THE GRASS WHISPERERS - MAKING PASTURES PERFORM FOR YOU!

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Introduction

Growth and consumption of pasture is a cornerstone of profitability in pasture-based dairy systems (Roche et al. 2016), and is critically important given the current low returns for New Zealand farmers. This knowledge has provided an emphasis on grazing management in pastoral regions of the world, resulting in a number of different grazing systems and rules being developed. Interestingly, while the principles of pasture growth are well understood and accepted (Fulkerson and Donaghy 2001; Chapman et al. 2014), it is mostly the terminology used in describing those principles that changes how messages are presented, along with the occasional 'grazing rule' that is not based on principles.

This paper focuses on the principles of ryegrass pasture growth and how these were used by the Hopkins Farming Group (https://hopkinsfarming.co.nz/) to achieve their goals. The Hopkins Farming Group own 11 dairy farms, 10 in the Manawatu region and 1 in Hawkes Bay, along with 2 dry-stock farms, covering a total area of around 4700 ha. The individual farms are run by farm managers, with a farm overseer, and consultant Brian Clarke is employed to review all of the farms. The farms rely on purchased supplement, in the form of maize silage along with palm kernel expeller, to fill feed gaps both in the dry summer/autumn period, as well as the cold winter period.

In 2015, facing a low milk price, and understanding the strong positive relationship between consumption of home-grown pasture and profit, a management decision was made to reduce the amount of purchased supplements by growing, consuming and conserving more of their own pasture.

In previous presentations by Danny Donaghy of Massey University, the group had heard about using 'leaf stage' management of ryegrass to set grazing rotation (i.e. the grazing interval,

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or when a paddock is grazed), and how around half of the pasture dry matter (DM) yield occurs between the 2-leaf and 3-leaf stages of regrowth. This was very exciting, but the group knew that longer rotations, especially in spring, could result in difficulty controlling pasture quality and postgrazing residuals. And with most Hopkins managers not actively monitoring leaf emergence, what did a 2-leaf or a 3-leaf rotation look like, in terms of number of days since last grazed? And would this have any effect on the current management systems being run, in terms of silage harvested, nitrogen (N) fertiliser used and postgrazing residuals?

So with a decision made to grow and conserve as much high-quality pasture as possible, by aiming to graze at the 3-leaf stage as often as possible, fortnightly meetings were scheduled where Danny Donaghy, Brian Clarke and the Hopkins management, farm managers, assistant managers and key staff, would meet at a farm close to Palmerston North (Waihora farm, 900 cows on 320 ha) starting in October 2015. Meetings took place in the evening, with the aim of spending 1-2 hours in the field discussing pasture management, then monitoring the effect of management decisions, and making sure that all the managers were comfortable in being able to identify plant-related indicators (e.g. leaf stage), and incorporate these into their management.

All of the group were issued copies of the DairyNZ booklet “Perennial ryegrass grazing management in spring, a paddock guide”, written by Sean McCarthy, Cáthal Wims and Julia Lee from DairyNZ, and Danny Donaghy from Massey University (McCarthy et al. 2015). This paddock guide explains how to identify and apply the key principles relating to grazing management of ryegrass pastures.

The remainder of this paper outlines the science that was presented as relevant in pasture management, the key messages coming from this that were observed and discussed, the results that the Hopkins Farming Group achieved, and some of their observations.

Pasture as a dynamic, evolving system - the importance of tillers

At the first meeting we started at ground level - literally on our hands and knees in a paddock. We identified ryegrass plants, which is an important first step, as a number of farmers don’t get close enough to identify what’s in their pastures. They can miss the fact that the ryegrass they sowed is disappearing and being replaced by less-productive grass species that can look similar to ryegrass. At discussion groups and field days we commonly hear comments of how ryegrass density ‘dropped out’ and paddocks ‘bared out’, and often this could have been identified earlier and possibly remedied, or a solution planned for, months before it became an issue.

This activity wasn’t aiming to turn the managers into qualified agronomists, but the plan was that a small amount of time spent identifying ryegrass would allow them to ‘get their eye in’ quickly when on their weekly farm walks, and add more useful information to these farm walks. It would also make it easier to recognise ryegrass when using leaf stage to set grazing rotations.

As part of the exercise we also identified the tillers of ryegrass (Figure 1). Each tiller has its own leaves and roots but is connected to other tillers at the base. Young tillers are known as 'daughter tillers'.

Figure 1. A mature perennial ryegrass tiller with 2 daughter tillers (McCarthy et al. 2015).

One of the important things about tillers is that they only live for about a year (Jewiss 1966). There are two major periods of tillering, autumn and spring, with spring the larger of the two. This was a major point that the group picked up - that all of their paddocks were a population of less than 1 year old 'plants', even if they had been established 10 or more years ago! Perennial pastures are therefore a 'repeating annual crop' and we have two opportunities (autumn and spring periods) to either increase, or decrease, pasture density.

As we were already in spring (October) with warm soil temperatures, some sunny days and good soil moisture levels, we were expecting to see lots of young daughter tillers. On the tillers that didn't have daughters, we peeled beck the dead material around their base to check if they had tiller buds ready to emerge (Figure 2). We used this exercise as a 'health check' on the paddock - since parent tillers will quickly abort their daughters if they are under stress, then tillers with multiple daughters and/or multiple healthy buds in spring or autumn are indicating

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that plants have enough energy and nutrients (i.e. are ‘healthy’). If they were low in energy or nutrients (i.e. ‘unhealthy’), then not as many daughter tillers would be present.

Figure 2. Base of a perennial ryegrass tiller showing healthy daughter tiller bud emerging but not yet visible from the outside as a daughter tiller.

From the group’s point of view, this early awareness of ‘pasture age’ was important to start viewing pastures as dynamic and evolving, and under their control. Of course they couldn’t control how spring was going to pan out, and at that stage we were all wary of the effects of the El Niño system, however they became aware of how their management could enable pastures to be healthy and dense, for whatever season was to come.

The key realisation that came to the group at the time was that the mature tillers we were seeing in October had been born earlier in the year in autumn, and would all be dead by the end of the coming summer. So if we wanted quality ryegrass pasture to feed the cows from around Christmastime onwards, we had to immediately focus on encouraging daughter tillers! Encouraging tillering would ensure that pasture density was maintained or improved, which would positively impact on pasture persistence (older parent tillers are replaced with daughter tillers), pasture DM yield (there are more tillers to produce leaves) and pasture quality (poorer quality weed species would be out-competed by denser ryegrass).

Seeding - determined in wintertime

Another discussion point was that in perennial ryegrass, seeding is a 2-stage process, with cold temperatures in winter the first stage and longer daylengths in spring the second stage. Generally, the colder the winter, the more seeding will take place the following spring. Knowing this can give early warning on farms where seeding is difficult to control. For the Hopkins Group, it meant that the new daughter tillers that we were seeing in October wouldn’t be going to seed (they hadn’t been through winter), and that as the previous winter had been mild, we could expect to have less seeding than usual.

Energy levels in plants and the importance of energy stores

Carbohydrates in the form of simple sugars are the main form of energy that pasture grasses use for maintenance and growth. Ryegrass makes these sugars in the leaves and stores them in the base of the tiller, especially the bottom 4cm; these energy stores are important for growth and persistence.

Knowing this, it’s obvious that grazing management will have the major impact on plant energy levels and therefore growth and persistence. The length of the grazing rotation will affect how much energy we allow the plant to accumulate, while the postgrazing residual (how hard a paddock is grazed) will affect how much of the energy storage organ (the bottom 4cm of the tiller) we allow to remain.

This got the group focused on ‘protecting the residual’ at a minimum of around 4cm, in order to protect the energy stores of the plants.

Leaf regrowth stage reflects plant energy levels, and also quality

All grass tillers maintain a set number of live leaves, after which each additional new leaf that emerges is balanced by the death of the oldest leaf. For example, ryegrass is termed a ‘3-leaf’ plant, as each vegetative tiller maintains around 3 live leaves (Davies 1960). This is a basic principle on which good pasture management practices are based, that leaves have a limited lifespan, and if they are not harvested (grazed, or cut and conserved as silage or hay), then they will die and be wasted (Fulkerson and Donaghy 2001).

The leaf emergence (i.e. time taken for 1 leaf to fully emerge) is influenced mainly by temperature and then soil moisture. Nutrient supply has no major effect on leaf emergence, although N in particular makes leaves longer and wider, affecting growth and pasture cover. The fastest leaf emergence for perennial ryegrass is around 9 days/leaf in springtime, may be similarly fast in autumn months as long as soil isn’t dry, and then decreases in dry/hot summers and cold winters.

In well-utilised pasture, leaf regrowth proceeds as outlined in Figure 3.

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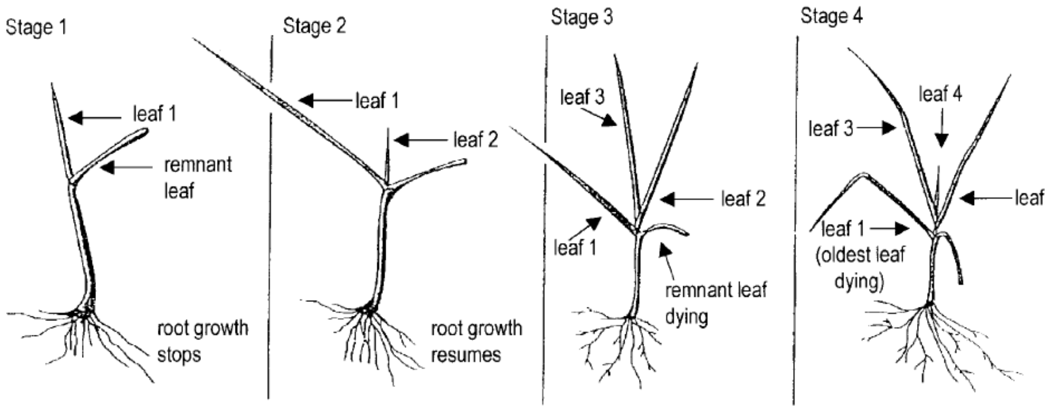

Figure 3. Regrowth of a ryegrass tiller following defoliation (Donaghy 1998).

Regrowth follows these stages because there is a priority for stored energy (Donaghy and Fulkerson 1998). The first priority is regrowth of the leaf to re-establish energy supply, and so growth of new tillers and roots stops, and energy stores are mobilised from the bottom 4cm of the tiller. At around the 1-leaf stage of regrowth, energy begins to be stored again, and this triggers the roots to begin regrowing. However, the plant is vulnerable to regrazing, with low energy stores, roots just starting to regrow, and young daughter tillers receiving no support from older parent tillers.

At around the 2-leaf stage, roots are actively growing, energy stores accumulate and daughter tillers begin to be supplied with nutrients and energy by older parent tillers. For this reason, the 2-leaf stage is considered to be the minimum grazing rotation for ryegrass plants. At the 3-leaf stage, root growth and tillering are fully active, energy stores in the tiller bases have been replenished, and overall growth is close to maximum. At the 4-leaf stage, the oldest leaf is dying, pasture quality starts to decline and increasing amounts of pasture are wasted. For these reasons, around the 3-leaf stage is considered to be the maximum grazing rotation (Fulkerson and Donaghy 2001).

This priority for energy stores, or energy partitioning, is shown in the lower part of Figure 4.

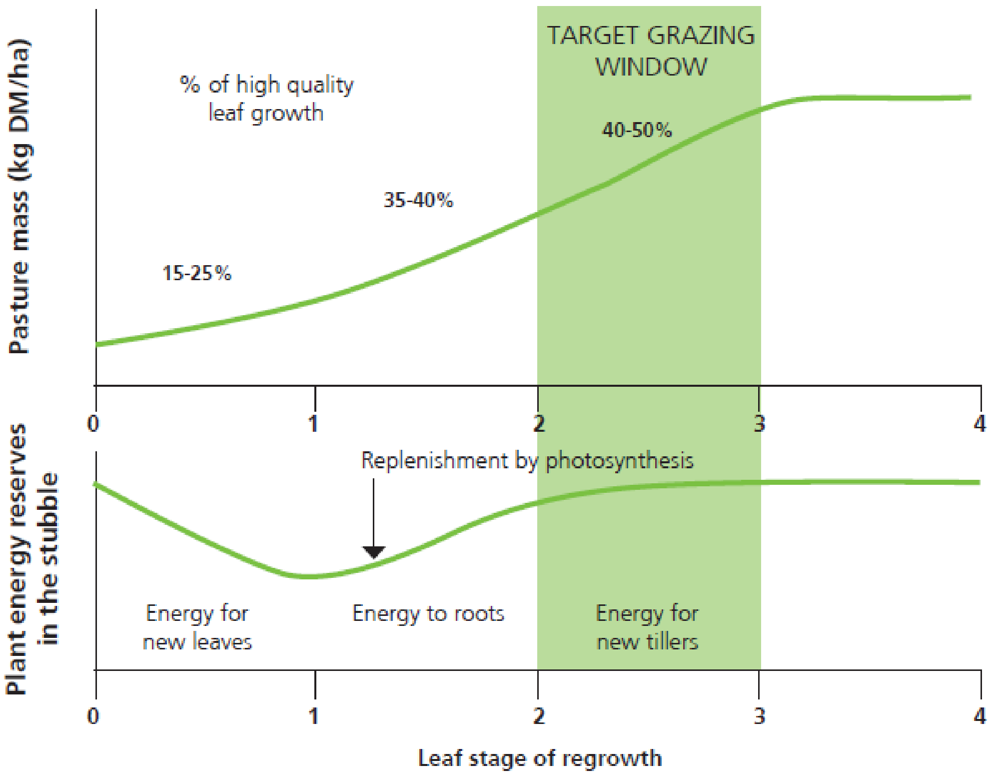

Figure 4. Relationship between leaf regrowth stage and either pasture mass (upper figure) or partitioning of energy stores to new leaves, roots and tillers (lower figure) (McCarthy et al. 2015).

Regrowth at the pasture level proceeds as shown in the upper part of Figure 4, with around 15-25% of pasture DM occurring in the time taken for the first leaf to fully grow (the 1-leaf stage), 35-40% in the time taken for the second leaf to fully grow (the 2-leaf stage) and between 40-50% in the time taken for the third leaf to fully grow (the 3-leaf stage). Only one leaf grows at a time, and each leaf is larger than the one before it, up to the 3-leaf stage.

The quality of pasture also changes with regrowth. Metabolisable energy (ME) declines with age and amount of stem material, and there is a trend for lower ME with regrowth of ryegrass, with a decline in ME between the 1-leaf and 3-leaf stages that ranges from 0.1-0.8MJ ME (Turner et al. 2006; Pembleton et al. 2016), with the higher decline in harsher seasons

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(hotter, drier). However this decline in ME is not low enough to limit milk production from dairy cows (i.e. total ME remained > 11 MJ in the studies quoted), and is insignificant in relation to the extra DM produced at the longer rotations.

The mineral levels in leaves also change with regrowth, with higher concentrations of N, potassium and phosphorus in young plant material (1-leaf stage), decreasing as plants age (3-leaf stage), and the reverse pattern occurring for all other minerals (Fulkerson and Donaghy 2001). Because N and potassium are often in excess of animal requirements in early regrowth (1-leaf stage), and can cause a range of metabolic issues, there is continually a better balance of minerals for rumen function from the 2-leaf stage onwards (Fulkerson and Donaghy 2001; Pembleton et al. 2016).

So leaf regrowth stage is a sort of ‘use by date’ for pastures, and the 2-leaf to 3-leaf stage has been used as an indication of when plants are ‘ready’ to be grazed (Fulkerson and Donaghy 2001). The exception to this is when canopy closure occurs before the targeted leaf stage is reached. Canopy closure is the point beyond which the base of the pasture is no longer visible when viewed from above (Rawnsley et al. 2014). At this stage, shading leads to a decrease in tillering, and an increase in the amount of fibrous stem material, so pasture quality declines. In diploid perennial ryegrass, canopy closure occurs at a pasture mass around 3000 kg DM/ha, while in tetraploid perennial ryegrass as well as annual and biennial ryegrasses, canopy closure occurs at pasture masses around 3300-3500 kg DM/ha. Pasture that is close to canopy closure should be grazed regardless of leaf stage (Roche et al. 2016).

Postgrazing residuals reflect how well cows are being fed, as well as affect the next rotation

The ideal grazing residual for ryegrass is around 4 to 5cm, as the majority of energy stores are below this point, and this height allows enough light into the pasture base to stimulate tillering. However, in terms of DM yield, there is little difference between residuals of 3 and 8cm (Lee et al. 2008; Rawnsley et al. 2014). Depending on pasture density and composition, this 4 to 5cm residual will equate to somewhere between 1000 (very open pasture) to about 1800 (very dense pasture) kg DM/ha (Roche et al. 2016). In New Zealand, the target postgrazing residual in a dense pasture is around 1500-1600 kg DM/ha (McCarthy et al. 2015).

In practice, ryegrass can adjust to both lower and higher postgrazing residuals - consistently low residuals lead to more dense tillers that are semi-prostrate (tillers grow along the ground and then upwards, to protect their tiller base - look at a lawn or a sheep pasture to see this), and consistently high residuals lead to less dense, upright, larger tillers. Higher postgrazing residuals (e.g. > 6cm) lead to shading that produces stem at the base of the plant to elevate the growing points towards the light, and which eventually leads to aerial tillering (tillers produced above the ground surface which don't survive) and a decline in tiller density, which reduces pasture persistence.

Postgrazing residuals also have an impact on grazing rotation. Since the point at which canopy closure occurs is relatively constant (e.g. around 3000 kg DM/ha for diploid ryegrasses), then at any given pasture growth rate, lower postgrazing residuals will result in a longer grazing rotation before canopy closure occurs again, whereas under higher postgrazing residuals, canopy closure occurs sooner. This highlights a key interaction between postgrazing residuals and grazing rotation - while most pastures can recover from even very low residuals (say 2cm) if given sufficient time to recover (e.g. a rotation of at least 3 leaves), higher residuals require shorter rotations to maintain pasture quality (i.e. avoid canopy closure) (Chapman et al. 2014; Roche et al. 2016). Therefore, higher residuals can result in pastures being grazed before the 2- to 3-leaf stage, reducing DM yield and negatively affecting persistence.

Postgrazing residuals are also a good practical indicator of how well cows are being fed - much higher than about 5cm (and uneven) indicates that pasture is being wasted with no great increase in cow DM intake, whereas if residuals are less than about 4cm, cow DM intake declines significantly (Roche et al. 2016).

Putting it all together in practice

The first meeting focused on identifying ryegrass plants, looking for daughter tillers and counting leaves to determine leaf regrowth stage. Subsequent meetings focused on setting grazing rotation from leaf regrowth stage and monitoring postgrazing residuals, and also monitoring tillering and when seeding occurred. The DairyNZ paddock guide (McCarthy et al. 2014) was a valuable resource throughout.

Identifying ryegrass and tillering

This activity in the paddock led to discussions about tillering and what we needed to do to maintain healthy plants (with lots of daughter tillers), which focused the group on the target rotation (3 leaves - to maintain high energy levels in the plants), and target postgrazing residuals

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(4-5cm - high enough to allow enough tiller base for energy to be stored, but not too high that shading would lead to aerial tillering).

Looking at tillers in several paddocks allowed the group to identify seeding tillers early and predict peak seeding in different paddocks - knowing that these would be harder to manage (‘the pasture would bolt’) focused the group on shortening the rotation (targeting 2½ leaves at peak seeding), and planning to cut paddocks for silage so that the mower could reset the desired postgrazing height.

Identifying and measuring leaf emergence and canopy closure

The group’s focus for rotation length was on grazing all paddocks close to the 3-leaf stage, to maximise high quality yield. There are 2 ways that leaf stage can be used in practice:

1. We visited 1-2 paddocks that were due to be grazed, and measured leaf stage, to make sure that they were close to 3 leaves. This is a confirmation moment of whether your management has achieved your targets (in this case the 3-leaf stage). If not, then adjustments can be made to rotation length; however this is a backwards look at what you have achieved, and is therefore always reactive.
2. So in order to plan ahead, we visited 1-2 paddocks that had been grazed 10 days previously, and again looked at leaf stage. Because the fastest that perennial ryegrass leaves emerge is around 9 days/leaf in spring, what we were looking for was whether a full new leaf had emerged, or was about to emerge (peeling back the emerged leaves to see how far away a new leaf was). As soil dried out in late spring and temperatures increased, we went to paddocks that had been grazed around 15 days previously, as it was now taking 13-14 days for a leaf to fully emerge.

The leaf emergence at the first meetings in October 2015 was initially around 10-11 days/leaf. We set a grazing rotation of 30 days, so that all paddocks would be close to the 3-leaf stage. We were also expecting leaf emergence to speed up from the current 10-11 days/leaf to 9 days/leaf within the coming weeks, and it did. Leaf emergence then remained at around 9 days/leaf until mid-November. As it got warmer and drier in late November into December, the rotation was kept at the 3-leaf stage, but this was now closer to 35 days and extended to over 40 days as it got dry in summer.

As the season progressed, targeting the rotation to the 3-leaf stage gave the group confidence that this would maximise plant energy levels and tillering, result in a strong root system and ideal pasture quality. In spring an excess in pasture growth was cut for silage, some paddocks multiple times. Not wanting to compromise on this target rotation, as growth slowed because of warmer and drier conditions, supplements were fed on several occasions to maintain the rotation. This is a key role for supplements in pastoral systems, to allow pasture to be managed at optimum rotation, resulting in high DM yield and quality.

In several paddocks, canopy closure occurred before the 3-leaf stage and that got the group focused on the reasons why this was occurring. Because leaf stage was the same between all paddocks, the major reasons for a big difference in growth between paddocks included N fertiliser and/or higher postgrazing residuals. There is no sense in using N fertiliser to grow more pasture if the result is a faster rotation to control that growth before it causes canopy closure; even worse, if that rotation is now less than 2 leaves, then lots of the N will still be soluble, and so instead of using N to boost pasture yield, all you've done is increase N cycling and potentially N losses to the environment.

Monitoring postgrazing residual

The key to postgrazing residual is to maintain a consistent and even residual. The group's focus for postgrazing residual was on grazing all paddocks to 4-5cm; allowing for compressed plate meter height this equated to around 1500-1750 kg DM/ha. This ensured that cows were being offered adequate amounts of pasture, that the plant's energy stores were protected, that shading wasn't occurring, and that the target rotation could be maintained more easily. We had to be careful with the upper limit (around 1750 kg), because when growth rates were high, it was easy to reach canopy closure before the 3-leaf stage. For that reason the lower postgrazing height, equating to a range of 1500-1600 kg DM/ha, was adopted as the target.

If postgrazing residuals were higher than target, then one of 4 management options were implemented: cows (the herd or a proportion of the herd, depending on the amount of pasture left behind) went back into the paddock the next day to graze down to target; the mower came out and paddocks were mechanically topped to the target; the paddock was cut for silage in the next rotation; cows came back earlier in the next rotation (prior to canopy closure) and attempted to graze to the target residual.

When growth slowed, to 'protect' the residual from being overgrazed, supplements were again used on several occasions. This is another key role for supplements in pastoral systems,

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to maintain the optimum postgrazing residual, ensuring high energy levels in the plants and maintaining growth rates.

End results

The Hopkins Farming Group are still applying, refining and honing the skills developed in spring 2015. Since 'results' are still ongoing, and though this wasn't an experiment with a range of treatments and lots of individual measurements, the following anecdotes and outcomes are worth sharing:

- Regular fortnightly visits to the paddocks were very practical, and added a focus to what the managers were doing, because as a group they were meeting regularly and sharing what they learnt. This focus led to increasing confidence with applying the methods, and a feeling of being more in control than previously. Coming back on repeat visits to particular areas allowed the group to clearly see the impact of earlier management decisions. The group can now determine what defines a healthy ryegrass plant, and how management achieves this, through several different seasons
- Changing grazing rotations based on leaf stage was a slower and more comfortable process than many of the group had expected. Because leaf stage is mostly driven by soil temperature, which is a highly buffered system, the leaf emergence being checked weekly as part of routine farm walks (and then confirmed each fortnight at the group meetings) allowed the group to see gradual increases or decreases in leaf emergence, and adjust rotation plans accordingly. Changes in leaf emergence highlighted that growth rates were about to speed up or slow down, usually a week or so before these were measured either visually or through using a plate meter
- Growth rates were consistently higher than the group was previously used to, and this required close monitoring and proactive management to conserve surpluses in spring and prevent postgrazing residuals from increasing
- By autumn 2016 the Hopkins Group had conserved around double their average amount of grass silage, and purchased around half their average amount of maize silage. From that result, the exercise was a success. More pasture was grown, and incorporated into their system, reducing the amount of purchased supplements
- The group also felt that density had improved (time will tell!), and the managers on farms where soil dried off quickly in summer felt that consistently targeting the 3-leaf stage, which was a longer rotation than they had previously managed, put them in a safer position in relation to managing pasture availability in the dry. With a 3-leaf rotation, the rotation could always be shortened a bit (say to 2½ leaves) if needed, without damage to pasture,

whereas on a shorter rotation (e.g. 2-leaf stage) there is no ability to shorten the rotation further without damaging plants and suppressing pasture growth

- The group understood that a key role for supplements is to assist in managing pastures to their optimum

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