How do I ...

optimise sub-clover based pastures?

The issue:	Subterranean or sub-clover is an essential component of the southern Australian feedbase but its productivity is not being maximised for optimum livestock production.
The impact:	Producers are missing an opportunity to produce more kilograms of meat or wool.
The opportunity:	Good establishment and management of the sub-clover life cycle will result in highly productive and persistent pastures. Sub-clover also provides free nitrogen to the soil, greatly benefiting productive perennial grasses which also lift livestock production.

Sub-clover is an essential component of a stable and productive pasture. Why?

- **Well nodulated sub-clover will 'fix' nitrogen that can be used by grasses and other broadleaf plants.**
  - One tonne of sub-clover dry matter (DM) can produce up to 25kg of nitrogen/ha/year.
- **Sub-clover maintains high feed quality throughout the growing season.**
  - In the vegetative stage, the green material is highly digestible, exceeding 75%, with correspondingly high energy content above 11 MJ ME (megajoules of metabolisable energy)/kg of DM and protein around 30%.
  - Even though the pasture declines in digestibility as it dries off, it still maintains a high crude protein content.
  - The seed and burr of sub-clover are also high in protein (Table 1).

Table 1: Feed test results for sub-clover plants and burr sampled in September and January

Sample	DM (%)	Crude protein (%)	Digestibility of DM (%)	Metabolisable energy (MJ/kg DM)
Vegetative sub-clover – early September	20.1	31.1	76.4	11.5
Mature sub-clover (no burr) – January	92.0	19.7	36.6	4.7
Sub-clover seed within burr – January	94.3	25.1	47.3	6.5

Pastures containing sub-clover increase animal intake and subsequent live weight gains.

How much sub-clover do I need?

Being an annual, sub-clover needs to germinate and re-establish each year to contribute to the pasture mix. A pasture with adequate sub-clover relies on the successful germination of 20–30kg/ha of seed (30–45 plants in 0.1m^2). This will result in a pasture with at least 40% sub-clover content by late winter.

Germination of three cotyledons per palm size (8x8cm) is required to achieve at least 40% sub-clover in a pasture.

Sub-clover has a trait that only allows 10–20% of seed in the seed bank to germinate each year. This staggered germination is a survival feature of the plant, as it guards against 'false breaks' and ensures seed will be available to germinate in later years if no further seed is set.

To get 20–30kg/ha of the sub-clover seed germinating the pasture needs 200–300kg/ha of seed in the soil.

Sub-clover will not germinate when the seed first develops in November and December because of a natural dormancy. This dormancy dissipates over summer but is replaced by an impermeable coating on the outside of the seed. This is called hardseededness and prevents moisture being absorbed and subsequent germination.

Management can have a major influence on the softening of sub-clover seed and on how much seed is produced each year. Under favourable management the germination of sub-clover can be greatly increased[1] and a single sub-clover plant can be manipulated to produce over 100 seeds.[2]

There are two major implications from understanding the seed bank dynamics:

1. Seed set needs to be maximised when new cultivars are introduced. Sub-clover is typically sown at 4–10kg/ha and needs to be increased by 30 to 40 times for a 200–300kg/ha seed bank to be created.
2. When trying to replace older, less productive or oestrogenic sub-clover with newer cultivars several years will be required to deplete the existing, established seedbank. If this does not occur the newer cultivars are likely to be outcompeted by previously dormant seed.

Types of sub-clover

There are three sub-species of sub-clover, broadly classified by their tolerance of different soil conditions and their capacity to bury their seed.

Seed colour helps in this classification, with yellow seed sub-clover (*yanninicum*) better suited to heavy, more acidic soils and waterlogging. Black seed sub-clover (*subterraneum*) are generally better adapted to freer draining, neutral or alkaline soils. The third sub-species (*brachycalycinum*) can have both yellow and black seed.

Two of the sub-species (*subterraneum* and *yanninicum*) push their burr into the soil, whereas *brachycalycinum* leaves the burr on the soil surface, under rocks or in soil cracks. These are more vulnerable to seed loss through summer grazing and predation by ants and crickets. The seed is also more exposed to drying out and damage when germinating compared to buried seed.

Within the sub-species there are many cultivars or varieties. Cultivar simply means cultivated variety. Varieties of sub-clover occur naturally in the Mediterranean and each has its own unique characteristics. Plant breeders cultivate or cross different varieties to select desirable traits. One of the main trait differences between cultivars is the time of flowering.

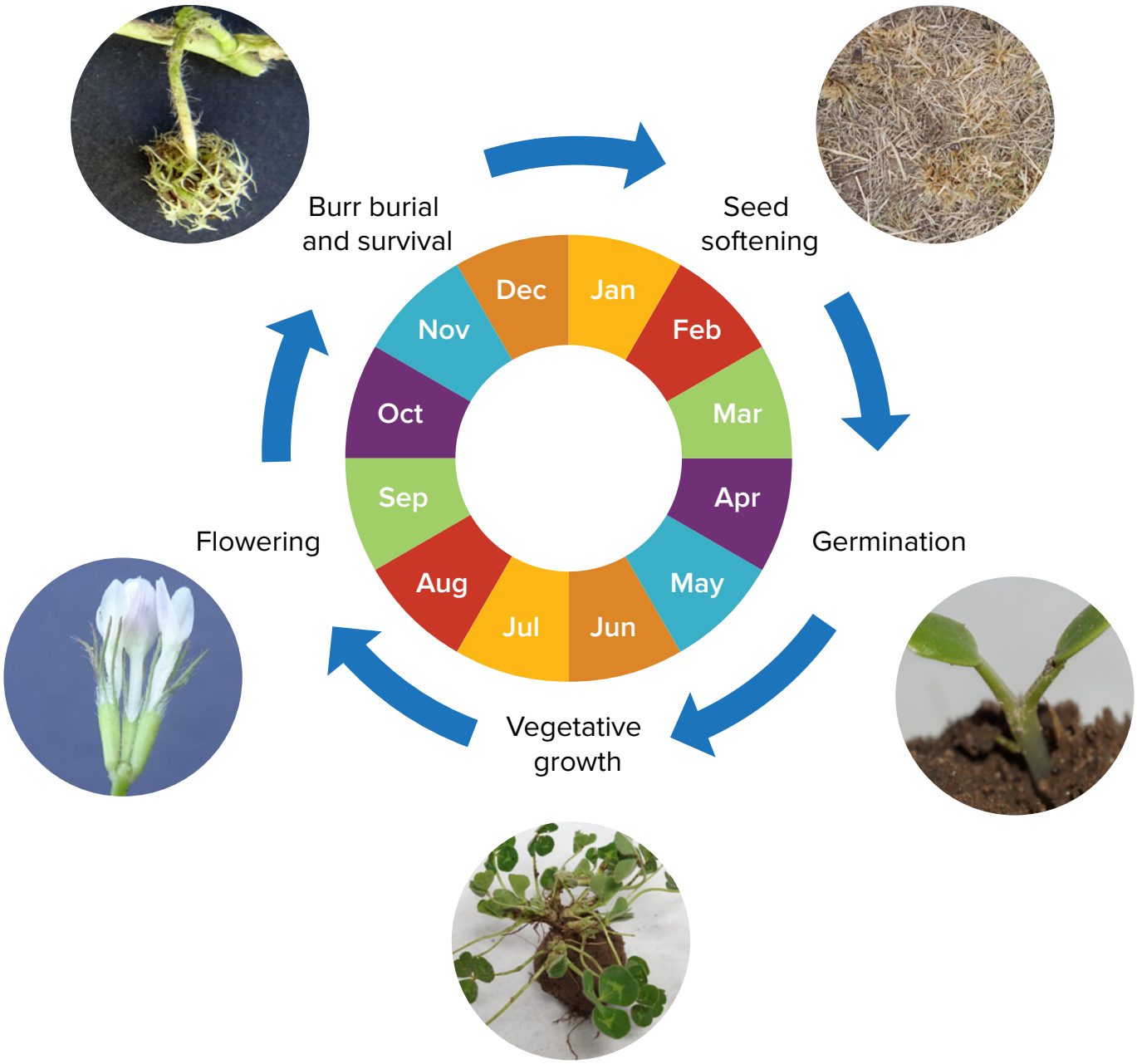
Choosing cultivars that best suit the soil type, grazing approach and time of flowering to match growing season length is critical to the long-term success of a sub-clover pasture.[3]

Ant predation of surface seed by stripping seed from burr to take down into nests.

The sub-clover life cycle

There are five main stages in the life cycle of sub-clover: germination, vegetative growth, flowering, burr burial survival and seed softening. Management can have a positive influence on all stages of this cycle.

Figure 1: The five main stages in the life cycle of sub-clover that producers can influence: germination, vegetative growth, flowering, burr burial and survival, and seed softening. Each stage contains key management strategies to favour sub-clover's production and persistence.



Germination – maximise seedling establishment

Seed germination occurs once hardseededness has broken down, soil temperature is below 26ºC and cumulative rainfall events are above 20mm. The dry seed absorbs moisture, initially producing a root called a radicle.

New root emerging from germinating sub-clover seed (blue coating is seed treatment).

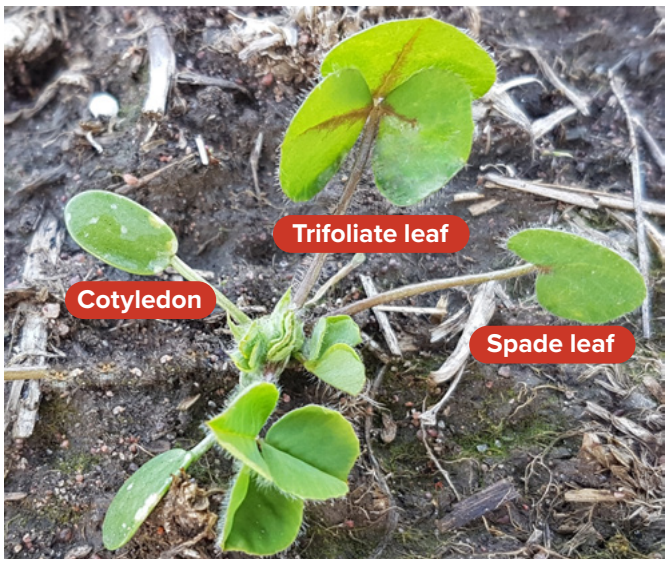
The tip of this root is very susceptible to drying out, insect attack and chemicals that are released from some dead plant material such as silver grass. If it does not anchor successfully in the soil, the plant dies.

After root anchorage, the plant produces two small leaves called cotyledons or seed leaves (image below). Like the radicle, cotyledons are very susceptible to damage, either from pest or animals. Once lost, the cotyledons cannot be replaced and the plant will die.

Sub-clover cotyledons.

Cotyledons support the growth of the next leaf called the spade leaf. Cotyledons will turn yellow and die 6–8 weeks after germination, having completed their task of establishing the spade leaf.

The spade leaf is followed by the production of the first trifoliate, or true, leaf.



Sub-clover showing cotyledon, spade leaf, trifoliate leaves.

Sub-clover showing cotyledons dying 6–8 weeks after germination.

The seedling becomes less vulnerable to grazing after the appearance of the spade leaves because the seed stem (hypocotyl) is drawn below the soil surface, forming a tap root and anchoring the plant more securely. The growing point also retracts below grazing height.

Ideally, grazing should be avoided until the plant has a minimum of three trifoliate leaves, which can take 3–6 weeks depending on the temperature and soil moisture.

Vegetative growth – graze to stimulate leaf production

Sub-clover grows from a central point, producing branches that commonly grow horizontal to the ground. Along each branch, between 8–16 leaves are produced, which gives the plants a rosette appearance.

Sub-clover rosette, 15cm in diameter, with six branches and many leaves visible.

Grazing stimulates leaf production by enabling light to reach the crown of the plant. A closely grazed sub-clover plant will have smaller leaves, but more of them, compared to a laxly grazed plant.

Maximum sub-clover production is achieved by frequent heavy grazing, rather than light grazing combined with long periods of spelling. (This is counter to the rotational grazing mantra.)

Runners are also produced from the sub-clover crown after the plant has experienced a certain amount of heat. Runners signal the beginning of flowering, or the reproductive phase, but are still capable of producing leaves. Sub-clover runners can be 20–30cm in length, meaning individual plants have the potential to reach at least 60cm in diameter and colonise vacant space.

Flowering – maximise seed production

Flowers and leaves grow from the same point on a runner. The more leaves produced, the more flowers formed.

Flowering only commences after the runner has produced three or four leaves. Flowers are self-pollinating.

Grazing pressure should be reduced once the first flowers become visible. Removal of flowers reduces seed production.

Runners will have flowers at different stages of maturity, with the oldest flower closest to the crown of the plant and the newest flower at the end of the runner.

Leaf production lessens once flowers appear on the runner, as energy is redirected into filling the seed rather than growing leaves.

A sub-clover runner with the newest leaf emerging from the end of the runner and flowers at the intersection of each leaf.

Burr burial – avoid grazing surface burr

As flowers mature, they form burrs, which are an essential part of sub-clover survival.

Each sub-clover plant will have between 5–12 runners with about six burrs on each runner. Each burr will contain three or four large seeds.

Burr buried in the soil is protected from grazing and is more likely to germinate successfully in subsequent years. Burr on the soil surface can be more readily grazed by sheep, is prone to predation and is less likely to establish successfully when it germinates because the root is exposed. Only 1% of the seed eaten survives the chewing and digestion process.

Mature sub-clover plants showing surface burr which contains seeds (important for re-establishment) much of which can be lost through grazing, predation or poor establishment.

More information

1. MLA technote: *How do I... maximise sub-clover establishment in existing pastures?* Available at www.mla.com.au/how-do-i-maximise-sub-clover-establishment
2. MLA technote: *How do I... manage grazing to maximise sub-clover seed set?* Available at www.mla.com.au/how-do-i-manage-grazing-to-maximise-sub-clover-seed-set
3. Nichols P 2018, *Choosing the right subterranean clover*, Department of Agriculture and Food Western Australia. Available at evergreen.asn.au and search 'choosing the right subterranean clover'

NSW Department of Primary Industries 2018b, *Part F – Choosing the right sub-clover variety*, NSW Department of Primary Industries. Available at dpi.nsw.gov.au and search 'choosing the right sub-clover'

A sub-clover runner showing the development of burrs.

Seed softening – hard seed breakdown

All sub-clovers develop hard seed but they vary in the rate the hard seed coat breaks down and the seed becomes soft or permeable to moisture.

The rate of breakdown depends, firstly, on the cultivar, as different cultivars have different levels of hardseededness and, secondly, on the day and night fluctuation in temperature. The greater the fluctuation in temperature, the more rapid the breakdown of the seed coat. Having lots of pasture litter insulates the soil and lessens the fluctuation and so slows down the breakdown.

Removing excess litter over summer by grazing helps soften the seed, ready for germination.

Following a drought, large germination of sub-clover occurs because all the surface litter has been removed, which encourages residual hard seed, that has been dormant for many years, to soften and germinate.

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