How do I ...

get perennial grasses to thrive and survive?

A RESOURCE FOR ADVISORS

The issue:	Pasture productivity and persistence is influenced by how we manage perennial grasses to recover with optimal growth following grazing. Under-grazing can be just as detrimental for growing productive, high quality pastures as over-grazing.
The impact:	Under-grazing leads to wastage of pasture, while dead plant material restricts new growth and reduces overall herbage quality. Over-grazing maximises utilisation of pasture, but repeated over-grazing draws down a plant's reserves and, over time, reduces its persistence.
The opportunity:	Understanding how perennial grasses grow and the factors affecting leaf emergence and tiller and root growth means we can better manage them. We can create and utilise flexible grazing systems to optimise productivity and persistence of sown perennial grasses in a mixed pasture.

Four introduced temperate perennial grasses are the backbone of pastures in southern Australia: perennial ryegrass *(Lolium perenne)*, phalaris *(Phalaris aquatica),* cocksfoot *(Dactylis glomerata)* and tall fescue *(Lolium arundinacea*, previously known as *Festuca arundinacea)*. Being perennial, plants survive from one year to the next, providing production stability, compared to relying on annual germination.

All four grasses share common characteristics of growing points, storing reserves for regrowth and producing tillers and buds from which new growth is initiated. But there are important differences between the four perennial grasses which should be considered when managing the grazing of mixed pastures. This fact sheet covers the main principles of perennial grass growth and the implications for grazing management.

Figure 1. Thriving pasture with perennial ryegrass and sub-clover.

How grasses grow and spread

The four perennial grasses increase in size primarily through growing more tillers (tiller development) from the growing points in the crown. These species also utilise tiller fragmentation, rhizomes and seedling recruitment to increase their density (Figure 2).

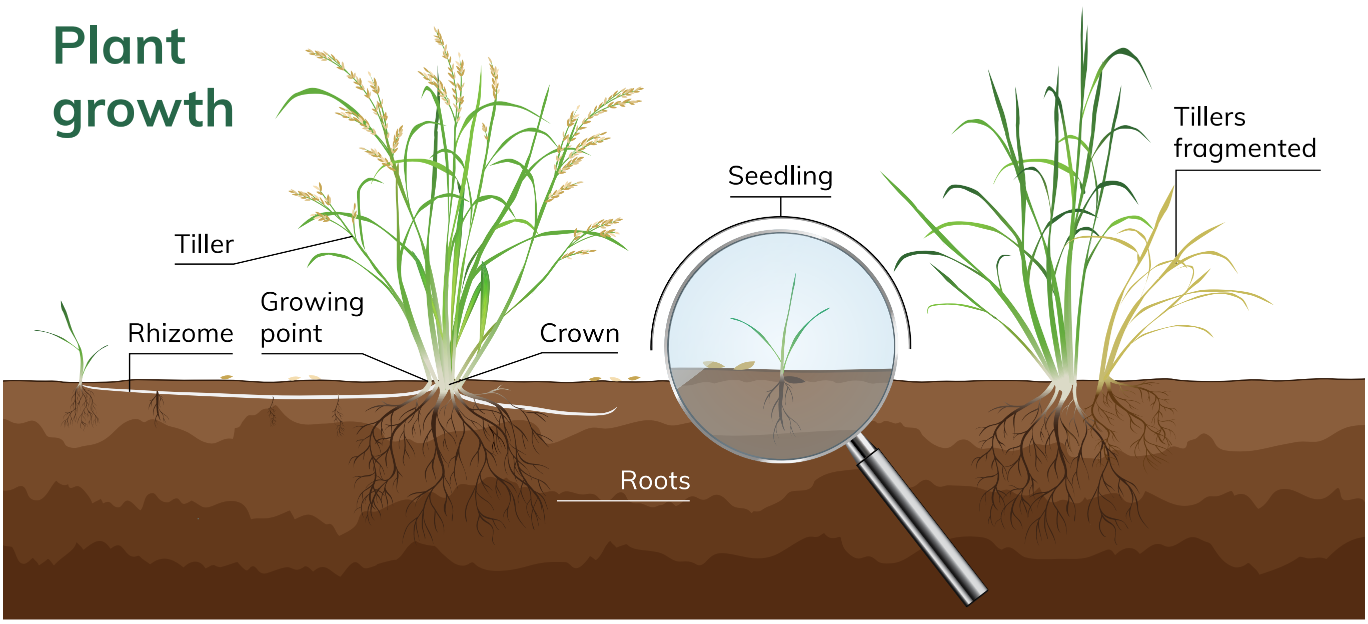


Figure 2. Perennial grasses mainly expand in size or number through tillers, seedling recruitment, tiller fragmentation or via below-ground stems called rhizomes.

Table 1. Dominant method of spread and expansion used by commonly sown grasses.

Species	Tiller development	Tiller fragmentation	Rhizomes	Seedling recruitment
Perennial ryegrass	✓	✓		✓
Phalaris	✓		✓	Minor
Tall fescue	✓		✓	Minor
Cocksfoot	✓	✓		✓

Tiller development

Tillers are the shoots on a grass which surround the original parent shoot. A plant can have many tillers, with each tiller having its own leaves, a stem, roots and a growing point. Plants with many tillers have a clump or crown-like appearance. It is not uncommon for perennial ryegrass to have more than 40 tillers per plant (Figure 3).

Active tillers are constantly dying and need to be replaced. They have a varied lifespan, from as short as a month or two, up to two years.

Tiller growth starts from within the white fleshy part of the crown or base of the plant which contains the growing point (known as apical meristem) (Figure 4). This growing point also contains the tissue which develops into the seed head, which moves up the plant stem during reproductive growth.

Figure 3. A perennial ryegrass plant made up of individual tillers and (right) an individual tiller with own leaves and roots.

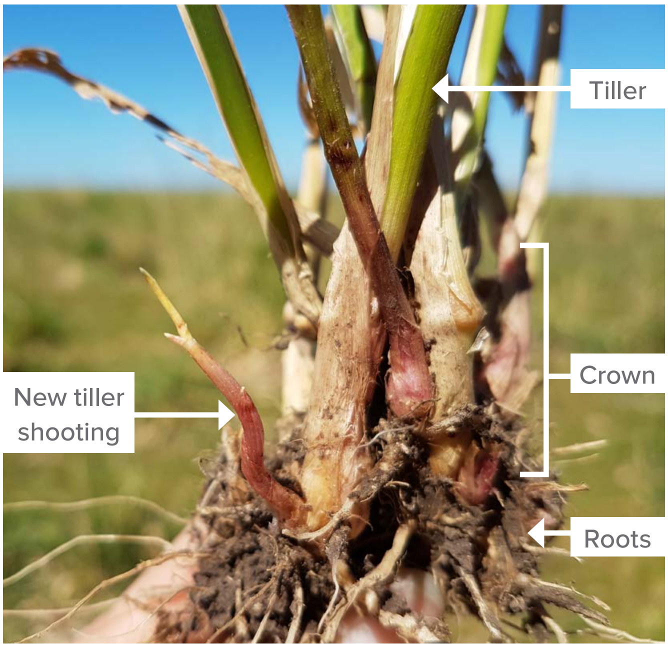


Figure 4. Tiller base of phalaris. Growing points in perennial ryegrass, tall fescue and cocksfoot are located in the white fleshy part of the crown. In phalaris this is underneath the soil surface.

Rhizome expansion

Rhizomes are below-ground stems which can form a new plant when the supply of carbohydrates from the leaves exceeds the demand for new leaf development and growth. Both tall fescue and phalaris use rhizomes as a method of plant expansion (Figure 6).

Rhizomes should not be confused with stolons, which are above-ground stems which grow horizontally from the main plant. Stolons produce roots and aerial shoots. White clover and kikuyu are examples of stoloniferous plants. The main four grasses do not use stolons to spread.

Tiller fragmentation

Tillers are connected to other tillers and they share water, nutrients and carbohydrates. Tiller fragmentation occurs when interconnected tillers become separated because old stems decay, which creates new, small plants. These small, separate plants are at greater risk from over-grazing and drought stresses compared to larger plants, because of their less developed root system (Figure 5).

Figure 5. Smaller tall fescue plant has become separated from mother plant.

Seedling recruitment

Seedling recruitment refers to the successful establishment of new plants from natural seeding. For this to occur, plants need to successfully produce seed and if the seed survives the summer, it establishes against other existing perennial plants. Seedling recruitment is more common in perennial ryegrass pastures and cocksfoot pastures.

Figure 6. Rhizome of tall fescue. Note the roots extending from the buried underground stem.

Principles of growth and implications for grazing management

All four grasses share commonalities in the way they grow and the conditions which affect their growth (temperature, moisture and soil fertility). These commonalities and the principles of growth are described here.

Tiller and leaf growth

PRINCIPLE
Plants can only support a set number of green leaves on a tiller before the oldest leaf begins dying.

A tiller will only support the growth of a set number of live and growing leaves. The new leaf emerges from the centre of the stem. For most perennial grasses, when a tiller reaches its predetermined number of live leaves, the oldest leaf begins to die (Figures 7 and 8).

This number varies between species (Table 2).

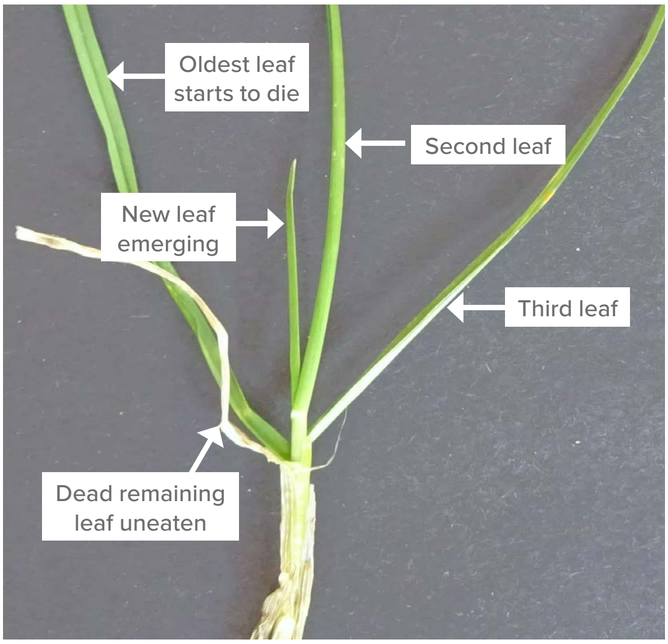


Figure 7. Tiller with new leaf emerging from centre of stem – perennial ryegrass shown.

Table 2. The set number of leaves a perennial grass tiller can actively grow and the leaf stage ready for grazing.

Species	Live leaves per tiller	Recommended active leaf number for grazing
Perennial ryegrass[1]	3	3
Phalaris[2]	4	4
Tall fescue[3]	4	3*
Cocksfoot[4]	4-5	4

* *Tall fescue is recommended to be grazed at lower leaf numbers to maintain quality.*

Figure 8. Perennial ryegrass with three live leaves (top left) and phalaris (top right), tall fescue (bottom left) and cocksfoot (bottom right) with four live leaves and a dying leaf.

At times of rapid growth, tillers may appear to support more leaves than suggested in Table 2. This is because the rate of new leaf emergence exceeds the visual appearance of older dying leaves.

Once the maximum number of live leaves is reached, additional growth is offset by decay from earlier grown leaves. Total plant production begins to plateau (Figure 9).

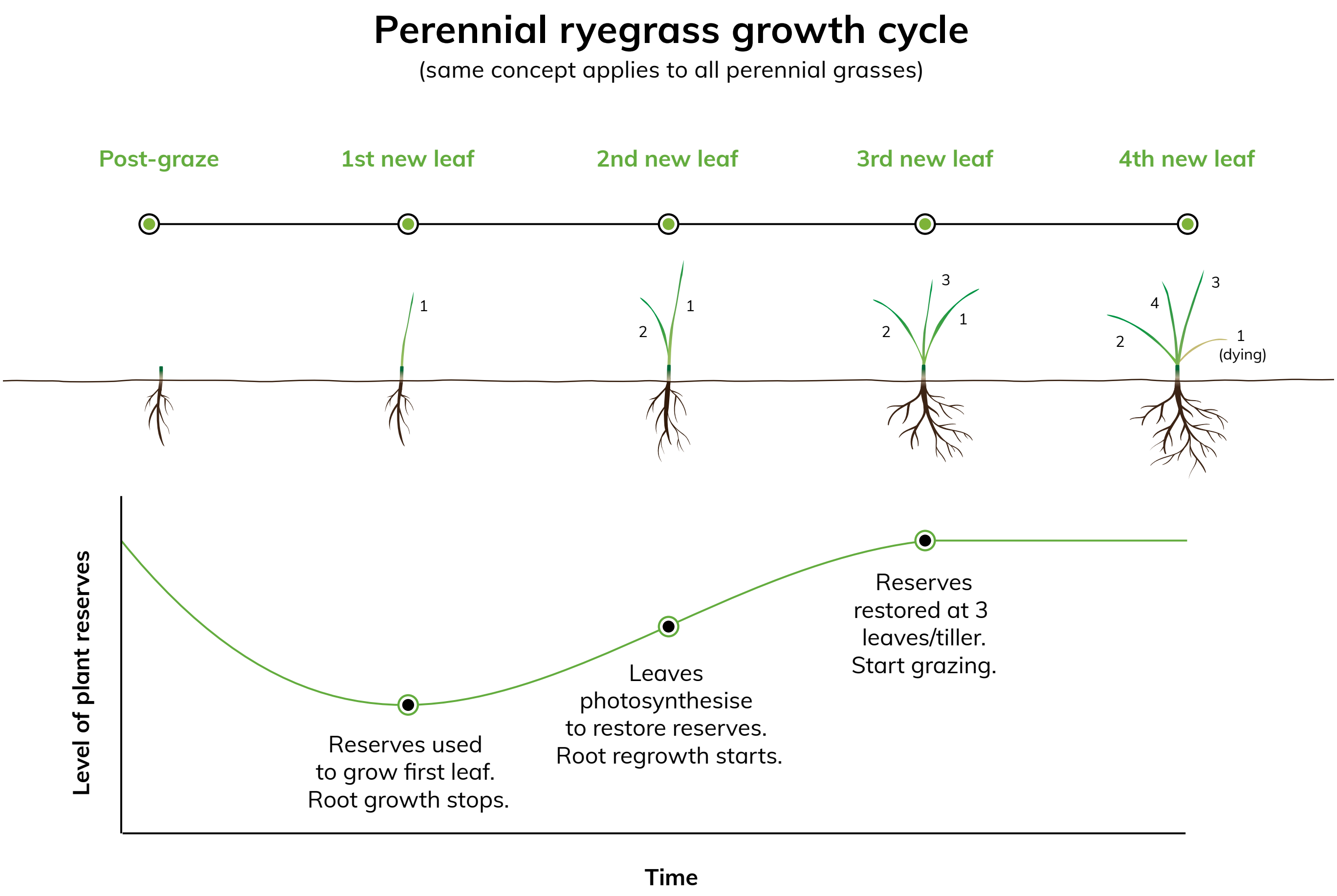


Figure 9. Stylised depiction of perennial ryegrass regrowth after grazing. (Adapted from Fulkerson and Donaghy[5])

Plant carbohydrate reserves and root growth

PRINCIPLE
When a plant is grazed, it uses its 'fuel reserves' (water-soluble carbohydrates in tiller bases) to try and regrow a new leaf.

When a grass plant is grazed, new leaf growth is initiated from a tiller within two to three days. The tiller uses carbohydrate reserves stored in its base to produce this first new leaf. The leaf can now capture sunlight and photosynthesise, assisting the growth of the second leaf. Once the second leaf starts to emerge there is enough leaf area for the plant to begin to replenish the used reserves. Full replenishment (100%) is completed by the third live leaf stage for perennial ryegrass,[5] while 95% of reserves is achieved with the growth of 2.5 leaves (Figure 9).

PRINCIPLE
Root growth only occurs once a plant starts growing its second new leaf and is optimised when reserves have replenished its full complement of leaves.

Root growth stops when a plant is grazed. Root growth starts again after the plant/tiller has one fully expanded leaf (Figure 9).

Failure to adequately replenish these carbohydrate reserves after grazing means the next grazing will suppress regrowth and further deplete the reserves. Doing this continually without periods of replenishment will reduce the plant's basal area (crown size) and root system (making it more vulnerable to grazing and dry conditions) and eventually kill the plant.

Grazing grasses based on live leaf number gives rise to the concept of 'phases' of pasture growth. This concept can be applied to a pasture sward with multiple species (Figure 10).

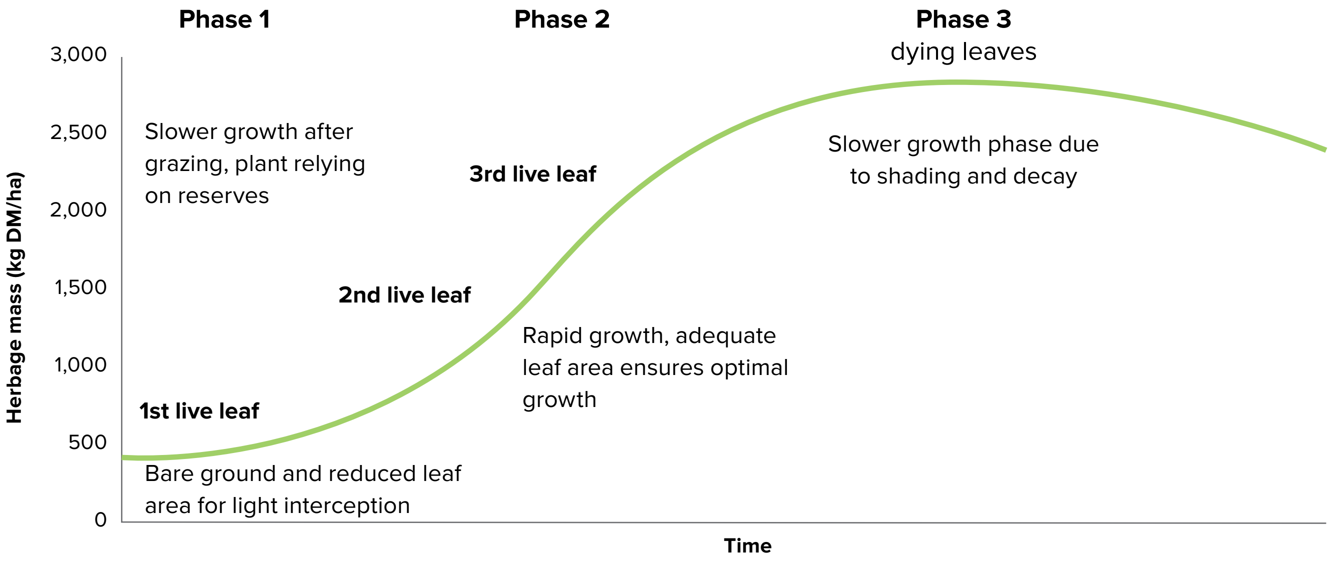


Figure 10. Phases of pasture growth over time as indicated by herbage mass accumulation (kg DM/ha). (Adapted from Prograze®[6])

Phase 1 represents a pasture which has just been grazed. Pasture growth is slow. There is inadequate leaf area to capture sunlight, so plants rely on reserves to produce new leaves.

Phase 2 occurs when there is enough leaf material for photosynthesis to occur. Growth rate increases. For perennial grasses, the growth rates increase because each subsequent leaf/tiller is larger than the previous one – adding to the herbage mass.

Phase 3 occurs when the net pasture growth rate plateaus due to shading and decay of leaf material. Overall feed quality declines and there is under-utilisation of active green leaves, leading to wastage (Figure 11).

Figure 11. Pasture in phase 3 (wasted feed).

Grazing into phase 1 is common when other feed is in short supply. While this extended grazing utilises more standing biomass, it can result in slower regrowth if all leaves are removed or if growing points are damaged. Keeping the pasture in phase 1 by continuously grazing will reduce regrowth and draw down plant reserves, ultimately leading to loss of perennial grasses.

Occasional extended periods of grazing in phase 1 (possibly at lambing or calving) can be 'repaired', provided the pasture has adequate rest afterwards and the growing points/tiller bases are not removed during the grazing.

Repeated grazing early in phase 2 can also be damaging because the plant has insufficient time to replenish reserves before the next grazing occurs (Figure 12). If this occurs on multiple occasions, the plants will be weakened and may eventually die out.

Implication for grazing management

The number of actively growing leaves is a good indicator of when a plant has replenished its carbohydrate reserves. Research has found to optimise recovery of carbohydrate reserves, perennial ryegrass and phalaris need to be matched to the number of active leaves they grow, whilst cocksfoot and tall fescue can be grazed at lower leaf numbers (see Table 2). Grazing at the recommended leaf number also maximises dry matter (DM) production.

Leaf number is a good indicator of when a plant is ready to graze during the growing season (from autumn to early spring and in summer). Once plants start to reproduce in spring, leaf stage is not relevant. In summer the percentage of ground cover should be an additional consideration.

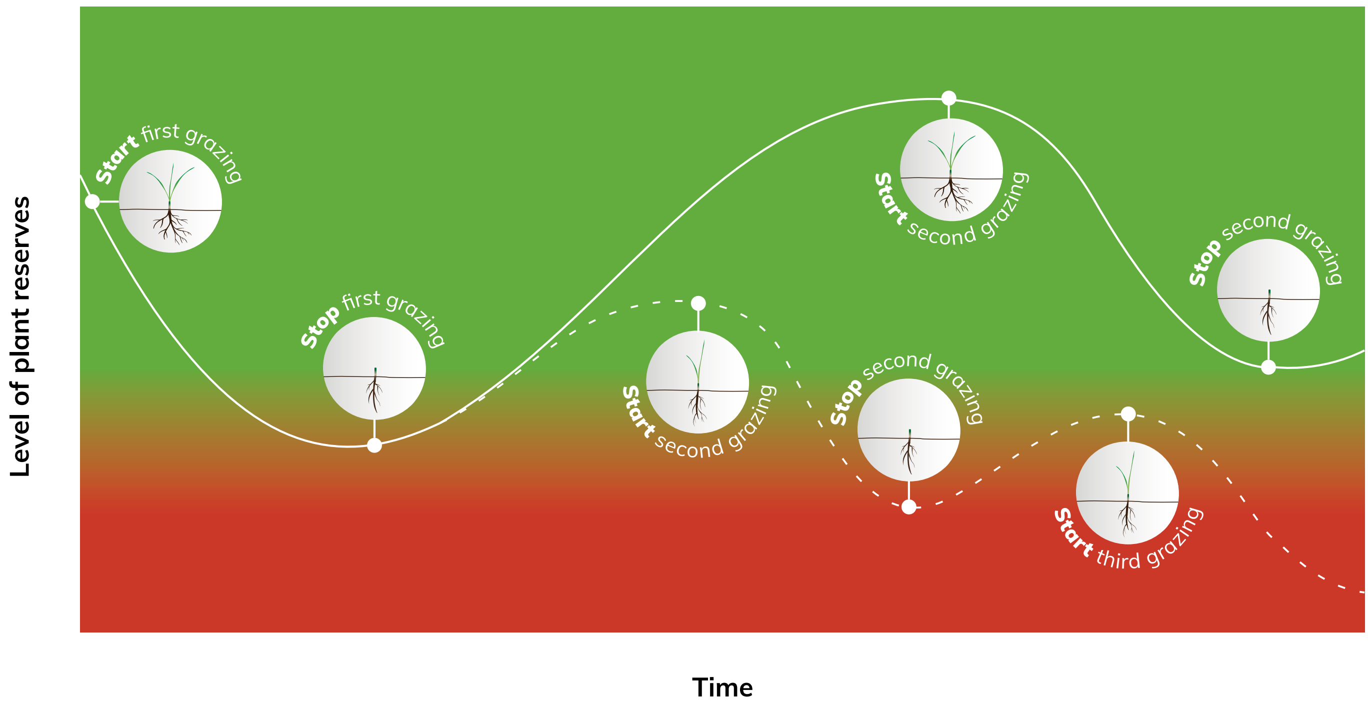


Figure 12. Fluctuation in plant reserves under different leaf recovery and re-grazing times. Solid line represents re-grazing once reserves are replenished and dots represent a decline in overall reserves when re-grazing occurs before full replenishment.

Growing points

PRINCIPLE
All new tiller growth is initiated from the growing points located in the plant crown and damage to the crown should be avoided.

The location of growing points varies between the four perennial grasses and even within cultivars. Perennial ryegrass, cocksfoot and tall fescue have more exposed growing points than phalaris and, therefore, are more prone to damage from stock grazing into the crown. The tiller bases and growing points of all phalaris cultivars are underground and therefore are protected from hard grazing.

Implication for grazing management

Damaging the growing point will cause a tiller to die or not emerge. Aim to avoid grazing into the crowns or damaging growing points.

Common triggers for stock removal to avoid crown damage (to avoid grazing the tiller bases) during the growing season is 500–800kg DM/ha (1–2cm of dense green pasture), especially in more vulnerable species like perennial ryegrass and cocksfoot and under sheep grazing. Sheep graze closer to ground level because they use their teeth to nip off pasture, whereas cattle wrap their tongue around grass and rip it away.

Temperature and moisture influence leaf appearance rate

PRINCIPLE
Leaf emergence is driven by temperature and soil moisture.

The time taken for new leaves to emerge on a tiller varies over the year and for different species. This is demonstrated in Table 3 which shows the days taken for monthly leaf emergence of temperate grasses in the Geelong region when moisture was not limiting. The time taken for a grass plant to reach its full complement of leaves/tiller sets the maximum grazing interval or rest period.

Table 3. Average monthly leaf emergence rates (days) for temperate grasses in Geelong Victoria (1960 to 2020) assuming adequate moisture. GrassGro modelling rates based on leaf emergence occurring for four out of five years (80% of time).

Month	Average	Range
April	10	9–12
May	14	12–16
June	20	17–24
July	23	19–29
August	20	16–23
September	15	13–18
October	12	10–13
November	10	8–11

While new leaf growth is initiated soon after grazing (about two to three days), temperature and soil moisture will determine how quickly the new leaf emerges. Rapid growth occurs in spring because soil temperature is rising and there is usually sufficient soil moisture. New leaves can emerge on a ryegrass tiller on average every 7–10 days in late spring. In the Geelong region, in the middle of winter it is much slower, taking 19–29 days for a new leaf to emerge.

In winter, low soil temperature reduces leaf emergence rates on a tiller. Most temperate grasses stop producing leaves when the soil temperature drops below about 4°C. This is why frosts appear to stop pasture growth. Leaf emergence rates for perennial ryegrass can be around 18–21 days in winter.[1]

Variable autumn and summer rainfall can result in sporadic pasture growth. Soil temperature is sufficient for rapid growth, and a ‘green pick’ can appear after summer or early autumn rain, but only until moisture again becomes limiting. Under ideal conditions the rate of leaf emergence can be similar to spring and is why the timing of the autumn break can make a dramatic difference to the amount of pasture you can build going into winter.

For any location, there will be a range of leaf appearance rates as seasonal temperatures can vary when there is adequate moisture.

Implication for grazing management

As rainfall and seasonal temperatures can vary from year to year, assessing when to graze should be based on examination of leaf stage (and herbage mass) rather than using fixed time intervals.

Figure 13. Phalaris growing points are located underground and protected from grazing.

Soil fertility and its influence on leaf size

PRINCIPLE
Adequate soil fertility will allow the plant to grow larger leaves (longer and wider). It does not make leaves emerge any faster.

The rate of appearance of leaves from tillers in grass is not impacted by soil fertility. It does, however, have a large effect on the amount of herbage grown. In low-fertility soils, the perennial grass plants are likely to be smaller and the leaves which emerge from each tiller are smaller than for plants growing with adequate nutrition. Hence the actual pasture growth rate (kg DM/ha per day) measured by the amount of herbage accumulating, is less with lower soil fertility.

Implication for grazing management

To maximise the benefits of adequate soil fertility, plants need to achieve full leaf expansion before the next grazing. Grazing at one or two live leaf stage not only diminishes plant vigour, but also reduces the ability for each of those leaves to make full use of the soil fertility available.

Figure 14. Uneven ryegrass growth due to urine and dung patches.

TOP TIP

A visual comparison

When showing producers the potential effect of soil fertility on plant growth, pick tillers or clover leaves with the same leaf number from high-fertility areas (urine or dung patches, stock camps) and the rest of paddock to compare growth (Figure 15).

Figure 15. Tiller and leaf size much larger in urine patches, most likely caused by higher levels of nitrogen or potassium compared to rest of paddock. Paddock had been spelled and additional growth in urine patches is due to nutrients rather than stock avoidance due to odour.

Vegetative tiller formation

PRINCIPLE
Tiller set is influenced by light at the crown of the plant and is closely related to carbohydrate reserves.

Tillers typically have a varied lifespan from as short as a month or two to a maximum of two years and need to be replaced by setting new tillers. New or replacement tillers are often referred to as daughter tillers.

New vegetative tillers develop in response to light reaching the crown of the plant. However, they also require adequate reserves. If they have little or no reserves as a result of continuous grazing, plants will not tiller.

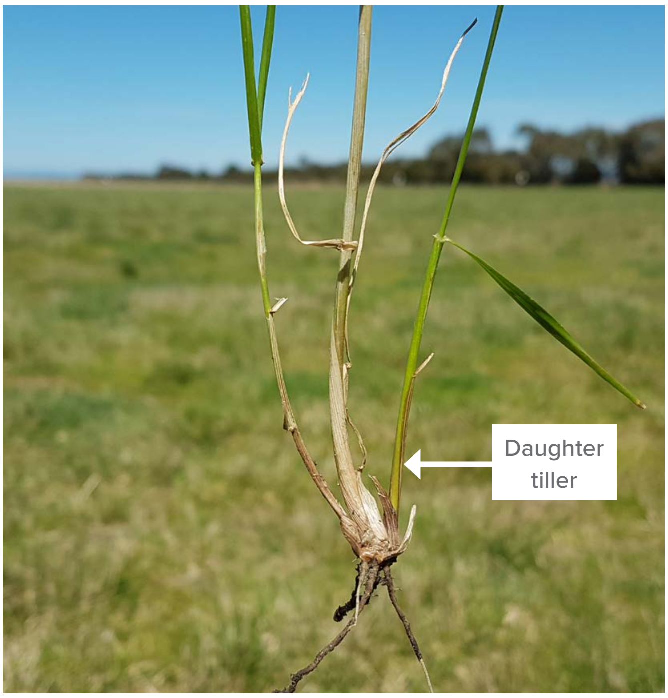
Daughter tiller formation in perennial plants occurs mainly in early spring but can also occur in late autumn. They cease being initiated when stem elongation (the reproductive phase) commences. New vegetative daughter tillers are initially less robust than older tillers and must be carefully managed to avoid carbohydrate depletion and loss over summer (Figure 16).

Tillering in grasses is also influenced by nitrogen. In most pastures, the supply of nitrogen is best achieved by having productive companion legumes, which is commonly sub-clover. More information on sub-clover management can be found in MLA fact sheets such as: [How do I maximise sub-clover establishment in existing pastures?]

Implication for grazing management

Avoid severe grazing in early spring because it limits the supply of carbohydrates from the parent tiller to smaller, dependent daughter tillers. However, also avoid excessive herbage mass from accumulating as this results in shading and prevention of light reaching the base of the plant to trigger tiller initiation. Shading also prevents small tillers from becoming bigger and independent, leading to tiller death.

Figure 17. Densely tillered perennial ryegrass plant.



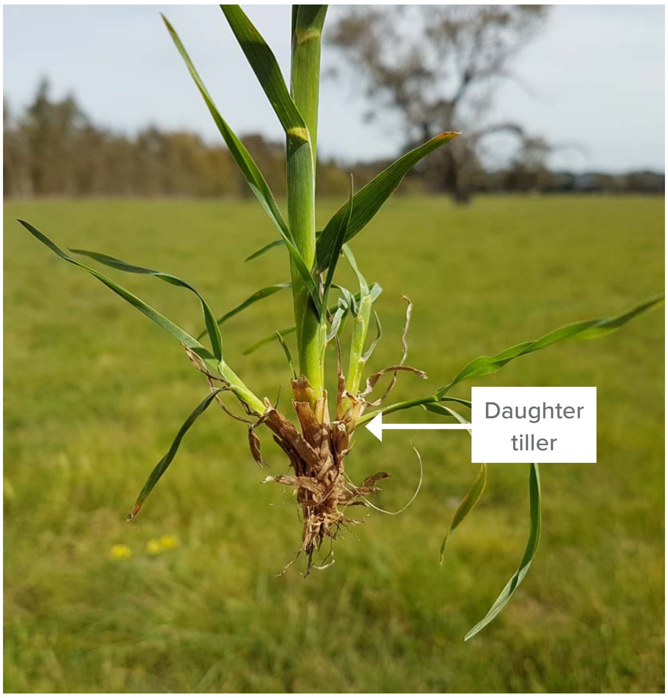


Figure 16. Daughter tillers formed at the base of the parent tiller in tall fescue (left) and cocksfoot (right).

Reproductive tiller and bud formation

PRINCIPLE
Plants have an inbuilt 'sensor' which switches them from vegetative to reproductive.

The four grasses (phalaris, cocksfoot, tall fescue and perennial ryegrass) will produce reproductive tillers each year. Exposure to cold temperatures in winter and/or increasing day length in spring changes the tillers from growing leaves (vegetative growth) to producing a seed head (reproductive phase). This is also referred to as stem elongation.

During stem elongation, buds start to develop at the base of reproductive tillers. It is an important summer survival mechanism for perennial grasses.

For more information on summer tiller management see MLA fact sheet: How do I get perennial grasses to thrive and survive in late spring and summer?

Implication for grazing management

Perennial grasses (with the exception of continental tall fescue (summer active)), need stem elongation to ensure buds are formed. In most years this will occur because seasonal conditions, especially soil moisture, are favourable. However dry springs may reduce stem elongation which, in turn, reduces bud formation. This can result in pastures thinning out. Therefore, careful monitoring and removing stock from 'good' pastures in a dry spring is important for plant survival.

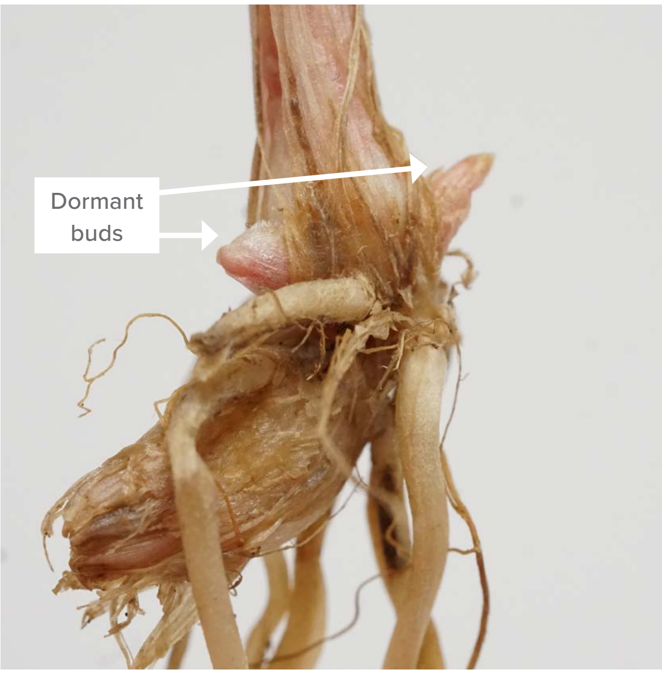


Figure 18. Phalaris buds are dormant, only shooting following summer.

Seedling recruitment

Perennial ryegrass and cocksfoot more actively recruit seedlings than tall fescue and phalaris. Seedling recruitment can be encouraged by resting the pasture to allow seed to mature and fall to the ground, removal of excess dry material and then spelling at the autumn break. The MLA fact sheet: How do I optimise seedling recruitment to avoid resowing? outlines the management needed to increase seedling recruitment.

Figure 19. Managing high feed demand post-autumn break with pastures in phase 1 is a grazing challenge.

The grazing challenge

Unfortunately, the optimal management of perennial grass is not always achievable in the complex animal pasture system and with the need to maintain sub-clover in the stand. This challenge and strategies to address are discussed further in MLA fact sheet: How do I meet the challenges of grazing mixed pastures?

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Figure 20. Flowering perennial ryegrass can help summer survival and recruit new seedlings.

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