Overview of the economic utilization and traits of interest of lucerne in Australia*

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INTRODUCTION: Lucerne (alfalfa, *Medicago sativa* L.) is grown on an estimated 3 – 3.5 Million hectares of Australia, concentrated in the south-eastern, medium rainfall agricultural zones. Over 90% of the total area is grown under rainfed conditions, where it is predominantly used as a specialist pasture that is cut opportunistically for hay and grazed by sheep and cattle for meat, dairy, and in rotations with cereal crops in low-medium rainfall environments. In this mixed cropping and livestock farming system a 3 – 6 year pasture phase provides nitrogen and a disease break for the following sequence of grain crops. Lucerne also has a minor use as a water efficient, heat tolerant summer grazing option in the dairy industry (usually under irrigation) where it is also cut for hay or silage. There is also approximately 100,000 hectares of lucerne managed for intensive lucerne hay production in NSW, concentrated along river valleys.

The south-east of South Australia is home to one of the world's largest areas of lucerne seed production. The region produces 4-8,000t of seed per year from 20-25,000 ha of rainfed and irrigated production (Lucerne Australia Pers. Comm. 2018). Irrigated seed yields range between 600 and 1500 kg/ha, dependent on seasonal climate variability.

In southern Australia the deep rooted nature of this perennial legume is valued for extending the growing season of winter-based pasture into summer, where it is used for finishing lambs, growing out vealer calves, or improving the fertility of maternal stock. In northern Australia rainfall is dominant in the summer months, and in these environments the quality of lucerne is valued for improving feed quality and the utilisation of C4 grasses.

Hay production for domestic and export markets

The domestic market for lucerne hay is a considerable size, but the volume is difficult to estimate because it is dominated by cash sales for the equine industries and local livestock markets (transported <100km). Hay yields in northern NSW from well managed commercial irrigated stands are in the order of 15-25t/ha across six-seven cuts per year. This is comparable to experiments that have reported 25.7 t DM/ha in northern Victoria (Greenwood et al. 2006) and 24.2 t DM/ha in south-eastern Queensland (Lowe et al. 2010). A recent change from winter active (fall dormancy) class 5 to 7 varieties has resulted in an increase in the number of cuts per year that can be achieved from 5 to 6 or 7 (with an average of 2.5 t/ha per cut), plus the possibility of an additional winter silage cut. Producers target 15-18% moisture quality, with around 55% being delivered to premium horse markets and the remaining 45%, lower quality hay, sold to cattle producers. The quality of lucerne hay is still largely purchased on appearance by horse enthusiasts, with colour, stem thickness and purity used to estimate nutritive value.

Under rainfed conditions only a single hay cut is possible in most areas, with the rest of the season used for grazing. Lucerne is increasingly conserved as silage where on-farm use for beef or dairy production is intended. The dairy industry is no longer a large buyer of lucerne or clover (*Trifolium* spp.) hay, having largely transferred to using cereal hay.

Australia does not have a significant export hay market for lucerne. Australia exports around 1.1 Million tonnes of hay and cereal straw a year to China, Japan and Korea, but it doesn't have the right environmental conditions to produce a consistent supply of quality lucerne hay for export. The large oaten hay exporters (Gilmac,

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Johnsons, Balco) are positioned in the cereal zones of WA, SA and Victoria, far away from the hay producing regions for lucerne. In Australia irrigation water is a scarce resource, and in the last two decades has transitioned to being used for either higher value crops or applied more efficiently to supplement the growth of annual crops growing during cooler months. In the last five years, the only considerable lucerne hay exports occurred during a US port strike that ran for four months, and this was < 1000t in total. There are some lucerne chaff exports, with one NSW company exporting around 1000t per year in addition to their domestic production of 6000 t/year.

Lucerne as a pasture for livestock systems

Lucerne is estimated to be adapted to over 30 million ha in Australia (Hill and Donald 1998), but its current area of cultivation of 3.2 million ha is approximately half of the area suggested as a realistic upper limit for adoption (Robertson 2006). In southern Australia lucerne is valued for its capacity to extend the growing season of winter-based pasture. The high nutritive value feed can be used to switch autumn calving or lambing times into spring. In cattle, spring calving can substantially reduce large costs associated with supplementing the lactating cow during winter (McKiernan et al. 2005). The weaners are younger, but the system allows for higher stocking rates (more calves per ha) that can be finished with lucerne on farm or supplied to feedlots. Producers are also using lucerne to hold onto weaner stock for longer into summer, adding weight and attracting a premium price for selling later in the season.

One of the greatest current drivers for promoting the expansion of lucerne in southern Australia is related to the aim to provide a consistent supply of preferred specification meat production to local meat processors. The capacity for livestock producers to supply this product is constrained by production systems that have a highly variable feed supply. Lucerne is one of the few options that can underpin a consistent feedbase, and has been linked to higher carcass compliance and eating quality beef in comparison to grain and ryegrass finished pasture (Frank et al. 2014). The opportunity to finish livestock at a younger age with lucerne also presents opportunities for reducing methane emissions intensity.

The limitation for further expansion of lucerne in Australia is that it is considered to be a specialist pasture, due to perceived difficulties with integration into the farm system. Also, for many environments, lucerne is adapted to only some areas of the farm, with seasonal waterlogging and acidic soils restricting its adaptation. Grazing systems in most areas are extensive, with a lack of rotational grazing over the farm contributing to challenges with adoption and integration. A single on-farm field of lucerne provides challenges for rumen function when taking livestock from dry senesced pastures and putting them onto highly digestible lucerne. Sudden changes to diet can increase the risk of bloat in cattle and red-gut in sheep, which is particularly relevant where lucerne is grown as a monoculture. New research is required to demonstrate the production of lucerne in mixtures with perennial grasses and chicory, including the development of new varieties that are adapted to growing in pasture mixtures.

Traits of importance for lucerne in Australia

Broad adaptation to diverse environmental conditions and farming systems is critical in Australia, as the market is not large enough to segregate varieties into rainfall, soil types or farming systems. Lucerne varieties with winter activity (fall dormancy) classes of 3 to 10 are sold, with persistent, multipurpose class 7 varieties being the most popular by volume.

1. Persistence under grazing

New grazing tolerant varieties released by SARDI and PGG Wrightsons (SARDI Grazer and Stamina GT5, FD5-6) have persisted extremely well in field evaluation trials under farmer management. An analysis of persistence versus winter activity from nine farmer managed sites after four years (Humphries, unpublished) shows (Figure 1) that persistence was improved for entries previously selected for tolerance to continuous grazing across a range of winter activity.

2. Drought tolerance

Lucerne forage production in south-eastern Australia is dependent on a variable rainfall supply. In much of southern Australia, deterioration of pasture quality and availability over summer and autumn (McKiernan et al. 2005) places lucerne under pressure from overgrazing when other feed sources are scarce. Lucerne is often set-stocked during drought conditions, and whilst this can be important to keeping livestock alive, the drought x grazing stress is a major cause of lucerne population decline.

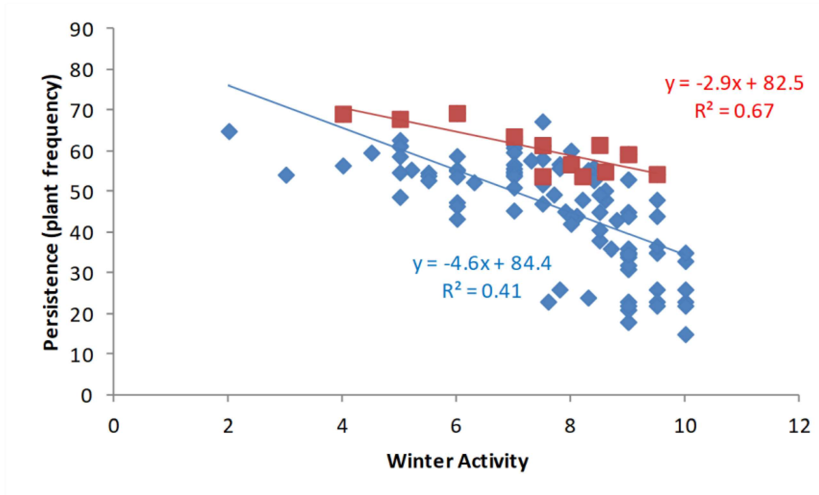

Figure 1. The relationship between persistence and winter activity for conventionally bred (diamonds) and grazing tolerant lucerne lines (squares) at nine commercially managed sites in Australia (Coolac, Cowra, Culcairn, Grenfell, Mingbool, Bendigo, Timboon, Rochester, Tintinara).

Climate change predictions indicate further warming of 0.8-2.8 °C and decreases of rainfall of 0-20% by 2050 (Ghahramani et al. 2013). This is likely to place greater pressure on a production system that is already constrained by a winter dominant rainfall pattern. The climate models suggest that later breaks to the winter growing season are likely, potentially coupled with warmer winters and less spring rainfall (Ghahramani et al. 2013). This may have a large impact on the ability to establish new lucerne pastures in low rainfall environments. This could see establishment being pushed from autumn and spring into a narrower zone of opportunity in winter. Seedling vigour and high winter activity (low fall dormancy) are likely to increase as important traits, in order to maximise seedling growth in cooler conditions. Despite these concerns, a higher incidence of summer rainfall has resulted in the prediction that an increased use lucerne is likely to have the greatest effect in reducing the negative impact of climate change (Ghahramani & Moore 2013).

The deep rootedness and drought tolerance of lucerne also has benefits for improved production efficiency using scarce irrigation water. In the Riverina region (Murray River irrigation), Kelly et al. (2005) showed that lucerne is very tolerant to deficit irrigation, with no loss of yield under an irrigation strategy that reduced the yield of white clover by 70%. Current recommendations for dairy farmers in hot climates with water restrictions are to incorporate winter-active lucerne on up to 20% of farm area, with a focus on supplementing natural rainfall with irrigation to produce feed from winter-growing annual species during the cooler growing seasons.

3. Aphid and disease tolerance

The four major pests and diseases of lucerne in Australia are bluegreen (*Acyrthosiphon kondoi*) and spotted alfalfa (*Therioaphis trifolii*) aphids, *Phytophthora* root rot (*P.medicaginis*) and Anthracnose (*Colletotrichum trifolii*). Plant-based resistance to bluegreen aphid (BGA, Acyrthosiphon kondoi Shinji) has broken down in south-eastern Australia (Humphries et al. 2012), with virulent biotypes now requiring chemical control when growing conditions are ideal for aphid development. Lucerne fields are also managed for lucerne flea (*Sminthurus viridis*) and red-legged earth mite (*Halotydeus destructor*) during seedling development, which has reduced the awareness of the new bluegreen aphid being a serious pest. An increase in reliance on chemicals for control of insects has already led to the development of chemical resistance in red-legged earth mite, and there are concerns that this could also develop in aphids. There are opportunities to breed for resistance using existing genetic variability to the new bluegreen aphid biotype, as well as maintain resistance to other pests and diseases. This aim needs to be realised if plant-based resistance is to have a future role in maintaining lucerne stability.

4. Tolerance to acidic soils

Acidic soils are strongly prevalent in the medium-high rainfall zones of southern Australia, with 11.2 M ha of agricultural land with surface pH_{Ca} 5.0-5.5 and a further 6.2 M ha with pH_{Ca} 4.5-5. An acid tolerant lucerne variety would be expected to have the greatest impact in areas where lucerne is currently grown but often at sub-optimum production levels, including the Riverine Plains, Central West and Northern Tablelands of NSW and Victoria and the south-east of South Australia.

The performance of new lucerne varieties and rhizobia strains selected for improved tolerance to soil acidity have recently been evaluated across a range of environments in south eastern Australia (Humphries et al. 2017). The results of this project have demonstrated that lucerne is more tolerant to highly acidic soils than previously described in literature. Forage production in the first calendar year after sowing ranged from 11 to 14 t/ha under rainfed conditions at three of the sites with soil pH_{Ca} 4.1-4.3 (Figure 2). However, the addition of 1.2 t/ha lime partially ameliorated the surface soil to pH_{Ca} to 4.6 and increased forage yield by 33%, nitrogen fixation by 26%, and plant persistence by 28%. The research showed that lucerne can be productive on acidic soils, but the long term production in these environments is associated with greater risk when this stress is combined with drought, grazing or seasonal waterlogging. The research has cumulated in the release of a new acid tolerant rhizobia strain, SRDI736, to be used as a specialised strain for lucerne on acid soils (<pHca 5.0).

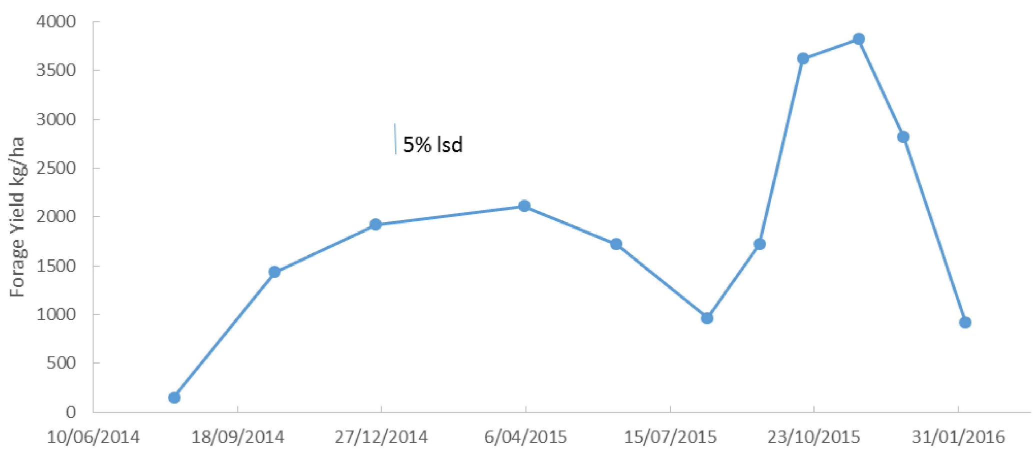

Figure 2. Average distribution of lucerne forage production on highly acidic soils (pH_{Ca} 4.1 go 4.3) at Tooperang, Pewsey Vale (SA) and Holbrook (NSW). Lucerne produced 11 – 14 t/ha with 52% of production over summer (Humphries et al. 2017).

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