Feed eaten is a measure of intake.
- Herbage samples can be analysed for ME and other nutritional components.
- Soil tests tell us if there is enough of the right nutrients available for the sown species to out-compete the weeds.
- The Pasture Condition Score tool[3] is a simple method for visually assessing weed species content and ground cover of the sown species as a guide toward pasture renewal.

Although there is a plethora of tools available, anecdotal feedback from farmers has highlighted a growing concern that pasture management skills in the industry are in decline. It's important to re-visit and re-activate the toolbox with your farm team.

Past issues of DairyNZ's *Technical Series* have covered the principles and practices for maximising pasture growth rate through grazing management[4,5,6] and nutritional value of well-managed pasture as a complete diet for dairy cows[7]. Refer to these for further information.

White clover: the forgotten component of high-producing pastures?

For the vast majority of NZ dairy farms, the list of requirements on the previous page describes a pasture with a high content of perennial ryegrass and white clover. The contribution of white clover to N supply (from biological fixation) and pasture nutritional quality in grass/clover mixtures is beyond dispute. Despite the benefits, clover typically contributes less than 15 percent of total annual DM in NZ dairy pastures[8], well below the 30 percent contribution considered necessary to capture the animal productivity benefits[9].

Less well recognised are the yield benefits available when clover contributes 20-30 percent of total annual DM, even though these too have been known for many years[10]. Increased use of N fertiliser in the pursuit of higher milk production over the past two decades has suppressed clover performance, since the negative impact of N fertiliser rates on clover percentage in mixed pastures is also beyond dispute.

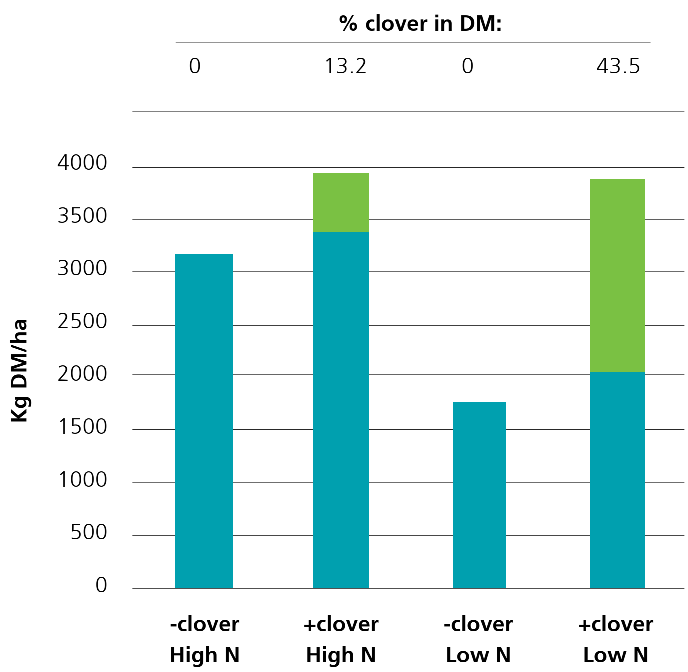
Recent experiments exploring grass/clover interactions in dairy pastures[11] have bought the yield advantages of mixed pastures with moderate-high clover percentage in the total DM back into the limelight. In three studies, one in Waikato and two in Canterbury, seasonal and total annual yields were measured for pastures sown either with or without clover (+ clover and – clover respectively), and receiving either low rates of N fertiliser (50 and 100kg/ha/year in Waikato and Canterbury respectively) or high rates of N (225 and 325kg/ha/year in Waikato and Canterbury).

In all, seven years of total annual DM yield data are available. Yields were significantly greater in the + clover treatment than the – clover treatment in all years. The yield advantage to + clover was greater at low N levels (3.4 t DM/ha, +42 percent) than at high N levels (1.4 t DM/ha, +12 percent). This was expected because competition from grass was restricted due to lower N inputs. Across all of these experiments, mean annual white clover content decreased one percent for every additional:

- 13kg N/ha above 100kg N/ha/year in Canterbury, and
- 19kg N/ha above 50kg N/ha/year in Waikato.

The yield increases described above are valuable, since almost all of the additional feed comes in summer (Figure 1) when it is has high economic value[12] and it is of high digestibility, due to the clover content. ▶

Figure 1. Dry matter yield in summer (mean 2012/13 and 2013/14) in Canterbury from pastures sown with ryegrass only ('- clover') or with a ryegrass/clover mixture ('+ clover') at two levels of N fertiliser ('High' = 325kg N/ha, 'Low' = 100kg N/ha). Blue bars = ryegrass DM yield; green bars = white clover DM yield.



White clover: how can farmers get more of it?

The answer to this question hinges around managing competition between grass and clover. While the ryegrass/white clover pasture is an 'ideal' mixture, the reality is that ryegrass and clover plants are in constant competition with each other for light, water and nutrients.

When we review what is known about the competitive ability of ryegrass and white clover, the score card looks something like this:

Competition for light:	Winner = ryegrass, Loser = clover
Competition for water:	About even (perhaps a slight edge to ryegrass)
Competition for nitrogen:	Winner = clover (it fixes its own N) ***but N fertiliser negates this***
Competition for nutrient:	Winner = ryegrass, Loser = clover

Therefore, 'home-ground' advantage for white clover is on soils that are low in N but high in phosphorus (P), potassium (K), sulphur (S), and, sometimes, magnesium (Mg) and molybdenum (Mo). Nitrogen is the only resource where clover is the clear winner, but, this advantage can be negated by high N fertiliser inputs. Total annual fertiliser inputs of less than 200kg N/ha combined with excellent control of pre-and post-grazing pasture cover to limit the shading competition from ryegrass is essential if clover content in the range 20-40 percent of total DM is to be achieved[9].

However, recent excessive focus on nitrogen and failure to recognise that white clover needs different amounts of the other major nutrients compared with ryegrass, has contributed to sub-optimal clover content and reduced pasture productivity on New Zealand dairy farms. Fortunately, the information required to rectify these issues is already available – it, like the required nutrients, just needs to be applied.

White clover: nutrient requirements

White clover requires 16 nutrients and can only grow as fast as the most limiting nutrient[2]. Furthermore, white clover has a poor root structure relative to grasses. As a consequence, higher concentrations of nutrients in the soil are required to optimise its production relative to grasses. It is for this reason that white clover can be regarded as the canary in the mine. If all 16 nutrients are not present in the soil at the optimal levels then white clover will not thrive.

The optimal soil nutrients levels for white clover-based pasture are given in *DairyNZ Farm Fact 7-5*[2], together with the critical nutrient levels for clover herbage. If these levels are not achieved then the clover will not compete against the ryegrass and the clover content in the pasture will decline. When this happens, less clover N is fixed and returned to the soil and hence the ryegrass component will also decline, unless of course fertiliser N is applied.

There are some obvious visual symptoms in clover-based pastures if the soil fertility is less than optimal. In the absence of fertiliser N the excreta patches will become prominent and very little clover will be found in the non-excreta patches which will also contain a high weed loading, particularly flat weeds.

A good soil fertility monitoring plan including soil tests and clover-only samples is essential to managing the fertiliser inputs for optimal pasture production[2].

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DairyNZ's post-grazing residual project – what it tells us about pasture management

Use of supplements when there is an adequate supply of pasture in spring may lead to pasture wastage and higher than target post-grazing residuals. DairyNZ senior scientist Kevin Macdonald explains a project set up to demonstrate the benefits of maintaining target post-grazing residuals.

Key points

- In spring it is important to achieve post-grazing residuals of 1500-1600kg DM/ha (7-8 clicks on the RPM; 3.5 to 4 cm).
- Failure to do so will result in poor pasture quality and lower milksolids (MS) production from pasture in summer/autumn and reduced profit.

Kevin Macdonald, DairyNZ

Introduction

During the last 20 years the use of supplementary feed in New Zealand dairy systems has increased[1]. When supplements are fed to grazing dairy cows, pasture dry matter intake declines which is known as substitution[2]. Feeding supplements when there is an adequate supply of pasture in spring (i.e. pasture growth is greater than herd demand) may lead to pasture wastage through substitution and higher than target post-grazing residuals which, in turn, results in reduced growth and pasture quality at subsequent grazings[3,4].

In 2015, DairyNZ set up farmlets at Scott Farm (Hamilton) and WTARS (Hawera) to demonstrate the benefits of maintaining target post-grazing residuals (1500-1600kg DM/ha or 7-8 clicks on rising plate meter on the RPM; 3.5 to 4 cm) during spring.

Demonstration design

Two farmlets were established at each site; cows on one farmlet grazed to the recommended target post-grazing residuals of 1500-1600kg DM/ha (Target Residual), while cows on the High Residual farmlet were offered up to 3kg PKE per day resulting in a higher post-grazing residual of 1800-2000kg DM/ha (Figure 1).

Cows in the High Residual group were supplemented from late August to mid-December at Scott Farm, and from mid-September to late December at WTARS. In mid-December at Scott Farm and late December at WTARS, the PKE was removed from the diet of the High Residual cows and both farmlets were managed similarly until the end of the project (late-March at Scott Farm and mid-April at WTARS). Supplements were removed to demonstrate the carry-over effect of high post-grazing residuals in spring on cow performance, and on pasture over summer and autumn at each location.

At both locations, milk production and pasture growth were measured, and at Scott Farm, pasture composition and nutritive value were also measured.

Preliminary results and discussion

Grazing residual

From the start of the project until December (spring), the average post-grazing residual was 1660kg DM/ha (9.2 clicks RPM) and 1905 kgDM/ha (11.5 clicks RPM) for the Target Residual and High Residual farmlets, respectively. Once PKE supplementation was stopped (during summer-autumn), the cows grazed to 1850kg DM/ha (8.8 clicks RPM) and 1995kg DM/ha (9.7 clicks RPM) on the Target Residual and High Residual farmlets, respectively. The lower post-grazing height measured on the RPM but greater kg DM/ha in summer is normal as the pasture base gets denser, thus there is an increasing kg DM/ha for any given height due to a buildup of dead material[5].

Total milksolids (MS) production at both sites was similar and the data has been averaged and is presented in Table 1.

Milk production and BCS

Although the MS profile differed at times, when cumulative production over the length of the project was measured, there was no benefit from cows peaking higher through feeding PKE and leaving a higher residual in spring, compared with cows grazing pastures only and achieving target residuals throughout the project (Figure 2).

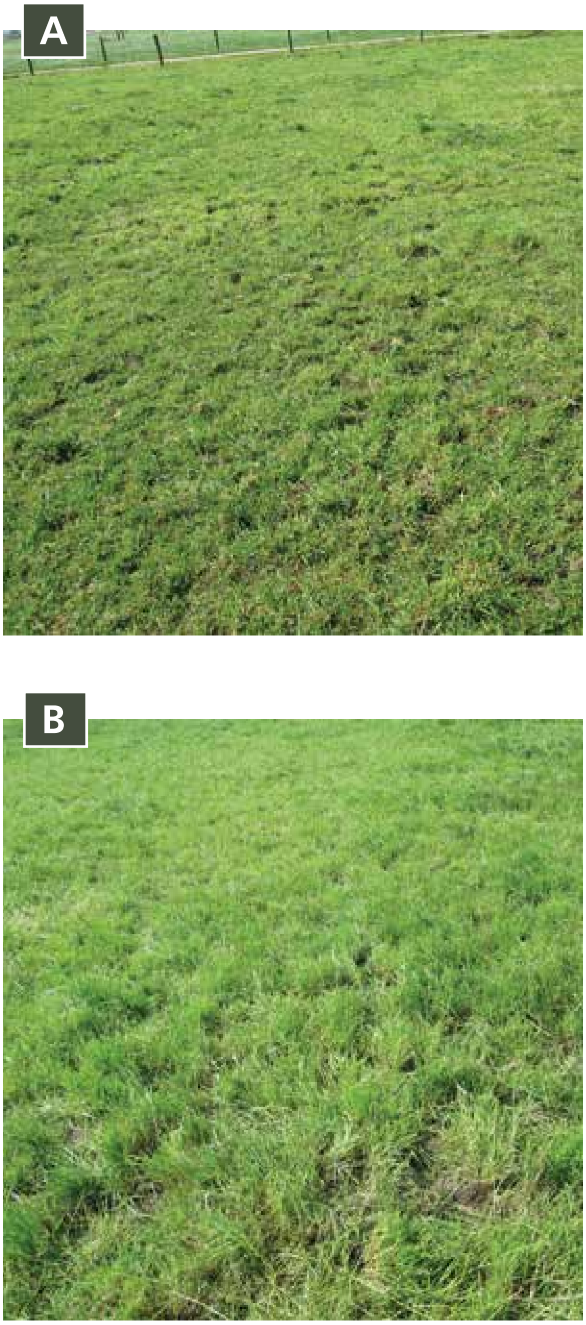

Figure 1: Post-grazing residuals in mid-October at Scott Farm for (a) Target Residual of 1500-1600kg DM/ha and (b) High Residual of 1800-2000kg DM/ha.

Table 1: MS production per cow during spring, and summer-autumn, when PKE was removed from the system and target residuals were pursued on both farmlets and silage conserved. The results which also show BCS at the end of the project, are averages from combined Scott Farm and WTARS data.

	Target residual	High residual	Difference
MS (kg/cow) from start to end of PKE (spring)	187.9	198.7	+10.8
MS (kg/cow) from end of PKE to end of project (summer-autumn)	91.1	87.1	-4.0
MS (kg/cow) from start to end of project	279.0	285.9	+6.9
BCS at end of project	4.05	4.15	+0.10
Silage made (kg DM/cow)	338	393	+55

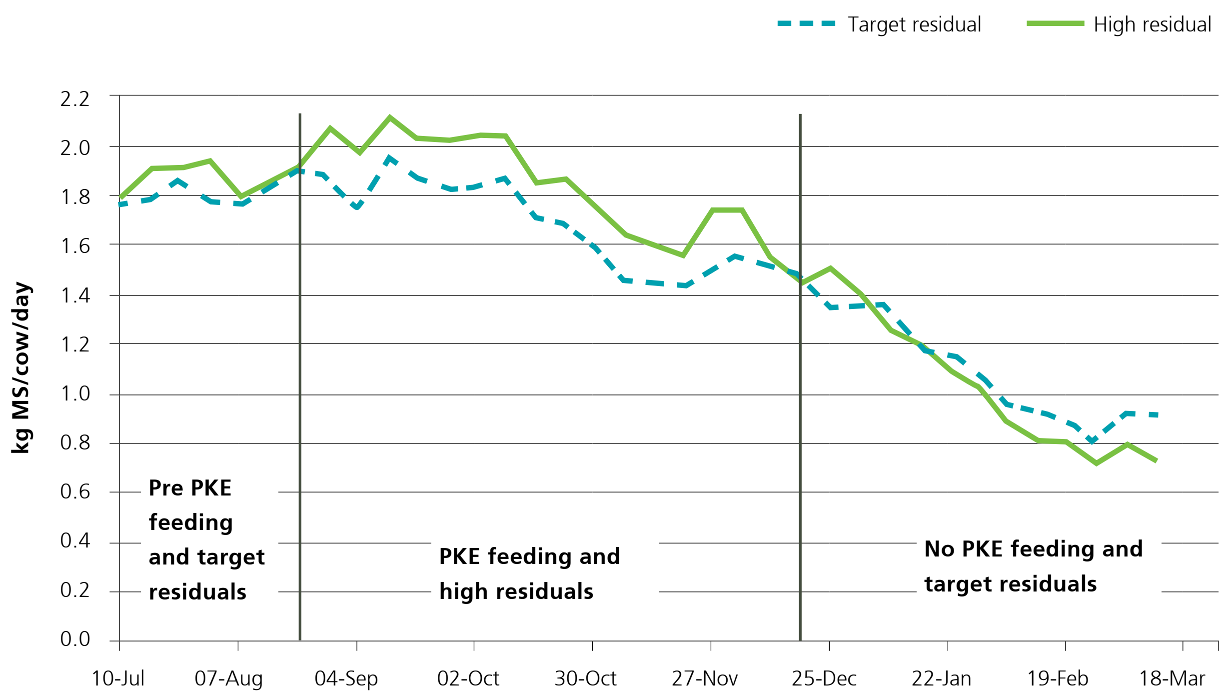

Figure 2: MS production per cow at Scott Farm for cows on the High post-grazing residual farmlet (High Residual) and Target post-grazing residual farmlet (Target Residual). Cows on the High post-grazing residual farmlet were supplemented with PKE from late-August to mid-December to attain a grazing residual of 1800-2000kg DM/ha, while cows on the Target post-grazing residual farmlet grazed to 1500-1600kg DM/ha.

The reduced MS production in summer-autumn of the High Residual cows can be attributed to the poorer pasture composition and lower quality arising from higher residuals in spring (Tables 2 and 3).

There was no difference in cow BCS at the end of the project at Scott Farm but at WTARS the High Residual cows were better – 4.2 compared with the Target Residual cows being 4.

Pasture composition and quality

While pasture composition and quality at Scott Farm was similar in spring, high post-grazing residuals in spring on the High Residual farmlet resulted in summer and autumn pastures with a lower perennial ryegrass content and higher proportion of dead material. This change in pasture composition resulted in reduced pasture quality in summer and autumn. (Table 2).

The pasture quality and composition data collected from the Scott Farm demonstration is consistent with expected trends. Research both in New Zealand and overseas has demonstrated that high post-grazing residuals in spring results in pastures with higher amounts of dead material and lower nutritive value at subsequent grazings[3,4,6,7,8].

Table 2: Metabolisable energy (MJ ME/kg DM), crude protein and neutral detergent fibre (% of DM) of the Target Residual and High Residual pastures during spring and summer/autumn at Scott Farm.

	Target Residual	High Residual	Sig
PKE feeding (spring)			
Metabolisable energy (MJ/kg DM)	12.6	12.5	ns
Crude protein (%)	19.2	18.5	ns
NDF (%)	44.4	45.0	ns
Post-PKE feeding (summer/autumn)			
Metabolisable energy (MJ/kg DM)	10.8	10.0	***
Crude protein (%)	18.3	14.8	***
NDF (%)	51.1	55.7	**

Table 3: Botanical composition of the Target Residual and High Residual pastures during spring and summer/autumn at Scott Farm.

	Target Residual	High Residual	Sig
PKE feeding spring			
Ryegrass leaf and pseudostem	69%	68%	ns
Ryegrass reproductive stem	17%	21%	ns
White clover	3%	2%	ns
Dead material	7%	7%	ns
Other species	4%	2%	ns
Post-PKE feeding summer/autumn			
Ryegrass leaf and pseudostem	52%	42%	*
Ryegrass reproductive stem	4%	3%	ns
White clover	7%	5%	ns
Dead material	20%	32%	*
Other species	17%	18%	ns

Costings

A simple analysis using cost/return was conducted to determine the profitability of each farmlet (Table 4). The analysis took into account revenue from increased milk production, increased BCS gain, silage made and increased feed on farm at the end of the project. The costs accounted for were purchase and feeding of PKE, and making silage.

An economic loss of $42 and $19 per cow at Scott Farm and WTARS, respectively, resulted from leaving a higher post-grazing residual by supplementing the cows with PKE.

a Milkprice of $3.90/kg MS

b Extra silage conserved valued at 10c/kg DM over and above conservation costs

c Value of extra BCS at end of project based on reduced feed required during the dry period for BCS gain (where 125 kg PKE required for 1 BCS gain).

d Extra pasture valued at 10 c/kg DM

e PKE costed at $220/t wet weight on farm and extra $30/t DM for costs associated with feeding PKE in trailers. Total cost of feeding PKE = $280/tonne DM

Table 4: A simple averaged cost analysis for both Scott Farm and WTARS from leaving a higher post-grazing residual by supplementing the cows with PKE during spring.

Income		
Numerical increase in MS kg/cow	6.9	$26.91[a]
Silage conserved kg DM/cow[b]	55	$ 5.50
BCS[c]	0.1	$ 3.45
Difference in farm cover at end of project kg DM/cow[d]	13	$ 1.25
		$37.41
Costs		
PKE fed kg/cow[e]	242	$67.79
Costs less return		**-$30.37**

Summary

This demonstration highlighted the carry-over consequences of not achieving target post-grazing residuals in spring. Feeding supplements when there was a surplus of pasture, and not achieving target residuals resulted in economic losses of between $20 and $40/cow at two sites. This was due to leaving valuable high energy feed in the paddock in spring and compromising subsequent pasture quality and production in summer and autumn.

To incorporate supplements into a pasture-based system profitably, they need to be added into the system in conjunction with good pasture management. Ensuring target pasture residuals are met throughout the season will minimise wastage of high energy feed during spring and result in good quality pasture throughout the remainder of the season.

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Pasture silage – maximising the return on your investment

Pasture silage is an important source of supplementary feed on New Zealand dairy farms. The better the silage's quality, the higher the milksolids (MS) production and body condition score (BCS) gain in cows. Senior scientist, farms systems, Kevin Macdonald and DairyNZ principal scientist, animal science, John Roche, set out fundementals to making great silage.

Key points

- Pasture cut for silage must be of high quality.
- Grazing residuals should be 1500-1600kg DM on paddocks to be closed for silage.
- Silage paddocks should be closed for no longer than six to seven weeks.
- Cutting, packing and covering the stack must be done quickly to reduce spoilage losses. Some inoculants can improve the fermentation process.
- Take care to minimise losses both at the stack and in the paddock/feed pad.

Kevin Macdonald, DairyNZ

Background

Pasture silage is a major source of supplementary feed on New Zealand dairy farms.

Making high quality pasture silage should not be difficult, but it must be viewed as an investment in supplementary feed, rather than just a necessity to manage pasture. New Zealand experimental results indicate that increasing silage quality by 2.3 MJ ME/kg DM increased MS production by 13, 17 and 41 percent in spring, summer and autumn, respectively[1]. Higher quality feed will also increase BCS gain/kg DM eaten.

Making of silage should only be done from a true surplus and the objective is to preserve as many of the original nutrients as possible. In practice, however, silage is often not made at the optimal time, and little attention paid to the silage-making process.

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 the feed "rotting" (i.e., stops microbial activity). This is achieved through "packing" the pasture and covering with plastic to exclude air, while microorganisms "burn" the sugars in the grass to produce lactic and acetic acid. If the silage is exposed to air (e.g. torn plastic), a chain reaction occurs that reduces silage quality.

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 compacting and covering the pasture, 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 is more costly but enables flexibility for crop size and storage location on-farm and feeding out of small amounts on set occasions.
- Stack silage can also be stored in multiple locations and is cheaper than baled silage.
- Pit/bunker silage does not offer flexibility in storage, but, when properly used, will result in less wastage. Pit silage is easier to compact and, therefore, expel air.

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 and that the pasture has a high ryegrass/clover composition.

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 indicates that pasture quality does not decline between 10 to 40 days after grazing in early spring[2]. Yet, on some farms, silage is often made more than 50 days after closure, with poor ensiling results (ME<10.5 MJ/kg DM and crude protein <15% DM2), plus there is an added disadvantage of a slower regrowth after harvesting.

Wrenn and Mudford[3] reported that with later closure of the paddock, pasture quality declined earlier due to increased seed head emergence. Their data from both Waikato and Taranaki indicates 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.

As well as the closing date effect on silage quality, Wrenn and Mudford[3] also noted an effect of post-grazing residual before closing. Their data indicated that for every extra 100kg DM/ha increase in grazing residual above 1500kg DM/ha in the grazing before closing for silage, pasture should be closed for 1.4 days less. Nitrogen fertiliser can be applied at 30-50kg N/ha to increase pasture growth and subsequent silage yield.

To inoculate or not

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

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. Choose carefully to ensure you get an inoculant that 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. Even in the best conditions these losses will be 5-10 percent of the pasture available[4]. If not careful, losses can be greater than 25 percent.

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 and promptly covered with plastic
- ensuring that the entire stack is covered in tyres (tyre to tyre touching) to hold the cover in place.

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. 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 is best reduced by using a trough or a feed pad so cows cannot trample it into the ground.

Deferred grazing

Deferred grazing is the practice of holding over pasture that is considered to be surplus to requirements and grazing it at a later date. For example, if a surplus is identified in late October/November, the surplus area will be skipped and not grazed until at least February. Advantages in doing this can be:

- reduction in farm costs, through avoiding the expense associated with making silage
- use of pasture to better fit feed supply/demand.

When used as part of a low cost farm system by McCallum et al.[5], they reported that it was more profitable than a traditional hay-silage system. The profitability was from an increase in MS production and no conservation costs. Further, the natural reseeding that occurred as a result of the deferral doubled the tiller density of the perennial ryegrass and increased pasture growth by 15-19 percent in the following season.

Management

To get the advantages of the natural reseeding through deferred grazing, it is important to not graze until the pasture has gone to seed. In the New Zealand research, the pasture was strip grazed as a 'supplement' to the grazing rotation and offered to the cows between morning and evening milking. They reported that mowing before grazing increased pasture utilisation but there was no increase in MS production[5].

In times of fluctuating pasture growth, deferral of areas for short periods can be an effective method of pasture control, and is often referred to as "rolling deferred pasture". In these cases the pasture may not be grazed for periods of 30-40 days. If doing this it is important to ensure that pasture utilisation is high as the grass is still growing and, because there is no seed drop, there is a reliance on good pasture growth immediately after grazing.

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Making the right decisions with spring grazing

Spring grazing managament decisions have a crucial impact on the amount and quality of pasture grown later in the season. DairyNZ scientist Cathal Wims explains why.

Key points

- Spring grazing management influences the amount and quality of pasture grown later in the season.
- Pasture quality is optimised when pastures are grazed between the 2 and 3-leaf stage of regrowth, and grazed to residuals of 3.5-4cm (or 7-8 clicks on RPM).
- Good pasture management in spring increases tillering in perennial ryegrass.

Cathal Wims, DairyNZ

Optimal time to graze

The timing of grazing during the regrowth cycle has a significant impact on the amount and quality of pasture grown. Pasture growth generally follows an 'S' shaped curve, beginning slowly (known as a lag phase), then accelerating before levelling-off. Understanding this growth pattern, and the factors that influence it, helps in determining the optimum time to graze.

Plant leaves capture light energy for photosynthesis, which provides energy for plant growth. Grazing or harvesting the pasture removes leaves and significantly reduces the ability of plants to photosynthesise as it deprives plants of their primary food source, light energy. With much less energy available from photosynthesis, the plant is reliant on 'reserves' stored in the tiller stubble immediately after grazing for maintenance and to grow new leaf. This reduced energy supply results in the first leaf produced after grazing being relatively small. As the first leaf expands and leaf area increases, an increasing amount of light energy is captured and the rates of photosynthesis and pasture growth increase. This in turn results in more energy for the next leaf, and it will be a bit bigger. This pattern continues until the plant regains it full energy status.

Each leaf produced has a limited lifespan. Perennial ryegrass is called a '3-leaf' plant as it only maintains about three live leaves per tiller (Figure 1). Once the third new leaf has been produced, the first leaf begins to die.

Eventually a ceiling yield will be reached, where the plant is still producing new leaves but the amount produced is cancelled by the rate of death and decay by older leaves. At this point there is no net gain in pasture growth (Figure 2).

From a grazing management perspective, this means that grazing too late in the regrowth cycle, i.e. after the third new leaf is produced leads to leaf death and pasture wastage, but grazing too early reduces pasture yield.

Figure 1. The leaf stages of perennial ryegrass as it regrows.[1]

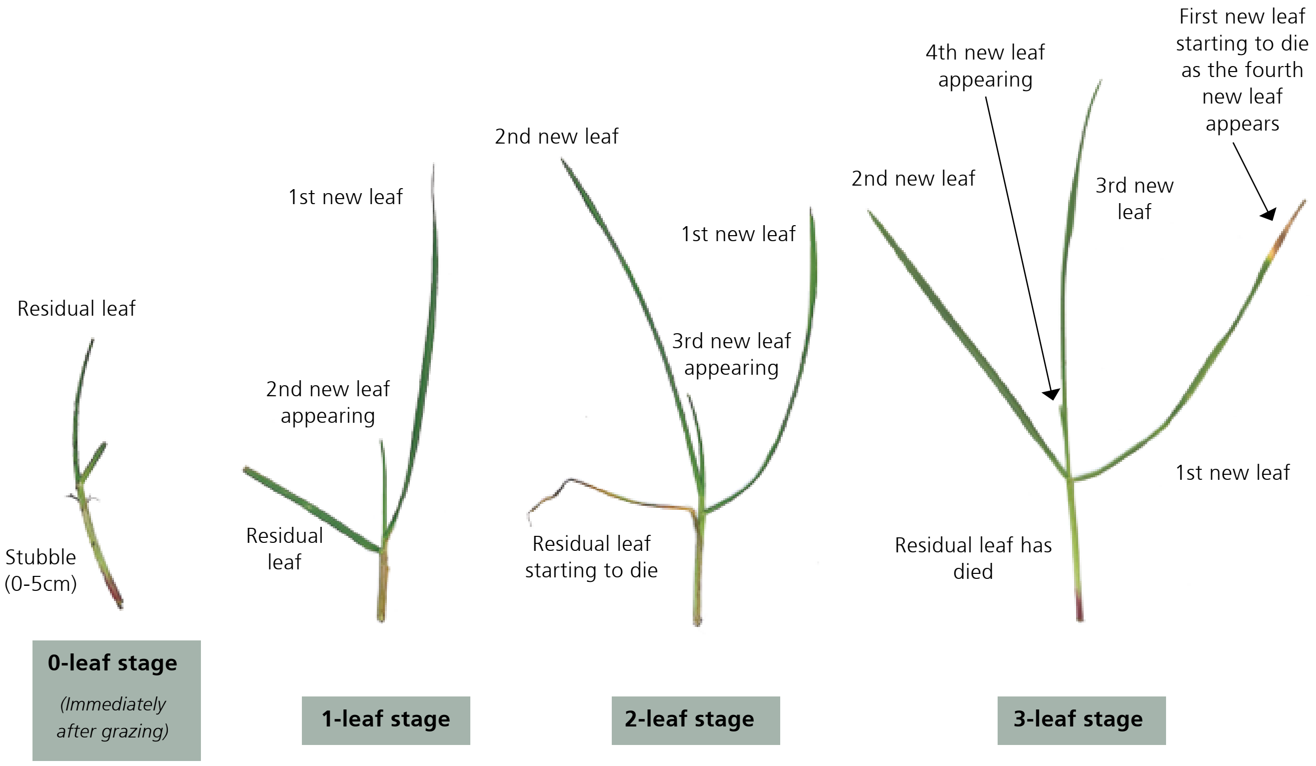
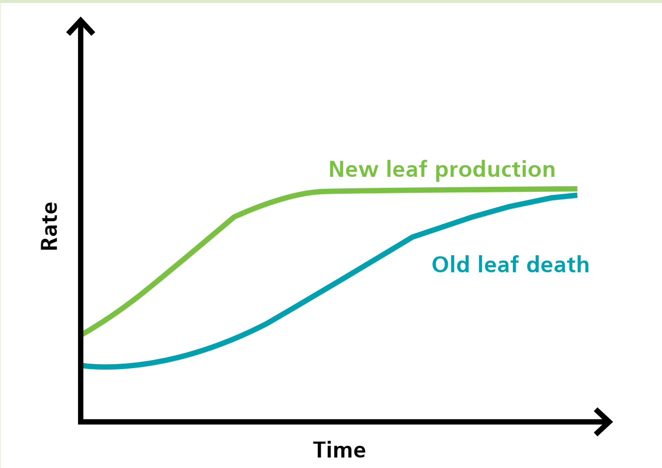


Figure 2: Changes in the rates of new leaf production and the rate of which old leaves die following grazing.[14]



How do I easily identify the optimal time to graze?

Maximum average growth rate occurs at approximately the 3-leaf stage after grazing[3]. Monitoring leaf stage is an effective indicator of when a paddock is ready to graze. Current recommendations are to graze pastures between the 2 and 3-leaf stage of regrowth. The first, second and third successive leaves produced after grazing contribute 25 percent, 35 percent and 40 percent, respectively, of the total available pasture mass at the next grazing[4]. As the contribution of the first leaf to total pasture mass is relatively small, fast rotations that consistently graze pastures before the 2-leaf stage of regrowth will significantly reduce pasture growth. Increasing rotation length to consistently graze pastures at the 3-leaf stage results in a yield advantage compared with grazing at the 2-leaf stage. Chapman et al[9] calculated this yield advantage to be 1.1 t DM/ha/year for Canterbury irrigated pastures (Table 1).

Managing regrowth interval in spring

The contribution of each successive leaf to total available pasture mass varies seasonally (Table 1). When reproductive growth is present and growth rates are high in spring (October – November) the difference between the contribution of the second and third leaf to the available yield at grazing largely disappears[4] and there is little additional yield benefit in delaying grazing from the 2-leaf stage to the 3-leaf stage[10]. There is always a yield penalty if pastures are grazed before the 2-leaf stage of regrowth. Leaf stage can therefore be viewed as a flexible grazing management tool with a grazing window between the 2 and 3-leaf stage[5]. Rather than rigid adherence to a single leaf stage grazing target, grazing management must also consider system needs such as pasture cover targets, feed demand requirements and pasture quality. For example, during periods of high growth rates in spring, lower stocked-farms may graze closer to the 2-leaf stage to control pastures covers and maintain pasture quality.

Pasture quality

Perennial ryegrass moves from vegetative to reproductive growth during spring which results in significant changes in pasture composition. Reproductive growth leads to stem elongation and an increase in the proportion of stem to green leaf which tends to lower overall pasture quality, as stem has a lower nutritive value[6]. More frequent grazing during spring removes stems before they are fully elongated resulting in pastures with lower stem content, less dead material, more green leaf and higher ME [11]. Current recommendations are to graze pastures at a pre-grazing mass of 2600-3200kg DM/ha[8], depending on stocking rate.

Residuals

The pasture regrowth recommendations are based on pastures grazed to an optimal residual of 3.5-4.0 cm (7-8 clicks on RPM). However, on farm research has identified that optimal post-grazing residuals are achieved only 50% of the time[7].

High post-grazing residuals result in reduced growth rates during the subsequent regrowth cycle[2]. Why is this? The greater residual leaf area following high post-grazing residuals actually results in higher growth rates initially. However, the rates of leaf ▶

Table 1: An example of the seasonal contribution of successive perennial ryegrass leaves to total dry matter yield based on typical growth rates and leaf appearance intervals for Canterbury irrigated pastures[9]

	Growth rate (kg DM/ha/d)	Leaf apperance interval	Contribution of 1st: 2nd: 3rd leaf total DM (%)	DM grown (kg/ha) when grazed at:		Difference
				2-leaf	3-leaf	
Feb-Mar	55	10	25:35:40	2970	3300	330
Apr-May	26	15	25:35:40	936	975	39
Jun-Jul	0					0
Aug-Sep	34	15	25:35:40	1224	1275	51
Oct-Nov	95	7.5	30:35:35	7410	7552	142
Dec-Jan	95	10	25:35:40	5130	5700	570
Totals				**17670**	**18802**	

death are also high (as there is more residual leaf and residual leaves tend to be older) and reach a maximum and cancel the rate of new leaf production earlier in the regrowth cycle compared with optimal residuals. As a result, the maximum average growth rate is reached earlier in the regrowth cycle and is a lower value than for well-managed pastures.

The post-grazing residual from which a pasture regrows also has a significant impact on pasture composition and quality at subsequent grazings, and subsequent milk production. Research both in New Zealand and overseas has demonstrated that lax grazing during spring results in pastures with greater stem content, higher amounts of dead material and of lower digestibility at subsequent grazings. As a result, laxly grazed pastures support lower levels of milk production at subsequent grazings[12].

Achieving optimal post-grazing residuals also stimulates the production of new or daughter tillers which keeps tiller density high. Daughter tillers are produced from buds located at the base of the parent tiller (Figure 3) and in order to maintain pasture productivity and persistence, each tiller must leave behind at least one offspring. Consistent post-grazing residuals of 3.5-4cm (or 7-8 clicks on the RPM) increases the quantity of light reaching the base of the pasture which stimulates tiller production and aids the survival of newly emerged tillers. Studies in New Zealand have shown that pastures that are grazed to optimal post-grazing residuals have a higher tiller density compared with laxly grazed pastures[13].

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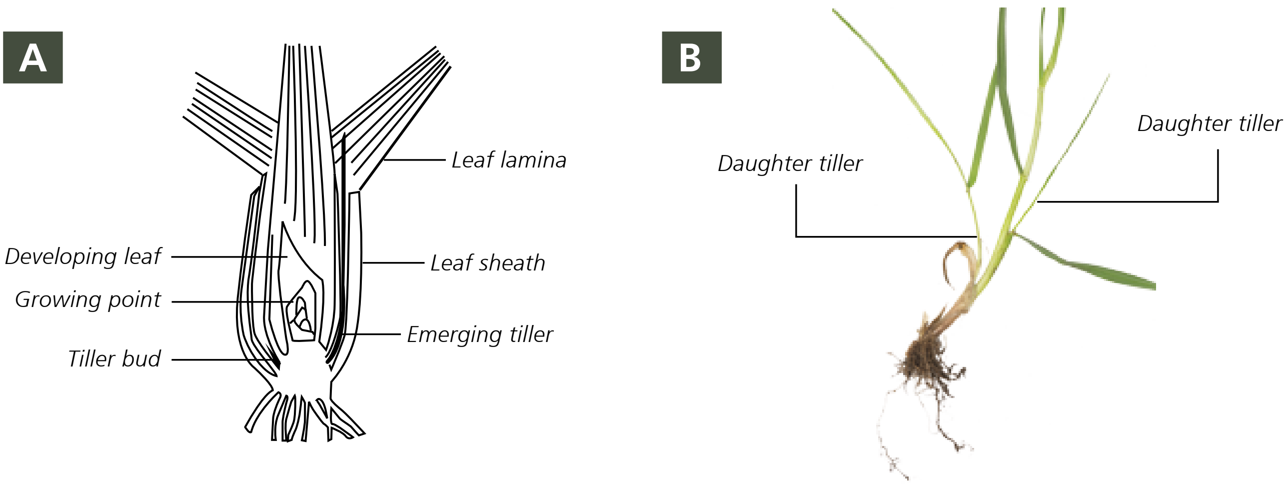
Figure 3: a) diagram of grass tiller showing tiller bud located at base of parent tiller and emerging daughter tiller and b) perennial ryegrass tiller with two daughter tillers



Nature to the rescue: Biocontrol of pasture pests

Biocontrol of invasive exotic weeds and pests has proved highly-cost effective in New Zealand with some spectacular recent successes. AgResearch science and team leader, biocontrol and biosecurity, Alison Popay explains.

Key points

- Pasture pests cost farmers more than $600 million each year.
- Populations of three weevil pest species have been suppressed in the short term using introduced braconid wasps.
- Natural pathogens of grass grub and porina can reduce these pest populations, but relying on natural occurrences of such pathogens alone is risky.
- Two bacteria used as biopesticides have been proven to significantly reduce grass grub populations.

Alison Popay, AgResearch

Biocontrol of invasive exotic weeds and pests has proved highly-cost effective in New Zealand. The country's productive sectors are vulnerable to invasion by species that arrive without their natural enemies, hence its strong focus on biosecurity. However, the careful selection and introduction of one or more of these natural enemies has led to the long-term suppression of the target weed or pest throughout the country.

Parasitoids and Predators

Parasitoids (parasitic wasps and flies) and predators are key components of sustainable pest management in pastures, whether they are natural inhabitants or deliberate introductions. Conservation measures that preserve and enhance their populations, such as maintaining host plant diversity and refuges where they can survive through unfavourable conditions, can help pest suppression.

Implementing a classical biocontrol programme involving identification and release of a suitable agent (or agents) requires careful consideration of the risks and benefits of introducing organisms into a new environment to ensure they don't harm non-target species. There are strict regulatory controls on introducing new agents into New Zealand and extensive testing is undertaken to ensure they will have limited effects on native species.

In New Zealand, biological control programmes have been successfully implemented for three major weevil pests, the lucerne weevil, Argentine stem weevil (ASW) and most recently the clover root weevil (CRW). For each of these weevil pests, different species of parasitic wasps (*Microctonus spp.*) were introduced (Figure 1). These tiny wasps lay their eggs in adult weevils making the females infertile, and the larvae develop within the weevil, eventually killing it when they emerge as pupae.

1) To control Lucerne weevila a Moroccan biotype of the parasitic wasp *M. aethiopoides* was released in the South Island between 1982 and 1985 with the parasitoid naturally dispersing throughout New Zealand by 1998 and providing a high level of pest suppression that has continued to this day[1].
2) In the early 1980s it was discovered that fungal endophytes protected ryegrass against attack by ASW, a major pest of ryegrass. To provide another tool for control of this serious pest, the wasp, *M. hyperodae*, was introduced[2]. This biocontrol agent initially appeared highly successful, but there is now evidence that parasitism levels may no longer be effectively reducing populations of this pest[3] and work is in progress to understand why.
3) The most recent parasitoid releases have been against CRW, first found inhabiting pasture in 1995. In this case an Irish biotype of *M. aethiopoides* has been released with spectacular success[4]. Beginning in 2006, the parasitoid was widely distributed throughout the North Island using nursery sites and many 'mini-releases' of parasitized weevils to farmers[4]. After CRW reached the South Island in 2006, strategic releases were made based on knowledge of dispersal of both the weevil and the parasitoid[5]. This project culminated in a mass release program in two regions in the southern South Island after very high populations of CRW caused clover to largely disappear from the area. Over two years an estimated 900,000 parasitized weevils have been distributed to farms across these regions by a small group of scientists and technical staff in conjunction with industry representatives. Already clover is returning to pasture with a cost benefit of $15/ha/year to dairy farmers in this region alone[6]. Overall, the programme has a cost benefit of $20/ha/year to dairy farmers nationwide (unpublished AgResearch data).

Figure 1: Exotic weevil pests of New Zealand pastures and their associated parasitoids (*Microctonus spp*).

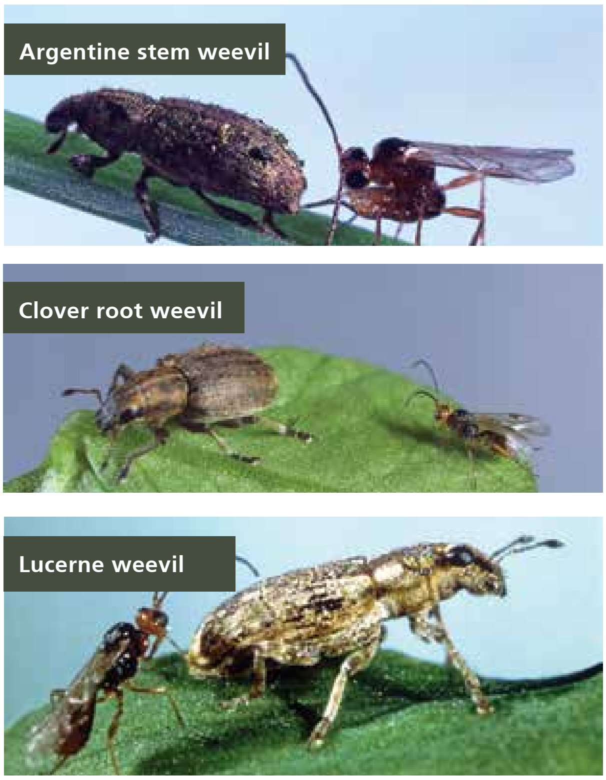


Figure 2: Some of the pasture pests that are killed by *Yersinia entomophaga*.

Entomopathogens

The majority of endemic and native insects, such as grass grub and porina, are likely to be associated with entomopathogens (disease organisms that attack insects), including fungi, bacteria, viruses, microsporidia and protozoa. The natural pathogens of grass grub and porina are able to reduce pest populations without human intervention. To be successful, the disease organisms need to be continually replenished in the soil by deaths of diseased individuals from the previous generation. Climatic and farm management interventions, such as drought and cultivation, can break the cycle of disease through successive generations by reducing both the host population as well as viability of the pathogens. Thus a reliance on natural disease cycles to maintain effective population levels is risky, particularly under intensive farming regimes where there is a low tolerance of yield reductions.

Biopesticides

The term biopesticide is applied to the mass production and application of pathogenic microbes such as bacteria, fungi, microsporidia, viruses, protozoa or nematodes for the management of pests. Biopesticides are usually not self-sustaining and repeat applications are required to suppress populations. Factors that limit the mass production of effective organism and their use in the field include shelf-life and stability, consistent efficacy in the environment, rapidity of effects and ease of application.

In New Zealand, two species of bacteria with specific application to grassland pests are *Serratia entomophila* and *Yersinia entomophaga*. Pathogenic strains of *Serratia entomophila cause* 'amber disease' in New Zealand grass grub, quickly stopping them feeding although infected individuals take some time to die[10]. Natural disease outbreaks are known to occur but the bacteria can be mass produced and have been formulated for commercial application as a bioinsecticide[11]. Farmers are encouraged to apply *S. entomophila* before grass grub reach damaging levels to establish a source of inoculum in the soil that will continue to naturally infect grass grub larvae in the next generation[7].

More recently, a toxin-producing bacterium, *Yersinia entomophaga*, was discovered naturally infecting grass grub. Although not common in populations, this bacteria has been found to affect a range of major pasture pests in New Zealand, including grass grub and porina larvae (*Wiseana spp.*)[8, 9] and black beetle (Figure 2). Its use as a biopesticide is still in the experimental stage but it can be applied as a spray, in granules or incorporated into bait. The activity of *Y. entomophaga* is specific to insects and, although it may affect other plant feeders, beneficial species such as predatory staphylinids and earthworms are unharmed [9].

Conclusions

New Zealand pasture ecosystems remain highly vulnerable to outbreaks and chronic infestations of pests, in spite of outstanding achievements in biocontrol and plant resistance. However, armed with better knowledge of what drives these pest populations, new pest control tools can be added, ranging from increased pasture resilience through increased biodiversity, to new endophytes, biopesticides, and classical biocontrol introductions. This will ensure farmers can meet market expectations of sustainable, environmentally-friendly food production systems and still remain internationally competitive.

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Research finds most pregnancy losses occur in first week

A new study shows that fertilisation failure and impaired embryo development in the first week are the greatest contributors to pregnancy failure, writes AgResearch senior scientist Debbie Berg.

Key points

- Around 55 successful pregnancies will be established for every 100 cows inseminated during the first round of AB.
- Pregnancy will fail in the first week after insemination for 34 of these 100 cows.
- Fertilisation failure and impaired embryo development are the greatest contributors to pregnancy losses up to 70 days after insemination.

Debbie Berg, AgResearch

We know from industry statistics that the odds of dairy cows establishing a viable pregnancy to any single insemination are little more than half a chance[1]. Improving these odds requires answers to key questions, such as: Were the cows actually on heat at insemination? Were the eggs fertilised? Did the embryo die between fertilisation and 21 days after insemination, or did the embryo die later, perhaps explaining why some cows have long-return intervals? These are examples of early embryonic mortality and international data suggests this represents the largest source of reproductive failure in dairy cattle, with the greatest loss occurring in the first three weeks after insemination. Fertilisation of the egg is not considered to be a major problem as 80-100 percent of the eggs are fertilised when cows are inseminated at the correct time[2]. New Zealand research has shown that six percent of cows pregnant to a single insemination will experience late foetal loss between 42 and 154 days after insemination[3]. The early embryonic mortality rate has not been determined in New Zealand dairy cattle and there is no information regarding the partitioning of embryo losses during critical developmental stages up to Day 35 of pregnancy. Science solutions for improving pregnancy rates are somewhat hampered by this lack of knowledge.

Accordingly, a two-year study was undertaken to address the issue of early embryonic mortality following the first insemination in the New Zealand dairy cows. The primary objectives of this experiment were to: (1) validate the premise that fertilisation of the egg occurs more than 80 percent of the time and is not the major source of conception failure to Day 35; and (2) measure and partition when losses are occurring between fertilisation and Day 35 of pregnancy. Secondary objectives were to: (1) account for cases where insemination did not coordinate with ovulation (i.e. fertilisation was not possible from the outset); (2) quantify likely pregnancy losses between Day 35 and final pregnancy testing 10-12 weeks after the first insemination; and (3) examine some of the possible risk factors for conception failure, such as calving date, cow condition, pre-mating cycling status, age, and milk yield.

Four farms located in Taranaki, Waikato and Northland were involved over two consecutive breeding seasons with 1890 cows enrolled in the study. Cows were randomly allocated into one of four groups at Artificial Breeding; 8, 16, 35 and 70 days after insemination. Determining embryo losses between 8 and 16 days required removing the embryo from the cow's uterus by flushing it out. This is possible because the bovine embryo floats unattached in the uterus until implantation at approximately 20 days after insemination. Recovered embryos were evaluated based on stage of development, quality of the embryo (based on the probability of producing a viable pregnancy if transferred into a suitable recipient), and serum progesterone levels. For the remaining two groups, pregnancy rates were determined by ultrasonography 35 and 70 days after insemination.

Submission rates averaged 77 percent and varied between farms, ranging from 67 to 89 percent. The majority of cows (96 percent) were submitted at the correct stage for insemination. We found that 1 percent of the cows had an acute uterine infection and another 4 percent did not produce adequate levels of serum progesterone to support a pregnancy, causing the cow to short cycle or return to heat at approximately 21 days. Recovering embryos eight days after insemination indicated that 87 percent of the eggs were fertilised. However, 13 percent of the flushed cows had embryos that had either arrested in development, or were of poor quality, and so had little or no chance of establishing a pregnancy. The percentage of flushed cows having an embryo that had a high probability of establishing a pregnancy was 66 percent. Thus, within the first week, 34 cows per 100 inseminated had no, or little, chance of establishing a successful pregnancy.

The fate of embryos recovered 16 days after insemination indicated that a further 5 percent of pregnancies had failed, leaving 61 percent of the cows with a good chance of going on to maintain a successful pregnancy. Pregnancy diagnosis by ultrasonography determined that 58 percent of the cows were pregnant 32 to 37 days after the first insemination, using the presence of a foetal heartbeat as the criteria for a viable pregnancy. The final pregnancy rate 70 days after first insemination was 55 percent. Preliminary results demonstrated a greater risk of embryo loss in the first 16 days following insemination for cows that had a body condition score (BCS) less than 4 at the planned start of mating. Cows that were three and eight years of age experienced greater embryo loss, compared with cows in other age groups.

Based on these results, 100 New Zealand dairy cows submitted for their first insemination would result in four cows inseminated at the incorrect time, one cow having an acute uterine infection and three cows not producing adequate progesterone to establish or maintain a pregnancy. Of the remaining 92 cows, 13 cows would have unfertilised eggs and another 13 cows would experience embryo loss. Eight days after insemination, 66 cows would remain pregnant. Sixteen days following insemination, 61 cows would remain pregnant. Pregnancy diagnosis at 70 days following the first insemination would determine that 55 of the original 100 cows remained pregnant. An additional three cows would experience late foetal loss after 70 days which would leave 52 cows calving[3]. These results demonstrate that fertilisation failure and impaired embryo development in the first week are the greatest contributors to pregnancy failure.

These findings indicate a huge opportunity to improve reproductive performance through science-based solutions for improving egg quality and the early maternal nurturing of a fertilised egg in dairy cows.

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This work was funded by the Ministry of Business, Innovation and Employment, New Zealand dairy farmers through DairyNZ and AgResearch Core Funding.

Science snapshot

DairyNZ levy funded or supported science

Carbohydrate reserves are important for chicory and plantain production *(Lee et al)*[1]

Stored carbohydrate reserves provide energy for leaf growth after grazing. As plants grow new leaves, they are able to capture more light energy and their reliance on the stored carbohydrates decreases which allows the reserves to be replenished. Herbage production and plant survival can be reduced if plants are repeatedly grazed before their reserves have been replenished (i.e. rotation lengths are too short).

This study measured the pattern of carbohydrate reserve depletion and replenishment in chicory and plantain during summer, the peak growth period, and assessed whether or not plant growth was reduced if plants were defoliated before their carbohydrate reserves had been fully restored.

Over a 35-day regrowth period in January/February, whole plants (including roots) of chicory (cultivar 'Choice') and plantain (cultivar 'Tonic') were removed at regular intervals and the leaf and root fractions were analysed for non-structural carbohydrate content. Dry matter (DM) production of the chicory and plantain pastures was measured simultaneously.

In chicory, non-structural carbohydrate reserves declined for seven days after the plants were defoliated. After this, replenishment began, with the stored reserves reaching pre-defoliation levels by day 21 of regrowth. In plantain, carbohydrate reserves declined for 14 days after defoliation. Reserve replenishment began from day 21, with pre-defoliation levels achieved by day 35 of regrowth.

Dry matter production was reduced if chicory was defoliated before 21 days of regrowth or if plantain was defoliated before 35 days of regrowth.

Chicory recommendation:

Dry matter production from a first-year chicory crop will be reduced if it is repeatedly grazed before 21 days of regrowth during summer. A rotation length of 21-28 days (pre-grazing height of 35 cm) optimises DM production and feed quality.

Plantain recommendation:

Plantain leaves become more fibrous and less digestible as they age. So while a longer rotation (e.g. 35 days) increases herbage production during summer, it also reduces quality. A summer rotation length of ~21 days (pre-grazing height of 25 cm) provides a good balance between growth and quality.

References

1. Lee, J.M., E.M.K. Minnee, and C.E.F. Clark. 2015. Patterns in non-structural carbohydrate and nitrogen reserves in chicory (Cichorium intybus L.) and plantain (Plantago lanceolata L.) during regrowth in summer. Crop and Pasture Science 66: 1071-1078.