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BALANCING PASTURE PRODUCTION AND RESILIENCE REQUIRES AN UNDERSTANDING OF GRAZING PRINCIPLES

This article reviews the impacts of grazing management, water and nitrogen stress on plants as the basic understanding required for successful pasture management.

Basic principles of pasture management

Solar panels are a hot topic at the moment, with their ability to provide renewable energy at the forefront of modern thinking. For New Zealanders, renewable solar panels have been the mainstay of our economic prosperity, national identity and production systems for over 100 years. They are so ingrained in our farming practices that we seldom give them a second thought – until they stop working. I am, of course, referring to the green leaves that capture the sun's energy and conveniently, through photosynthesis, convert it into sugar (dry matter) on a daily basis for us to graze livestock on for milk and meat production systems.

Grazing management underpins our pastoral system, and we like to believe we are world-leading at doing it. However, disappointment about pasture persistence and productivity has become a familiar complaint from farmers in recent years. It is therefore timely to revisit some basic principles of grazing management. These issues were at the forefront of a special New Zealand Grasslands Association 'Resilient Pastures Symposium' held in 2021.

Plant response

Plants respond in predictable ways to the environment in which they grow. To summarise:

- If plants are short of carbon they grow leaves
- If plants are short of nitrogen (N) or water they grow roots.

Best management practices must take account of these facts if pastures are to be productive and persistent. In its simplest from dry matter (carbon) yield comes from the product of the amount of photosynthetically active solar radiation available (PARo), the fraction of that which is intercepted by the solar panel of green leaves (PARi) and the efficiency (RUE) with which it is converted to dry matter (**Equation 1**).

Equation 1:

$$\text{Yield} = PAR_o \times (PAR_i / PAR_o) \times RUE$$

In practice, PAR_o is set by location (day length and light intensity) and RUE is consistent amongst similar species. It is higher for plants that produce mainly sugars (e.g. fodder beet) compared with those that produce a higher proportion of more complex products like proteins (legumes) or oils (canola). Therefore, differences in the yield of a pasture or crop are mainly caused by how much light the canopy of leaves can intercept.

To fully capture all of the available radiation, a pasture canopy needs at least 3 m^2 of green leaf per m^2 of ground area (leaf area index (LAI) >3.0). On a daily basis, the total amount of assimilate supplied by the canopy is then allocated to leaves, stems and roots. Grazing management affects both the supply and allocation of assimilates, so it is the major determinant of pasture production and persistence.

Recovery of plants after grazing

For plants like perennial ryegrass, best grazing management practice has been well defined based on the recovery of plants after grazing. Specifically, when the canopy of green leaves is defoliated then the plant is short of carbon. Its solar panels have been removed and the priority is to restore the green leaf area to capture more carbon, which is done through the remobilisation of water soluble carbohydrates (sugars) from roots and leaf sheaths to regrow green leaves. To capture all of the radiation available and restore the reserves to the roots and shoots each tiller needs time to produce three green leaves.

If defoliation occurs before the reserves have been fully restored, then the plant will once again deplete root and sheath reserves to re-establish the canopy of green leaves (it is responding to being short of carbon). Continuous early defoliation of the canopy inevitably leads to a shallower root system. These plants are therefore exploring less and less of the soil so have reduced access to water and N.

The consequences of early defoliation are compounded during periods of water and/or nitrogen limitation. For example, when a period of dry weather occurs on a dairy farm the plant immediately reduces its leaf area and allocates a greater proportion of available assimilates to root growth. This reduced leaf area results in lower pasture growth rates and thus less feed is available to meet animal demand.

N fertiliser and the provision of supplementary feed can slow down the grazing rotation. The aim of using them is to increase post-grazing residual cover and ensure the ryegrass plants have fully recovered three green leaves before defoliation (**Figure 1**). In practice, grazing rotations are often shortened, residuals lowered and plants grazed early at the 2–2.5 leaf stage, particularly in regions where the availability of supplements is minimal.

Use of browntop and other species

The impact of continuous early grazing is most detrimental to perennial ryegrass, which has lower levels of carbon reserves than tall fescue. Cocksfoot is the most resilient of our commonly sown grass species, but the most adapted species to intensive defoliation is browntop. Therefore, it is not surprising that browntop and similar species (e.g. creeping bentgrass) are commonly used for urban lawns and on golf courses, where defoliation is both frequent and to low residuals (see first photo).

The ability of browntop to initiate minimal leaf, but produce a carpet of storage rhizomes and stolons, is advantageous for its survival and if you are developing a fairway or green (see second photo). However, it is less useful for providing feed to grow animals. Browntop is also highly competitive at accessing phosphorous (P) from the soil. Plants that are short of P also become carbon limited because P is used as an energy source in photosynthesis. Therefore, a direct consequence of lower levels of soil P and overstocked or set-stocked pastures is the dominance of browntop.

It begs the question as to whether we have forgotten these facts in our management of hill country pastures. Indeed, we commonly hear people suggest we can grow as much feed under set stocking as rotational grazing, but have we forgotten the research that indicated the pasture cover needed to be 1,500 kg DM/ha to achieve it? Only at this level of cover is the LAI high enough to capture most of the available light (see **Equation 1**).

For New Zealand's summer-moist regions, the implications for pasture management are clear:

- Minimise set stocking to avoid browntop
- Fertilise with P and S to ensure higher quality species can compete

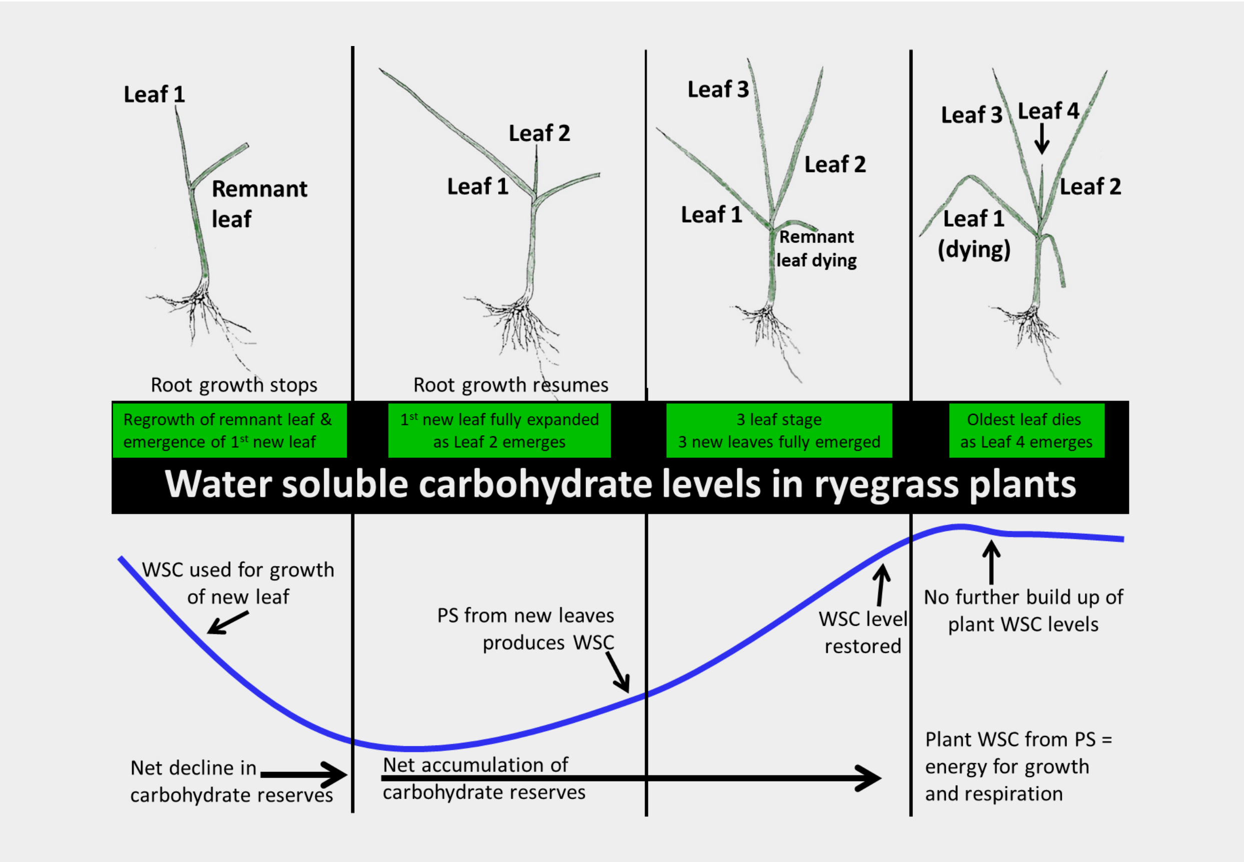

Figure 1: Relative change in water soluble carbohydrate levels (blue line) in ryegrass plants during a regrowth cycle. Modified from McCarthy et al. (n.d.), www.dairynz.co.nz/media/2634153/perennial-ryegrass-grazing-guide-web.pdf

Soil core showing rooting depth of creeping bentgrass (*Agrostis stolonifera*) taken from a golf course. Source: E. Lyons, University of Guelph, Ontario, Canada

Golf green consisting of 30-50% browntop, creeping red fescue and annual bluegrass (minor component) at St Andrew's golf course, Scotland. Source: E. Lyons, University of Guelph, Ontario, Canada

- Adjust rotation lengths to allow sown species to recover root reserves
- Graze ryegrass at the appropriate three green leaf stage
- Use N to increase pasture cover if deficits are developing
- Utilise supplements early in periods of water or N stress.

For our summer-dry regions similar strategies are required, but the emphasis has to be on managing the spring when moisture is usually available:

- Minimise set stocking – increased LAI also increases water use efficiency
- Use N in late winter to increase cover for lambing
- Maintain flexible stock policies so you can trade in periods of deficit
- Identify high-yielding paddocks and use them for improved species
- Identify your legume and manage it.

Managing nitrogen deficiency

The strategic use of N to increase pasture cover before times of deficit is advocated to overcome the fact that plants are N deficient most of the time. Intuitively we know this because we frequently see taller, darker green urine patches within pastures. Many of our grasses, including perennial ryegrass, adjust their leaf area to try to maintain an N content in the leaves of about 3%, which is why N deficient pasture is frequently short with small leaves.

In high fertility environments (e.g. dairy farms) the addition of N is estimated to produce 10 kg DM/kg N applied, which comes from a quicker recovery from grazing and higher photosynthetic rates at higher leaf N concentrations. In lower fertility environments (such as on hill country) the N deficiency can be much greater leading to responses of 20–40 kg DM/kg N applied. The greater response is because the leaf area of the plants increases to a greater extent to overcome the deficiency, which allows more light interception.

The alternative to applying N to pastures is to encourage an appropriate legume for N fixation. The N is then mainly transferred to the grass through the grazing animal. For dairy pastures this has traditionally been, and is returning to, encouraging white clover. Recent work from Lincoln has shown that a perennial ryegrass/white clover mix was as productive with and without 200 kg N/ha applied.

For hill country sheep and beef pastures, the limited land for cultivation reduces the opportunity for pasture renewal. However, the impact of legumes to provide N-rich herbage can be measured compared with resident pasture. In a summer-safe environment one study showed that clover-dominant pastures produced more than three times the feed of the resident browntop. Similarly, in a summer-dry environment lucerne has produced two to three times the feed of the resident pasture on hill country on Banks Peninsula during low and high rainfall years (**Figure 2**).

Lucerne and red clover

The lucerne in this situation is utilised for lambing hoggets from mid-September until December. The management of root reserves is the key to maintaining a productive stand. For example, it is well known that lucerne root reserves are depleted in spring as the plant maximises shoot production. However, in autumn the above ground growth rate is reduced as a higher proportion of assimilates are partitioned to roots and crowns.

This process can also be enhanced or reduced by grazing management. By grazing lucerne on a fixed 28-day rotation, one study carried out in 2021 showed that root reserves were depleted to almost zero with 2 t/ha of structural root biomass (**Figure 3**). In contrast, under an extremely lax regime (84-day grazing) the root biomass increased by 8–10 t DM/ha, but crops lodged and were largely unpalatable. Therefore, the 42-day regime provided a balance between shoot and root reserves and plant and animal requirements. In practice, a fixed rotation is not recommended with the emphasis on shorter rotations (28–35 days) in spring but longer (42–50) in autumn.

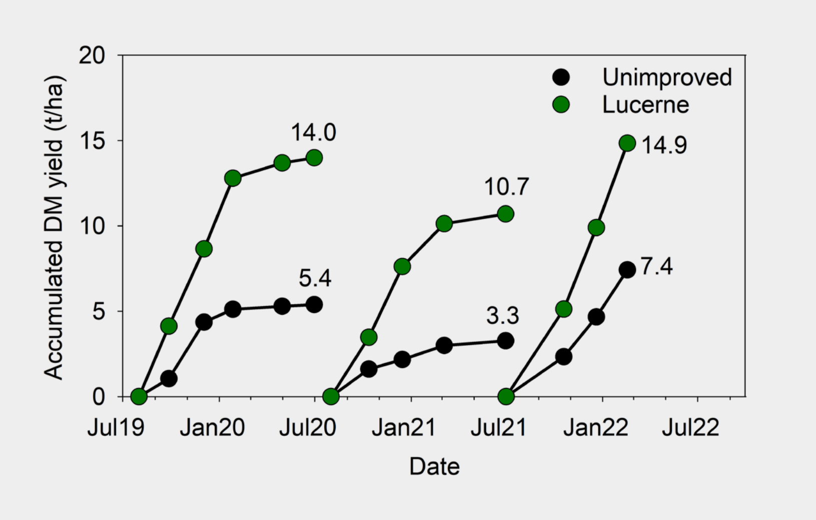

Figure 2: Comparison of accumulated dry matter (DM) production (t/ha) of unimproved resident pasture compared with a lucerne monoculture on Banks Peninsula, Canterbury. Note: Data shown for year 3 (2021/22) only includes measurements to mid-February 2022

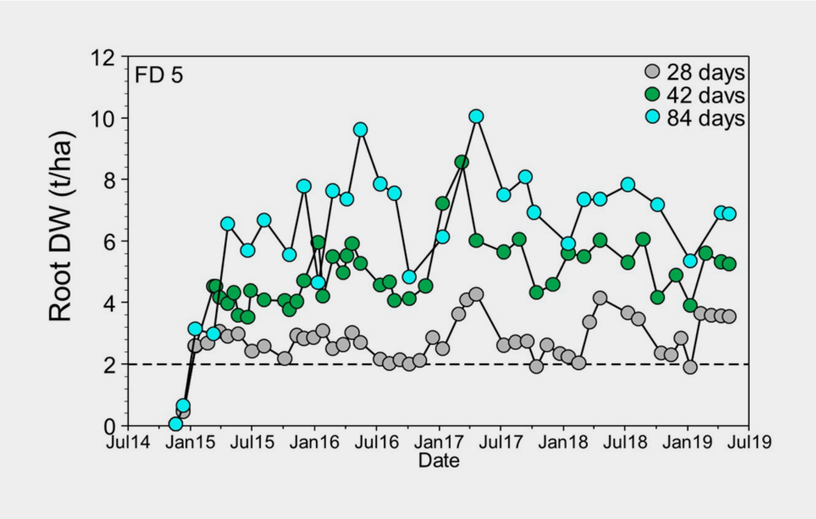

Figure 3: Change in perennial (root + crown) biomass (0-0.3 m) over time of irrigated 'Grasslands Kaituna' lucerne (fall dormancy (FD) rating = 5) subjected to regrowth cycles of 28, 42 or 84 days during active growth for five growth seasons (2014/15 to 2018/19) at Lincoln University, Canterbury (Data sources: Ta, 2018; Yang, 2020). The horizontal dashed line represents structural perennial biomass that cannot be remobilised

In short, rotational grazing of tap-rooted species like lucerne and red clover is considered best practice. It allows recovery of the canopy to maximise light interception, recovery of root reserves and the high grazing allowance of high-quality feed to maximise animal production. The rules may not be followed as strictly when grazing grasses, but the cyclical nature of depletion and recovery of reserves needs to ensure overgrazing does not result in reduced pasture persistence and dominance of low-quality species (such as browntop).

The impact of climate change may require us to become even more aware of these principles. Ryegrass is still going to need three green leaves to recover its carbohydrate reserves, and lucerne will still produce more feed in spring than in autumn because of the changes in partitioning. N is still going to be an important tool for recovery from adverse conditions.

However, the expected increases in summer-dry periods, and warmer winter and night temperatures (coupled with increased legislation around the use of N fertiliser and greenhouse gas emissions), will drive practice change. To maintain pasture production, persistence and farm profitability, farmers will need to make quicker decisions about how to manage their most important resource – feed supply. This will require changes in grazing management of existing pastures, with less set stocking and greater use of other grass species (such as cocksfoot and tall fescue).

For hill country, the future can be seen in the development of satellite farming, where small areas of high-quality feed (such as legumes and herbs) are well managed to maximise animal and plant performance. Other areas will be retired to trees to capture carbon.

In all cases, the efficient use of resources will start with maximising the interception of solar radiation with the world's most efficient green solar panels.

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