Perennial legumes:
Lucerne, red clover and white clover

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In brief

One of the aims of the 3030 Project was to explore forage alternatives to complement perennial ryegrass production on dairy farms of southern Australia. The growth and nutritive value of perennial ryegrass in summer is one of its greatest weaknesses, so perennial legumes have been evaluated as potential alternatives to supply high-quality and quantity feed during summer. This Information Sheet discusses some of the 3030 Project experiences with perennial legumes on plots, farmlets and partner farm studies, and highlights some key aspects of their potential role in dairy farm systems of southern Australia.

This Information Sheet will cover only the perennial legume species that have been used in 3030 Project studies: Lucerne (*Medicago sativa),* red clover *(Trifolium pratense)* and white clover *(Trifolium repens).*

Key features

- Lucerne is a drought-tolerant option to provide feed in summer and adapts well to grazing conditions under the right management.
- Red clover and white clover perform best when combined with perennial grasses or herbs to increase summer feed production and quality.
- All perennial legumes tend to increase nutritive value and milk production response of grass-based diets.
- Bloat risks are important and should be considered but they can be managed. Feed allocation is a key factor to reduce the risk.
- Lucerne, red clover and white clover all require soils with good fertility to perform and lucerne, in particular, requires well-drained soils.

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Where do perennial legumes fit into your feed plan?

Filling the summer feed gap (alone or in mixes)

Deep-rooted perennial legumes such as red clover and lucerne can respond to summer rainfall and also have the potential to reach water deep in the soil profile. These species are able to keep growing when most pasture species, and perennial ryegrass in particular, are already under water stress and have stopped growing.

The capacity of deep-rooted legumes to complement the growth curve of ryegrass was seen at a 3030 Project partner farm in south-west Victoria, near Colac. This dairy farm is in a lower rainfall area that is marginal for perennial ryegrass persistence. The focus of the feeding system put in place by the farmer and the 3030 Project management team was a resowing/oversowing program with different proportions of annual and short rotation ryegrass, Brassicas and summer herbs to complement perennial ryegrass. However, one of the most successful strategies was to use lucerne for grazing to fill the summer feed gap.

The lucerne paddocks were sown every year in late August in order to have time to develop a strong root system and reduce the risk of water stress during summer. Mainly 'dry' paddocks where ryegrass was not performing well were selected to be sown to lucerne. These were free-draining areas, where soil pH($CaCl_2$) was above 5.

Due to the success, other farmers linked to the 3030 partner farm also started using lucerne with similar purposes. The group highlighted its "low cost of production, low labour, high quality green feed growing in summer, drought tolerant, complements ryegrass really well and it is a flexible crop—can be direct grazed or harvested and stored as a supplement".

In a forerunner study to the 3030 Project, the production from four mixed pasture swards was compared for three years on three sites in south-west Victoria (Tharmaraj et al. 2008). The treatments comprised:

- A short-term winter active (STW) based on Italian ryegrass (cv. Marbella), balansa clover (*Trifolium michaelium*; cv. Bolta) and white clover (*T. repens;* cv. NuSiral).
- A long-term winter active (LTW) based on winter active tall fescue (cv. Resolute), white clover (cv. NuSiral) and subterranean clover (*T. subterraneum*; cv. Leura).
- A long-term summer active (LTS) based on summer active tall fescue (cv. Advance), white clover (cv. NuSiral), red clover (*T. pratense*; cv. Colenso) and chicory (*Cichorium intybus;* cv. Choice).
- A ryegrass high-N (RHN) mix based on perennial ryegrass (cv. Resolute), white clover (cv. NuSiral) and subterranean clover (cv. Leura).
- A Control based on perennial ryegrass (cv. Resolute), white clover (cv. NuSiral) and subterranean clover (cv. Leura).

The fescue + legumes + chicory mix (LTS) and ryegrass high N (RHN) mixes showed a significantly higher accumulated DM yields on average (Table 1).

Table 1. Annual average accumulated pasture growth (t DM/ha) of species mixes in a three-year study in south west Victoria (adapted from Tharmaraj et al., 2008).

Pasture mix	Pasture accumulated
	(t DM/ha/year)
STW	9.5
LTW	8.8
LTS	10.6
RHN	10.9
Control	9.7

In terms of seasonal distribution of feed supply, the LTS mix produced around 0.8 t DM/ha less feed in winter than the Control but 1.3 t DM/ha more during summer, while autumn and spring yields were similar. This showed how perennial legumes could be combined with tall fescue to achieve high summer feed production.

Deep-rooted perennial legumes (red clover and lucerne) are not suited to all environments (details of specific soil characteristics required for lucerne and red clover are given below). Also, to achieve their growth potential these species need to be sown in a soil without impediments for root growth. In soils where there is a physical barrier for root growth such as underlying rock, calcium carbonate as a solid layer or a very hard clay layer, the plants are not able to develop their root system.

Improving diet quality in summer

The reduced soil moisture and increased temperatures typical of summer not only cause a decline in the growth of perennial ryegrass but also a reduction in its nutritive value.

Both red clover and lucerne are more adapted to grow under drought conditions than most perennial grasses. In these species, the decline in nutritive value during summer is less marked than for perennial ryegrass.

Extensive literature has shown benefits of feeding legumes compared to pure grass-based diets in terms of increased milk and milksolids production (Harris et al., 1998; Woodward et al., 2010), reduced methane emissions and improved nitrogen use efficiency. The production responses are usually due to the higher DM intake of cows fed legumes and the higher nutritional value of the legumes.

The strategies to increase the diet quality in summer by using these deep-rooted legumes can differ. They can be grown as a pure crop to be grazed through summer during part of the day, or alternatively, sown as companion species of grasses.

In the study by Tharmaraj et al. (2008; see description of mixes above) different pasture + legume mixes were compared. The LTS mix (fescue + legumes + chicory) maintained a higher average ME value than the other pastures in summer (Figure 1), reflecting the contribution of high-quality summer-active species such as red clover and chicory in the mixture. This helped utilisation of the LTS pasture by grazing cattle during the summer.

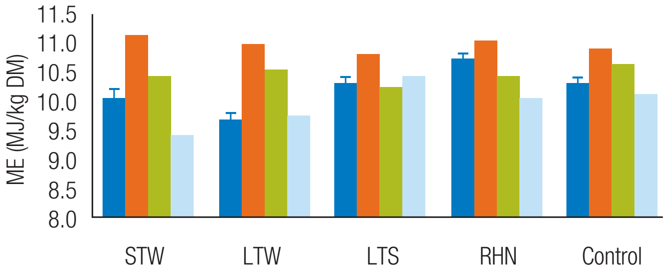

Figure 1. Metabolisable energy content of five pasture mixes in autumn (dark blue), winter (orange), spring (green) and summer (light blue) evaluated at Terang, Heytesbury and Naringal between 2001 and 2004 (Tharmaraj et al., 2008).

The study showed that the seasonal spread of pasture production can be manipulated by including alternative species without sacrificing total annual pasture yield. In this way, the most effective mix was the mixture of tall fescue, chicory, and red clover on medium and lighter textured soils. This pasture type improved summer herbage production compared with ryegrass-based pastures, at the expense of some loss of winter production.

A farmlet study in New Zealand (Woodward et al. 2008) compared the impact on milk production of including additional perennial legumes with pasture. A Control farmlet (9 ha) was based on traditional ryegrass/white clover pastures while a Forage Mixed Ration (FMR) farmlet (9 ha) included 2 ha of annual ryegrass undersown to a red and white clover mix, 2.5 ha of lucerne, and 1 ha of lotus (*Lotus corniculatus*).

The milksolids (MS) production per cow and per hectare was 9.5% and 5.5% higher on the FMR farmlet compared to the Control farmlet in two consecutive years. Most of this advantage was in late summer-autumn when milk production in FMR was 20% higher than in the Control due to the higher nutritional value of their diets, which contained at least 50% legumes.

All of the Control farmlet had to be undersown due to drought damage to the perennial ryegrass based pasture, whereas the legume crops tolerated the drought better and only 4 ha were undersown. [Note: this was a New Zealand drought which is normally less severe than in the Australian conditions].

Nitrogen use on the FMR farmlet was lower than on the Control but the FMR incurred extra expenses to drench cows for bloat, irrigation and the greater need for weed spraying of the legume crops compared to perennial ryegrass. The additional income on the FMR farmlet from extra milksolids production offset the higher expenses.

In summary, deep-rooted perennial legumes can complement perennial ryegrass, providing a source of high quality feed in the diet when the overall nutritive value of the base forage source (pasture) is the poorest.

Picture: INTA Rafaela

Lucerne

Lucerne options

There is a broad range of cultivars available in Australia (30+) which are differentiated mainly by their winter activity. Ratings are from 4 (winter dormant, most productive in spring and summer) to 10 (highly winter active, it can grow through spring, summer and autumn).

Alone or in a mix?

Lucerne is usually grown as a monoculture. It has been sown with species like red clover and chicory, but they do not complement each other since they all grow predominantly in late spring and summer. However, in other regions of the world (e.g. South America) lucerne is sown with perennial grasses such as cocksfoot (*Dactilis glomerata*) or prairie grass (*Bromus* spp.).

Graze or harvest?

On most Australian dairy farms, lucerne is harvested for hay or silage on outblocks. However it has been proven in overseas studies (Baudracco et al., 2011) and commercial experiences in Northern Victoria that, with the right management in place, this species can be grazed all year round.

By grazing lucerne the cost per tonne of DM of consumed is lower than when it is made into hay or silage with all the additional costs and losses when being cut, conditioned, transported, stored and fed out.

An important consideration when cutting lucerne for hay, silage, or for 'cut and carry' systems, is that the paddocks will not receive the nutrient return from cows' excreta. For example, a herd of 600 Holstein cows consuming 15 t DM/ha of lucerne in 10 grazings/year, the amount of excreta that the cows leave in the paddock is estimated to be close to 490 kg nitrogen, 50 kg phosphorus, 150 kg potassium and 10 kg sulphur per hectare.

In 'cut and carry' systems, the cost of replacing the nutrients extracted will increase the cost per t of DM of lucerne. If these nutrients are not replaced, the negative balance will continue to undermine the productivity of the soil.

Specific requirements

The right soil

The specific soil requirements of lucerne can restrict its use in some dairying regions or in some paddocks within a farm. It is not adapted to acid conditions (needs pH($CaCl_2$) 5 or higher), poorly drained soils or soils with high content of aluminium. Lucerne performs better in deep, light-textured soils.

At a 3030 Project partner farm in Poowong, Gippsland, summer active perennial forage options were evaluated to replace perennial ryegrass on a river flat area subject to flooding. Tall fescue, chicory and lucerne were sown in mixture in the autumn of 2009. Tall fescue and chicory established and grew satisfactorily, but lucerne did not survive (similar observations have been drawn from small-plot trials). This was probably both the effect of waterlogging and different grazing requirements of the species in the mix.

The right grazing management

Lucerne does not tolerate frequent grazing. The plant needs to be given enough time to replenish the reserves stored at the base of the plant (the 'crown'). The rotation length for lucerne is therefore different to ryegrass-based pastures.

There are simple practical rules based on paddock observation that allow the right grazing frequency. A common recommendation is to graze when there is a 10% of lucerne shoots presenting flowers (early flowering stage). Another common practice (needed during winter when the plant will not produce flowers) is to graze when the regrowth shoots at the base of the plant are at least 5 cm high. The right frequency will ensure three key factors are covered:

- The reserves in the base of the plant are replenished in order to maximise the productivity and persistency of the crop.
- The crop is grazed at a stage of growth just before the ME value starts to decline and NDF% starts to increase.
- The crop is grazed at a stage of growth that is not too soon after the last grazing when it is more likely to cause bloat.

The right diet control

If grazing lucerne as the main component of the diet, aim to maintain it in the diet for at least a week. Intermittent grazing does not achieve the same responses in milk production as grazing for an extended period. In a New Zealand study cows fed 95% lucerne produced 20% more milk per day than cows fed ryegrass (Woodward et al., 2010). However, changing the cows from ryegrass pasture to lucerne caused a temporary (3 day) decrease in production as rumen microflora adapted to the diet change.

The risk of bloat can be managed to a large extent by monitoring plant growth stage at grazing. It is important to introduce fully-fed animals (hungry cows are more at risk) gradually over several days. The risk it is never completely eliminated as other factors, such as variation of other components of the diet or cows breaking into regrowth paddocks, can lead to cases of bloat. Feeding roughage or using anti-bloating agents are some of the preventive measures to minimise risk.

For more information on how to manage and control bloat in dairy cows access the DPI Victoria online information: http://new.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/animal-diseases/beef-and-dairy-cows/controlling-bloat-in-dairy-cows

The right crop protection

Although modern cultivars have better resistance, lucerne can be susceptible to pests such as the red-legged earth mite (*Halotydeus destructor*), lucerne flea (*Smirinthus viridis*) and various cutworms.

It can also be affected by diseases such as root rot (*Phytophthora* spp.), crown rot (*Colletotrichum* sp.), bacterial wilt (*Corynebacterium insidiosum*) or leaf spot (*Stemphylium* and *Leptosphaerulina*). See a comprehensive description of diseases of lucerne for Victoria at www.new.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-cereals

Weed control in lucerne is important to achieve a good stand. The greatest attention should be during the establishment period, since lucerne normally has a slow growth rate and there are more opportunities for weed invasion. Most grass weeds can be controlled with selective herbicides whereas there is only a limited range of broad-leaf weeds that can be controlled by selective herbicides. Weed control can be done at either at sowing or post-emergence, although to apply most common herbicides the seedling should have developed at least three trifoliated leaves, which can delay the application for several weeks after sowing.

For more general information on lucerne see the Lucerne Australia website (www.lucerneaustralia.org.au) and the Dairy Australia 'Pastures Australia' website (www.pasturepicker.com.au).

Picture: pregonagropecuario.com.au

Red clover

Red clover is similar to lucerne in terms of summer production, adaptability to grazing conditions and high nutritive value all year round.

However, it is different to lucerne in several aspects:

- It does not tolerate drought to the same extent as lucerne.
- It is slightly better adapted to temporary saturated soil conditions than lucerne.
- Most cultivars persist for two to four years and they generally have relatively poor winter growth. Stoloniferous types (such as the cultivar Astred) are more persistent and tolerate close grazing better.
- It is more easily adaptable than lucerne to be sown in mix with grasses or herbs (chicory, plantain) as it is more tolerant to frequent grazing.
- In 3030 Project plot studies at Terang, red clover seemed to combine well in a mix with chicory (*Chicorium intybus*) and plantain (*Plantago lanceolata*) and annual ryegrass (see Figure 2).

Figure 2. Mix of annual ryegrass, plantain and red clover at Terang.

Studies by Jacobs et al. (2006) on commercial farms in south-west Victoria showed that sowing red clover in a mix with chicory, plantain and white clover was only successful if sown in the spring. The proportion of red clover in the pasture was reduced to zero when sown in the autumn.

Although the optimum growth of red clover occurs in the range 20–25°C, it prefers more temperate environments than lucerne. Depending on the cultivar, it can be found growing naturally between latitudes 30°N and 65°N.

Note: There is some evidence of red clover causing reduced fertility performance if fed fresh to cows at mating due to oestrogenic compounds present in most cultivars (Marley et al., 2011). However, the studies on dairy cows have been contradictory.

See the Dairy Australia 'Pastures Australia' site (www.pasturepicker.com.au) for more information on red clover.

White clover

Usually sown in mixtures with perennial ryegrass, white clover has historically been part of the predominant pastures of most dairying areas of southern Victoria.

This mix has been characterised by a strong spring growth (up to 70% of the annual DM production) and low productivity throughout the summer in dryland conditions.

Because of its shallow root system, it suffers in summer drought conditions as it normally cannot reach enough moisture to provide a consistent production to complement perennial ryegrass.

However, even after severe droughts white clover has the capacity to 're-appear' from seeds on the ground and contribute to increase the nutritive value of grass based pastures. This is because its capacity to expand with stolons (stems that run across the surface of the ground) and disseminate its seeds. As soon as there is a spring or summer with good moisture in the upper layers of the soil, white clover is able to regenerate from seeds and quickly proliferate with its stolons. Summer grazing is critical for white clover to be able to persist through this strategy. Overgrazing should be avoided during summer in order to keep the stolons intact and, hence, the regrowth capacity of this legume.

Another important feature of white clover is its flexibility in terms of grazing or cutting timing compared to lucerne and, to a lesser extent, red clover. In lucerne and red clover, the digestibility of the upper part of the stem is high only up to the flower bud stage but declines considerably thereafter (Wilman et al., 1984). White clover can maintain high digestibility even when at flowering as it does not produce lignified stems.

For these reasons white clover is a valuable companion in permanent pastures mixes. Several 3030 Project studies (component, farmlets and partner farms) have included white clover with perennial grasses such as perennial ryegrass and tall fescue as well as herbs such as chicory and plantain (see Figure 3). However, it is important to note that white clover cannot compete effectively with perennial ryegrass if large amounts of fertiliser N are used. This is one of the causes of its low proportion in mixed swards from the second year onwards.

Figure 3. Mix of tall fescue, white clover, chicory and plantain evaluated at the 3030 Project at Terang.

On the 3030 Project partner farm at Poowong, Gippsland, tall fescue and chicory were used in a mix with white clover to replace perennial ryegrass on a river flat area subject to flooding. The on-farm experience with these mixes was successful and indicated that white clover could grow well with both species for those particular conditions.

The suitability of white clover to grow with chicory and tall fescue was expected. Both the latter species are deep-rooted and therefore may not compete as actively with white clover for moisture in the upper layers of the soil. In contrast, when white clover grows with more shallow rooted species, such as perennial ryegrass, both species depend only on the limited moisture in the first 30-50 cm of soil. This complementarity between species becomes important in environments with a high likelihood of drought, such as occur in dryland dairy systems in Victoria.

White clover in the diet of dairy cows

Component studies in New Zealand have shown that the optimum level of white clover in pasture based diets for milk production is 55–65% (Harris et al., 1997). Increasing clover content above this has little effect on milk production due to the metabolic cost of excreting the excess N. However, maintaining such a high proportion of white clover in a perennial ryegrass stand all year round has shown to be impracticable for Australian conditions.

When white clover is the predominant species in the pasture sward the risk of bloat can be high. It is important to be aware of this when grazing grass-based pastures in summers with increased rainfall. This is because the proportion of white clover can increase significantly within a grazing rotation, and sometimes only in certain areas of the paddock. Again, to prevent bloat issues, ensure cows are fully fed and there is some roughage in their diet.

Cultivar choice

Two key factors for the choice of cultivars are **growth habit** and **summer activity**.

Cultivars that grow upright, with large leaves (such as Grasslands Kopu II and Itaifa) and a long growing season are more suitable for grazing dairy cattle as they are more productive than small leaved genotypes (e.g. Prop or Grasslands Tahora) which grow closer to the ground and are more suited to be grazed by sheep. These small-leaved cultivars, however, are normally more persistent.

In terms of summer activity, very summer active cultivars should only be chosen for high summer rainfall areas as otherwise the persistency of the stand could be severely affected.

See the Dairy Australia ‘Pastures Australia’ site (www.pasturepicker.com.au) for more information on this species.

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About 3030

PROJECT 3030 aims to help farmers achieve a 30% improvement in farm profit by consuming 30% more home-grown forage (pasture plus crop). It is aimed at dryland farmers in southern Australia who have mastered the challenge of growing and using ryegrass pasture for dairy-cow feeding.

For further information

Contact Dairy Australia
T 03 9694 3777
E enquiries@dairyaustralia.com.au
W www.dairyaustralia.com.au

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