Future Forage Systems Project

Lucerne – A brief literature review

Introduction

Lucerne is a perennial legume that produces high quality feed from spring through to autumn. Its long tap root enables it to draw moisture from deeper in the soil profile than relatively shallow rooted species such as ryegrass and white clover. Trials at Lincoln showed lucerne extracted water down to at least 2.3m whereas chicory and red clover (also with tap roots) only extracted water to a depth of 1.9m (Brown *et al.* 2005). After a dry spell, lucerne generally recovers more quickly than ryegrass dominant pastures due to more rapid mobilisation of root reserves. Lucerne is palatable to livestock, typically has ME values of at least 11 MJME/kg DM, crude protein levels greater than 20%, and high digestibility. Yields and feed intake on lucerne are likely to be higher overall than on lower yielding, lower quality pasture species – this is particularly the case in summer. However, it appears that winter dormancy may create an issue at a farm level. This may require a change in farm system or the growing of winter feed crops or supplements. With good management lucerne stands can persist and produce significant quality feed for more than 8 years.

Management

Good plant density at establishment is essential for a persistent lucerne stand. Paddocks should be well drained and sprayed out to eliminate all weeds (including grasses). Soil pH should be at least 6.3. Cultivate to achieve a fine, even seedbed with no compaction layers. Use only certified seed suitably inoculated. Avoid sowing seed into dry soils and sow early in dry areas to ensure that seedling plants have adequate moisture for successful establishment. Spring sowing is preferred with seed sown no deeper than 25 mm with – the optimal soil depth is 6-12 mm on clay and loam soils and 12-25 mm on sandy soil at a rate of 12-18 kg/ha for pelleted seed. Weed control during establishment may be required. The aim is to establish a plant stand of 60-90 plants per square metre in low rainfall areas and 110-130 plants per square metre in high rainfall or irrigated areas. Stems per hectare can also be used as a guide. Aim for 700-900 stems per square metre under good growing conditions and 400-600 stems per square metre under lower rainfall conditions. Lucerne is a self-thinning crop and it is more desirable to over-populate than to reduce the sowing rate – the latter results in a plant population too low for maximum production. High initial densities do not detrimentally affect long-term yields or stand persistence.

Whereas ryegrass leaves grow from nodes in the base of plant, Lucerne leaves and nodes grow from the tips of stems. After cutting or grazing, new stems grow from basal buds in the crown at the base of the plant. As stems mature and start to produce flowers, the accumulation of DM in the leaves declines and carbohydrates are directed to the crown and tap root reserves. These reserves are used to produce basal buds for the next regrowth cycle. Rotational grazing is essential to prevent damage to the crown and developing shoots and allow root reserves to be replenished. Lucerne should never be set stocked. Moot *et al.* (2003) recommend stocking rates should be set so that animals remove all leaf and soft stems - ideally within 7 days and no longer than 10 days. Too high a stocking rate or grazing durations longer than 10 days may damage newly forming shoots and basal buds. This means new buds must develop which delays regrowth, draws on more root reserves, and leads to reduced yields and persistence. Priority stock such as lambs should be grazed first to remove high quality leaves and stem tips, followed up by lower priority stock to eat stems, particularly in summer when the proportion of lower quality stem increases in the stand. Lucerne management and grazing recommendations also vary with season:

- ***Spring.*** Flowering is delayed by shorter days, so grazing is determined by the amount of feed accumulated. The exception to this is the first grazing after establishment when 50% of the plants should have open flowers before grazing. Plants should be at least 20cm tall or about 1500 kg DM/ha before grazing and some basal buds or shoots should be evident, indicating the next source of regrowth. To avoid exhausting root reserves accumulated during autumn and winter, intervals between grazing need to be 35 – 42 days to allow regrowth of developing basal buds. More frequent grazing leads to a greater reduction in root reserves as more buds need to form over the season. For example, Lincoln trials showed that a grazing frequency of 28 days resulted in plants being unable to rebuild root weight (an indicator of root reserves) to early spring levels. This would mean lower reserves available for regrowth the following spring. However, longer intervals between grazing tend to reduce overall stand quality as greater quantities of low quality stem and dead material build up. Ewes and lambs can be

slowly introduced onto Lucerne stands once the lambs are 2-3 weeks old. When grazing, the aim is to have enough stock so that the paddocks will be grazed off within 4-7 days.

- ***Summer*** The appearance of nodes and leaf expansion depends on temperature. For example, in winter (at a mean temp of 4.5^{o}C) a node appears every 7 – 10 days and in summer temperature (at a mean temp of 17.5^{o}C) nodes appear every second day. Consequently growth is faster in summer and intervals between grazing may be reduced to 30 – 35 days if water is not limiting. If drought significantly reduces plant growth, stands should be grazed to make use of existing vegetation then rested. Grazing should take place over no more than 7-10 days. During this time basal buds still slowly accumulate allowing plants to respond rapidly when rainfall does eventuate. Under irrigation, Lucerne stands should be spelled for at least a week after grazing to allow some leaf and stem development to take advantage of the water. Leaving irrigation until lucerne leaves and stems are actively growing will help out-compete any germinating weeds.

- ***Autumn*** Before winter, plants redirect some of their carbohydrates to rebuild root reserves in response to decreasing day length. To encourage this process, at least 50% of the plants should be allowed to flower before grazing (it is during the flowering phase that root reserves are mainly replenished). Failing to allow root replenishment at this time will adversely affect the following seasons yield.

- ***Winter*** Regrowth over winter is slow and grazing over this time will severely reduce the following season's growth potential. Lucerne normally stops growing after a series of hard winter frosts. It will also open up the canopy and allow winter active weeds to develop and compete with the more slowly growing lucerne plants. A final clean up grazing should occur before the end of June. Seven to ten days after this final "clean up" grazing has occurred the application of a suitable contact and residual herbicide should take place if required.

Pests & Disease

Lucerne can be affected by a range of pests and diseases, which left untreated can cause rapid collapse of the stand. Paddocks must be monitored for pests and diseases such as Blue green aphid, Spotted alfalfa aphid, Sitonia weevil, white-fringed weevil, green looper caterpillar, Verticilium and Fusarium wilts, Phytophthora root rot, Stem nematode and leaf diseases such as pepper spot. These diseases all reduce yields and persistence so it is important to sow resistant lucerne cultivars. Older cultivars such as Wairau are very susceptible and are likely to have poor persistence. Whilst there are approximately twelve lucerne cultivars being marketed (some of which have been bred overseas) there is little or no comparative data as to their performance under New Zealand conditions and in the face of our pests and diseases. Lucerne grown under irrigation or in wetter areas tends to be less persistent because of greater competition with weeds and grasses, and a greater likelihood of pest and disease attack, particularly root rots.

Controlling weeds before and during the establishment phase provides some of the greatest challenges to a lucerne farmer as many of the standard herbicides will affect lucerne. Nevertheless, weed control is essential. Herbicides should be targeted to the weed species present and registered

for use on lucerne. On established stands, herbicide should be applied within seven to ten days of the last grazing in autumn or early winter to control perennial and winter active weeds. Spraying later than this may damage newly forming basal buds and shoots and delay spring regrowth.

Yields

Lucerne can produce a wide range of yields, from 4.2 Tonnes in dryland Maniototo (Central Otago) to 28 Tonnes under irrigation at Lincoln (Table 1). Generally, lucerne grown on shallow soils or in drier areas can be expected to have higher yields than grass dominant pastures. Under irrigation, ryegrass pastures may have similar yields to lucerne but feed quality is often lower over late spring/ summer as grasses tend to be in their reproductive stage (Brown et al. 2004).

McGowan et al (2003) compared six cultivars between 1982 and 1987 and found average yield ranged from 9.6 – 12.9 Tonnes DM/year depending on cultivar and season. There is very limited data on lucerne yields under East Coast North Island conditions and none from a grazing situation using modern cultivars. Slay (unpublished data) recorded 42% more lucerne under mowing than in an adjacent old pasture (10814 vs 7632 kg DM/ha) in a particularly dry year (1994/95). In that study, lucerne produced 12.8% of its total DM over winter and actually out-performed the old pasture during winter (1387 vs 845 kg DM/ha). However, most of the benefit to lucerne occurred over the summer.

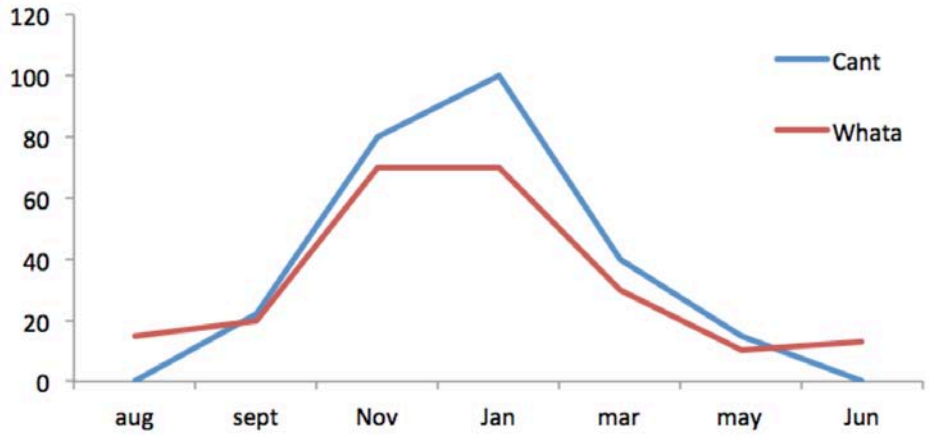
Table 1. Total yields of lucerne grown under a range of situations

Site	Annual yield (t DM/ha)	No. of regrowth rotations	Soil type	Irrigation	Pasture yield (t DM/ha)
Lincoln[1]	17.5 – 21	5 – 6	Wakanui silt loam	No	8.5
Lincoln[1]	16 – 28	5 – 6	Wakanui silt loam	Yes	16
Lincoln – Ashley Dene[1]	7	3	Lismore	No	-
Lincoln – Ashley Dene[1]	18.8 – 21.4		Lismore	No	-
Lincoln – Ashley Dene[1]	10.9 – 15.1	6	Lismore	No	-
Maniototo,Central Otago[2]	4.2 – 8.4	-	YG and YB soils	-	2.4 – 5.3
Whatawhata, Waikato[3]	9.7 – 12.9	6 – 8	Dunmore silt loam	No	12.2
Poukawa, Hawkes Bay[4]	10.8	-	-	No	7.6
Manawatu	23.0 – 18.4	6 – 8	-	No	

[1] Lucerne vs red clover (Brown et al, 2005), [2] Stevens et al (2011), [3] McGowan et al. (2003), Moot (2001), Roger Ball (1983)' Slay (unpublished data) Poukawa data – recorded in a particularly dry year - 1994/95, Bennett (2012), Theobald & Ball (1983).

The seasonal growth pattern of lucerne is typified by Figure 1, using data from Whatawhata (McGowan et al. 2003) and Lincoln (Brown et al. 2003). One of the limitations of most lucerne cultivars is winter dormancy, particularly in the South Island. Data from Lincoln (Figure 1) suggests lucerne has no growth during the winter. In the North Island, the proportion of Lucerne grown during the winter ranges from 3.9% in Rotorua (Baars et. al. 1990) to 9% in the Waikato (McGowan, 2003). The six cultivars compared by McGowan et al. (2003) had winter growth rates ranging from 9 to 14 kg DM/ha/day. By comparison, an adjacent "old" pasture had winter growth rates of 20 kg DM/ha.

Figure 1. Seasonal yields of lucerne in Canterbury and Waikato



Data from Lincoln (Brown et al. 2003) and Whatawhata (McGowan et al. 2003).

Animal performance on lucerne

Lucerne is a high quality feed, with metabolisable energy (ME) in leaves of 12 MJME/kg DM in leaves and 8.5 MJME/kg DM in stems. Crude protein levels of leaves are around 27% and stems 15% (Moot and Bray 2009). Leaf and stem quality does not significantly change over the growing season but because the proportion of stem in the diet increases as plants mature, overall lucerne quality declines from spring through to autumn.

As a consequent of higher yield and quality, stocking rates on lucerne are usually higher than on pastures. In a Central Otago trial, the relative stocking rate (weighted for number of lambs being reared) on lucerne was 9.4 ewes and lambs per hectare compared to 4.0 ewes and lambs per hectare on pasture. Also in Central Otago, mean ewe liveweight at weaning on lucerne was 58 kg as compared to 55.4 kg on pasture (Stevens et al. 2011). It is worth noting that lucerne versus pasture trials often compare a new lucerne stand against an older less productive pasture which may not be a fair comparison.

Pre-weaning lamb liveweight gains on lucerne are variable and in the range 220-390 g/day (Table 1). Lamb growth rates depend on the relative proportion of leaf to stem and what grazing residual is left, along with the size and milking ability of the ewe. As a general rule, where pre-weaning lamb growth rates have been compared against similar ewes on pasture, lamb liveweight gains have been 21% higher on Lucerne (296 g/d vs 245 g/d) than on pasture.

Post weaning lamb growth rates averaged 243 g/d (range 183 - 294 g/d; Table 1). However, there are only two studies comparing lambs on pasture and lucerne – one in spring and one in summer. In the spring study, lambs on lucerne grew 11% faster (261 vs 236 g/d) and in the summer study, lambs grew 82% faster (191 vs 105 g/d). The size of the effect in summer will reflect the severity of the summer as lucerne will maintain its quality whereas pasture quality deteriorates.

Clearly, lamb liveweight gains on lucerne are seldom as good as the claims made. This is simply because under rotational grazing, stock need to consume all the plant – including the low ME stalk. By comparison, in the only study where lambs were set stocked on lucerne, liveweight gains of recently weaned lambs averaging 19 kg liveweight were 430 g/d (Poukawa unpublished data).

Table 1. Pre and post weaning lamb liveweight gains on lucerne and pasture

Site	Growth rate on lucerne g/lamb/day	Growth rate on pasture g/lamb/day	Advantage to lucerne	Reference
Pre-weaning				
Bonavaree	390	-		Moot and Bray 2009
Lincoln	248	--		Bennett 2012
Central Otago	280	224	+25	FITT project 09/112
Central Otago	330	275	+20	Stevens et al 2011
Central Otago	292	253	+15	Stevens et al. 2011
Hawkes Bay	221	246	-10	FFS - Anawai 2011
Hawkes Bay	355	225	+58	FFS - Anawai 2012
Overall	**296**	**245**	**+21**	
Post-weaning				
Bonavaree	275	-		Moot and Bray 2009
Lincoln	294	-		Bennett 2012
Lincoln	183	-		Bennett 2012
Hawkes Bay	250	-		FFS – Anawai 2013
Hawkes Bay	248	-		FFS – Kinburn 2013
Manawatu	191	105	+82	Burke et al. 2002
Hawkes Bay	261	236	+11	FFS – Kinburn 2012
Overall	**226**	**170**	**+33**	

*Overall average values only pertain to the highlighted values where there is a valid pasture comparison

The main animal health problems that occur with animals grazing lucerne are:

- ***Redgut*** The high digestibility of lucerne, particularly in spring or after rain, means plant material passes quickly through the rumen, resulting in more fermentation and an increase in size of the large intestine. This de-stabilises the organs and can result in a 'twisted gut' and rapid death. To reduce redgut risk, transition animals slowly onto lucerne (over 10 – 14 days) by grazing pasture in the morning and lucerne later in the day when the rumen is already partially filled. Fibre (e.g. meadow hay) should also be available during lush growth periods.
- ***Bloat***. The high quality of lucerne can also cause bloat. Practices to reduce the risk of bloat are similar to those for reducing redgut - feed fibre such as hay or straw, don't put hungry animals onto the crop and provide mineral blocks.

- ***Sodium*** Stored in the roots of lucerne but the level present in the leaves frequently does not meet animal requirements so salt blocks need to be provided.
- ***Enterotoxaemia*** (pulpy kidney) may cause animal losses on lucerne as on many other high quality feeds. Ensure that sheep are vaccinated.
- ***Oestrogen*** Older crops of lucerne that have been attacked by leaf diseases, insects or viruses can have high levels of oestrogen that can temporarily affect ewe fertility. Only healthy young lucerne stands can be used to graze ewes before and during mating. At least 50% of the plants should have open flowers before grazing in autumn so flushing ewes prior to mating may not fit with stand management.

Cultivars

The lucerne market was originally dominated by New Zealand-bred cultivars released by AgResearch and its predecessor, the Department of Scientific and Industrial Research (e.g. Wairau, Otaio, Kaituna and Torlesse. In the last 10 years overseas varieties have emerged with higher yields and greater resistance to aphids and disease. A new breeding programme is underway as a joint venture between Luisetti Seeds and Grasslanz Technology to breed and develop a new lucerne cultivar specifically for the New Zealand market. Cultivars with more winter/early spring activity will integrate better into most dryland farming systems. For cooler areas winter dormancy will assist persistence. There are three main types of Lucerne which are classified according to their dormancy. Under this new system 1 is the most winter dormant and 10 is the most winter active.

- **Winter dormant**:(Rating 1 to 4) Have little or no winter activity and have the potential to last 8 years + if well managed. Usually show excellent disease resistance and normally the highest quality because of a high leaf to stem ratio.
- **Semi winter dormant**: (Rating 4 to 7) Will normally only produce 5- 10% of their growth during winter. Have improved disease resistance and if well managed can last between 5 to 7 years.
- **Winter actives**: (Rating 7 to 10) Can produce up to 20% of its growth during winter. Generally more susceptible to disease and therefore normally have a short stand life 4-6 years.

Wairau 3 – New Zealand bred, winter dormant, much more susceptible to diseases and pests than Kaituna and Torlesse.

Torlesse 4 -New Zealand bred, excellent disease and insect resistance, suited to grazing and cutting, low winter activity

Kaituna 4 - Grasslands Kaituna is New Zealand bred, ideal for grazing and mixed swards and is persistent under grazing and hay/silage production. Kaituna is highly productive in spring and summer, with later autumn and earlier spring growth than Wairau.

54V09 4 - High disease resistance, is ideal for grazing, silage or hay, high yielding, high persistence, low winter activity.

Force 4 - Robust under cutting and grazing, high yielding, high persistence, low winter activity - a New Zealand developed fine stemmed lucerne, selected for improved resistance to the range of pests and diseases in our environment.

Stamina 5 - A grazing, Lucerne with good overall disease resistance and good hay making properties. Low winter activity and is the Australian standard.

Stamina 6 - Anew selection with higher winter activity than Stamina 5.

Icon 6 - Moderately winter active, good dual purpose hay, silage and grazing cultivar. Developed from selections grazed by sheep and cattle. Icon has low crowns that will tolerate closer grazing, particularly by sheep.
SuperSonic 9 – Highly winter active, suited best for grazed pastures and intensive forage cutting programmes. The high leaf to stem ratio provides high protein and digestibility

Summary

Lucerne is highly palatable and in regions with low annual rainfall and dry summers, use of lucerne can lead to improved lamb liveweight gain and ewe body condition. However, lucerne needs rotational grazing and has poor winter activity both of which may create a need for alternative feed for set stocking ewes at lambing. It does require careful and on-going monitoring and management to ensure persistence.

Farms such as Bonavaree in Marlborough (Avery et al. 2008) and Greenfield Agribusiness farms in Central Otago have successfully integrated lucerne into their farming systems, resulting in improved lamb performance compared to traditional, grass-dominant pastures. Both of these farms are in colder areas where poor winter growth is typical. In these situations, a change to growing lucerne is not necessarily disadvantageous. However, where good winter growth rates are expected, integrating lucerne into a farming system may effectively reduce winter carrying capacity. Other significant changes to the farming system may be necessary to overcome this handicap. For example a cereal, brassica or annual ryegrass crop may need to be grown to fill a possible feed deficit in late winter/early spring until lucerne is ready to graze. Lambing dates may need to be adjusted to better match the new feed supply curve.

To date, lucerne can only be successfully established and managed on cultivatable land – there are no technologies to allow lucerne to be utilised on the large areas of the North island East Coast which are too steep to cultivate. Historically the persistence of grazed lucerne stands has been an issue due to pest and disease and miss management. However, new pest and disease resistant varieties combined with better grazing management strategies have improved persistence and yield. Surprisingly, in spite of ten lucerne varieties being marketed, there is little or no comparative data on cultivar yield (particularly winter growth) and performance and persistence under grazing.

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