Grazing management of white clover in mixed pastures

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Abstract
Poor performance of white clover in the current climate of innovation farm management practices has become problematical, particularly within the dairy industry. There are as many grazing management systems as there are farmers and management guidelines can only be broad generalisations at best, with little interpretive value in the face of the multitude of options available and variables recognised and unrecognised. The principles of plant growth are used to interpret grazing management strategies in order for farmers to have greater understanding of their pastures and determine for themselves what the expectations and outcomes of various management strategies may be. This is of greater relevance to the dairy industry where innovative changes (pasture covers, grass cultivars, pasture renewal and establishment techniques, fertiliser N) can combine to produce a 'clover unfriendly environment'.
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Introduction
Before the recent adoption of fertiliser N, clover underpinned the pasture ecosystem of New Zealand's pastoral agriculture by maintaining adequate N nutrition through N fixation. It also provides superior quality herbage for animal production. The chief factor above all others governing the use of white clover is water (Levy 1970). Summer is the most critical and an estimate of the amount of rainfall needed is 40 mm/month for survival but 60 mm+/month for performance (Brock, unpub. data), otherwise without irrigation white clover should not be considered. Clover also needs space and light. In mixed grass/clover swards, this is maintained by grazing management, firstly by controlling the dominant grass component to provide the clover with the space and light required, and secondly, by manipulating the seasonal growth complementarity of the grass and clover as defined by their differential temperature responses. This basic research was carried out through the 1950s and summarised in a review for the NZGA 50th Conference (Brock *et al.* 1989). White clover has a higher and wider optimum temperature for growth (24°C; 18-30°C) than ryegrass (20°C; 18-21°C) (Mitchell 1956; Mitchell & Lucanus 1962). Clover stolon elongation is greater at higher temperature but branching increases as temperature decreases. In general, close frequent grazing favours white clover and lax infrequent grazing favours ryegrass. Brougham (1960) showed clover could be close grazed without adverse affect at any time of the year except over summer when temperatures and light were high and clover was growing at its maximum rate, but more importantly, when moisture availability was short.

By the 1960s, grazing management systems contained the following guidelines to maintain a good clover content.

- Close graze over winter while light levels and clover growth are low.
- Close, frequent grazing in spring (set stocking if possible) to reduce ryegrass flowering and increase both grass and clover density.
- Lax, infrequent grazing in summer to encourage potential clover growth and spread.
- Close, frequent grazing in mid-late autumn to reduce clover growth and promote ryegrass for winter.

Since then, research into both grass (ryegrass, cocksfoot, tall fescue) and white clover plants and population dynamics have explained the essential reasons underpinning such a system.

Ryegrass, competitor, protector, or both?
The above guidelines portray ryegrass essentially as a major *competitor* of white clover needing to be constantly kept in check. This is true to a point but both species need each other, clover to provide the nitrogen for the grass, and grass in sufficient density to prevent overgrazing and weakening of the clover i.e. a *protector* of white clover's vulnerable stolons and growing points. Manipulation of grass density using grazing frequency and intensity is the key. Using the annual cycle of death and renewal undertaken by white clover (Brock *et al.* 1988), the following is an interpretation of pasture management within the context of clover's requirements.

Late-autumn/winter: After autumn rain, earthworm activity increases and combined with stock treading on the softer soil, buries white clover stolons and growing points so that only the leaves remain above ground (Hay *et al.* 1983). Low temperatures reduce growth and low light levels necessitate close grazing and shorter pasture to allow enough light to reach the clover. Long pastures (autumn saved) are detrimental to clover.

Late-winter/mid-spring: Close grazing is beneficial for white clover, particularly in late winter, as N fixation has a lower temperature threshold (4°C) than soil N mineralization (6°C), allowing clover to start growing before ryegrass. Most importantly, this is the time when clover stolons buried over winter are regaining the soil surface and putting down the major roots on which clover will largely depend for the coming season. Allowing clover the best opportunity to grow and establish these roots at this time is extremely important. By mid spring, rising temperatures and pathogenic decay cause old redundant stolons from the previous season to be cast off and decay up to the newly formed roots. Side branches are released as new independent plants. Thus large plants quickly break up into smaller plants without any loss in growing point population. Growth as expressed by herbage production continues unabated, but now from more numerous but much smaller plants. Mismanagement, either from over grazing or shading by long pasture (resulting from late winter N for calving and early lactation, silage crops) is detrimental to clover during this period.

Late-spring/early summer: Frequent close grazing promotes grass tiller density at any time of the year, but never more so than in spring. Flowering is initiated by stem elongation which also induces daughter tiller formation. Removal of the flower head as it emerges then diverts energy back to the daughter tillers, enhancing their survival. Thus tiller density can be increased dramatically at this time and 'post-flowering depression' in ryegrass growth minimised. While close frequent grazing may not produce more clover herbage for animal feed in spring, it promotes clover branching, increasing growing points and potential growth in the coming summer. Close grazing also provides more light to the base of the pasture so that the stolons do not have to elevate to follow the light as can occur in longer lax grazed pastures. Keeping the stolons in contact with the ground promotes more rooting and reduces the chances of stolon stripping.

Mid-late summer/autumn: Laxer grazing in summer encourages white clover to spread and reach its potential. While the increase in tiller density induced by close frequent grazing in spring may make the ryegrass more competitive with the clover in summer, it also acts as a very effective protection for white clover should dry conditions prevail, greatly reducing stolon death from over exposure to the sun once soil water reaches critical levels during drought (Brock 1988).

That basically, is the background to grazing management to promote clover growth in mixed pastures as practiced up until the 1980s. The major overriding determinant in the ease of maintaining white clover in pastures is soil fertility, being easier to maintain in soils of lower N availability than high. But even with high soil fertility, when a system runs out of readily available soil N, the advantage swings back to clover, provided it is still around in sufficient quantity to respond.

That was then, this is now. What has changed?

With the deregulation of farming in the mid-1980s, the drive to increase farm productivity introduced many new innovative techniques into farming systems. Productivity has lifted dramatically, but with the emphasis now on total DM, the importance of clover has diminished and its relevance has been drawn into question. What changes have these innovations made to cause this?

- *Maximising production*. Under high soil fertility, grass is more productive than clover and management systems have swung to grass management, as opposed to the clover driven systems of yesteryear.
  - More productive grasses, particularly annual and biennial ryegrasses. Short-term in nature, these can be viewed more as a crop than a long-term perennial pasture, fitting in with true alternative specialist forage crops used to fill pasture shortfalls.
  - Increased fertiliser N use and specialist fertilisers for grass herbage production.
  - Higher pasture covers, and a lax grazing system aimed at greater grass yield.
- *Pasture establishment*. Despite maximising production through grass growth, most farmers still include clover in their seed mixtures, but have lost sight of the requirements of clover during sowing and establishment. The high cost of traditional mixed pasture establishment methods has led to the widespread adoption of less 'clover friendly' but more 'grass friendly' methods of pasture renewal such as
  - Direct drilling.
  - Minimum or zero tillage systems.

These systems do not meet the special needs of the small seeded clover, with over 50% of clover seed sown (and grass!) wasted through incorrect sowing leading to poor emergence (Brock & Kane 2003). The key is a fine firm seed bed and shallow sowing (5 mm) for maximum emergence. In cultivated conditions this means *heavy* rolling and broadcast sowing by roller drill (preferably Cambridge over V-roller) (Brock *et al.* 2005). Good results can be obtained by direct drilling if care is taken with low speed and shallow placement. Direct drilling into crop residues is more problematical for clover with grass to grass renovation the most variable (Brock & Kane 2003).

Pasture management

In general, it is the dairy sector that has instigated the most challenging changes to pasture management for clover. Evolution of the 'pasture covers' concept appears to be a compromise between yield and quality, aiming at the best of both worlds. Maximum animal production means maximum herbage intake; maximum herbage production comes from long rotations; but long herbage can also lower herbage quality. The pasture cover solution imposes short rotation to maintain quality and maximise intake. This is, in reality, a 'grass' solution and from an animal production perspective may be good thinking. Pastures are typically grown to 2500-3500 kg/ha then grazed down to 1500-2000 kg/ha. The result is a residual pasture of high cover but low grass tiller density (3000-5000/m^2) i.e. high ground space but low light making conditions unfavourable for clover. Clover is clearly not part of this management equation which raises the question whether clover has a role at all. Such a question cannot be answered without some understanding of the plant growth processes to rationalise the outcome.

So what is happening? Clover needs light to grow and spread and it needs a management to promote rooting at the nodes in order to ensure that stolon spread is capitalised long-term. The natural cycles of branching and rooting must be met for clover to have any chance of performing. The major nodal roots are put down in the late winter/early spring and then more are added as the stolons branch and run during the warmer spring and early summer. Light at the base of the pasture is necessary to keep stolons on the ground and increase the success of new roots establishing. The long 'pasture covers', because of reduced light at ground level causes the stolons to be drawn up off the ground to follow the light, which prevents successful rooting, even if there was sufficient rainfall. In summer this becomes particularly important as rooting is difficult when the soil surface dries out and when root knot nematodes are at their worst. As a consequence, while it may appear there is a good amount of clover in the pasture, the plants are large, few in number and operating from the centralised spring root system. Stolons are susceptible to stripping and populations are unable to build up the necessary plant numbers particularly during dry periods when overgrazing can easily occur. Such small clover populations may be highly susceptible to clover root weevil, which would account for the comment and observation that clover can disappear extremely quickly from dairy pastures, resulting in its total loss. As such, the pasture cover approach, while seemingly maintaining a reasonable clover content, may actually be setting clover up for a dramatic crash should a number of stresses impacting white clover occur simultaneously.

But this scenario does not necessarily happen over the whole pasture. Because of the uneven distribution of dung and urine during grazing, there are always low fertility areas between urine patches where the grass is weaker, grazing is closer, and therefore clover is able to persist, grow and perform.

Fertiliser N

But then the major innovation, fertiliser N, arrived and was widely adopted by dairy farming. Compared to clover N, fertiliser N gives more reliable, predictable and greater yields, predominantly of grass, which, depending on the amount of N applied, evens out the soil fertility patches leaving clover no place to grow. Applying 'pasture covers' grass management exacerbates the situation and clover declines rapidly to levels of little consequence to animal productivity. However, research and farm experience shows that it is possible to grow clover with up to 200 kg N/ha/year of fertiliser N (Barr 1996), the upper level that is environmentally acceptable. This happens to be around the level of N fixation clover was able to contribute to the system to balance the losses driven by the grazing animal, thus maintaining the status quo with no overall gain in N. Clover can be maintained but this requires greater skill to ensure grass growth is controlled. Frequent grazing to a lower base to reduce competition and increases protection of the clover. The perception that shorter pastures are less productive than longer is more apparent than real as the reciprocal trade-off in tiller size and density ensures the quantity of green herbage per unit area is maintained, although its availability to the grazing animal (prehension) may be lower depending on stock type.

Other fertilisers

Changes in the pattern and of use of different fertilisers (Parliamentary Commissioner for the Environment 2004) make interesting contrasts. Paralleling the large increase in fertiliser N use by the dairy sector, has been greater use of high analysis fertilisers e.g. diammonium phosphate (DAP). Perhaps this is in recognition that clover needs P, but there has also been a reduction in the use of phosphatic fertiliser such as superphosphate. The result is many dairy farms with soils of high (luxury) P levels but low in that equally key element for clover, sulphur (Brock & Kane 2003). In the form of sulphate, sulphur behaves similarly to nitrate, leaching out of the system and requiring regular replenishment as occurred when annual maintenance dressings of superphosphate containing high S were the main fertiliser input and N came from clover N fixation. Using elemental S is needed to build up stable organic S levels for good white clover growth. As productivity increases, other important trace elements are molybdenum, boron and copper.

Most of the above portrays dairy grazing management as not 'clover friendly'. The chances of growing sufficient clover for animal diet preferences (50-60%, Parsons *et al.* 1994) to increase animal productivity in a system that has little biological requirement or potential for clover growth (Brock & Hay 2001), makes even considering clover in such systems questionable.

Recommendation for clover in dairy farming

Establishment takes a year.

- Reduce available soil N before sowing using cropping (maize, brassicas, etc.).
- Sow into well prepared, fine, friable and consolidated (heavy rolled) seed bed.
- Use a roller drill, preferably Cambridge over Vee roller, or direct drill at low speed.
- No fertiliser N in first year.
- Frequent, light grazing to low residual (1000 kg DM/ha) over the first 6-9 months.
- Longer rotation in summer to encourage clover.
- Renovating pasture by over sowing (grass to grass) is highly problematical and should only be contemplated if reduced N and the correct grazing management to control grass growth can be provided.

Grazing management.

- Graze to lower pasture residuals (1000 kg DM/ha)
- Avoid high covers over late winter-early spring – no fertiliser N.
- Develop longer rotation over summer (autumn?) to encourage clover.
- Fertiliser N is not detrimental to clover, provided the grass is kept under close control.

With the other major sector, sheep and beef, uptake of pasture covers has been less and the development of intensive systems such as 'techno grazing' featuring high utilisation with low pasture residuals, is much less challenging to clover. Here, phosphatic fertiliser use has increased and the clover environment is more 'clover friendly'.

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