Developing resilient and productive pasture mixtures for southern Australia

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Background

A major problem with the feedbase in the broad-acre, dryland, mixed farming belt of southern Australia is the absence of compatible perennial companion species to mix with lucerne to produce a pasture that has good drought survival with minimal feed gaps. While broadly adapted, lucerne plant densities typically start at 40–80 plants/sq m but often decline to as low as 5 plants/sq m within 2–4 years of sowing (Humphries *et al.* 2006). Typically a pasture phase of 3–4 years is needed before going back into cropping to ensure a build-up of biologically fixed nitrogen. A pasture with 5 lucerne plants/sq m has inadequate ground cover exposing the soil to wind and water erosion and produces neither enough forage nor sufficient fixed N for following crops.

Cool-season, annual species such as subterranean clover have traditionally been associated with lucerne in mixtures but these annual legumes are suffering increasingly severe shortcomings because the length of their growing season has shortened by approximately 1 month within the last decade (B. Dear pers. comm.). Consequently these species contribute substantially less forage and N fixation than previously. Moreover, these annual plants do not provide any protection against soil erosion which is an increasing problem over summer. Therefore, we need to identify replacement compatible species with a perennial habit able to provide protective ground cover all year round.

Recent physiology research with temperate perennial grasses and lucerne has shown that the dormancy trait whether expressed over summer , as in the perennial grasses , or over winter, as in lucerne, is a powerful survival trait over periods of stress (McKenzie *et al.* 1988; Volaire & Norton 2006). However, the problem remains in determining how to use these dormancy traits to maximum benefit within farming systems requiring year round availability of forage. We hypothesise that a mixture containing a winter-active, summer-dormant perennial grass and winter-dormant, summer-active lucerne will be more persistent than a mixture containing two summer-active varieties or two winter-active varieties. The component of the pasture mixture which expresses summer dormancy will exhibit an enhanced level of summer drought survival. In addition, winter dormant lucernes have demonstrated better survival of summer droughts than the winter-active types (Pembleton *et al.* 2009). Such a mixture would have the added advantage of being able to provide forage throughout the year whenever conditions are favourable. Although much of southern Australia has a Mediterranean climate with cool, moist winters and hot, dry summers, climate predictions indicate less rainfall in the cooler seasons with an increasing summer rainfall incidence. Moreover, even under the present climate intermittent summer storms in south-eastern Australia can drop significant amounts of rainfall so pastures dominated by summer-dormant grasses, unable to use this rain, can become infested by summer-active weeds. The development of mixtures of summer-dormant grasses and summer-active species such as lucerne should limit the influx of these weeds. Similarly the presence of the highly winter-active perennial grass component should reduce the invasion of lucerne pastures by annual cool-season weeds such as annual ryegrass, barleygrass and vulpia.

The winter-active types of lucerne, which are primarily used in Australia, are less adapted to dryland production systems than winter dormant types. When exposed to water deficit winter dormant types are able to maintain a more favourable plant water status (Pembleton *et al.* 2009) and possess a greater capacity to express stress tolerance genes than winter-active types. Lucerne is also known to be deeper rooting than perennial grasses such as phalaris and cocksfoot so mixtures of these species may exploit water from different parts of the soil profile (Sandral *et al.* 2006). Moreover, winter-dormant lucernes should compete less over winter with the companion grass because of their greater dormancy. Indeed, the greater drought tolerance of the winter-dormant lucernes combined with their lower cool-season growth indicates that the winter-dormant types should have greater compatibility with summer-dormant grasses. Typically lucerne is regarded as most productive in the warmer seasons but one of the major developments over the last decades has been the release of winter active germplasm. As Australia does not have intensely cold winters these winter-active cultivars have become the norm and there are very few lucernes commercially available in Australia with high winter dormancy (i.e. ratings less than 4). Nevertheless, commercially available lucerne cultivars still tend to be less productive over winter than the strongly winter-active, summer-dormant grasses such as Kasbah cocksfoot. We suggest there is a need to explore the potential of growing a mixture of species together that have non-competitive and complementary growth rhythms and study the potential of these underexploited types of lucerne and grasses to form compatible and more resilient feedbase mixtures. The research program below addresses this objective.

Materials and methods

The proposed experiments will study the effect of dormancy level of both the lucerne cultivar (winter dormancy) and the companion grass cultivar (summer dormancy) on resilience (survival) and productivity of the pasture. The currently recommended winter active lucerne/sub-clover mixture will be the control and pure sward treatments of each of the summer active/dormant grasses and winter active/dormant lucernes will also be tested.

Field based experiments will be conducted at relevant locations across the mixed farming zones of south-eastern Australia. Measurements will assess productivity and persistence of the different treatment mixtures and explain the reasons for the different performance of the treatments. Such measurements might include soil water use, production constraint due to N availability, dry matter production, species composition, ground cover and plant density.

Potential outcomes

The development of compatible pasture mixtures is expected to: (1) increase the stability and resilience of the feedbase and reduce the severity of feedgaps; (2) enhance the contribution of the legume to the soil nitrogen pool through greater and more stable forage legume production; (3) increase soil cover to reduce erosion and protect the soil resource; (4) provide a more-balanced diet to grazing animals thereby reducing health problems such as redgut; (5) reduce the prevalence of annual grass weeds and thereby the burden of carry-over agents of cereal disease pathogens.

References

Humphries, AW, Kobelt, ET, Bellotti, WD & Auricht, GC (2006) Tolerance of Australian lucerne (*Medicago sativa*) germplasm to grazing by sheep. *Australian Journal of Experimental Agriculture* 46, 1263–1270.

McKenzie JS, Pacquin R, Duke SH (1988) Cold and Heat Tolerance. In 'Alfalfa and Alfalfa Improvement'. (Eds AA Hanson, DK Barnes, RRJ Hill) pp. 259–302. (American Society of Agronomy: Madison, WI).

Pembleton KG, Rawnsley RP, Donaghy DJ, Volenec JJ (2009) Water deficit alters canopy structure but not photosynthesis in regrowing alfalfa (*Medicago sativa* L.). *Crop Science* 49, 722–731.

Sandral GA, Dear BS, Virgona JM, Swan AD, Orchard B (2006) Changes in soil water content under annual- and perennial-based pasture systems in the wheat-belt of southern New South Wales. *Australian Journal of Agricultural Research* 57, 321–333.

Volaire, F & Norton, M (2006) Summer dormancy in temperate perennial grasses. *Annals of Botany* 98, 927–933.