Improving the phosphorus efficiency of temperate Australian pastures

Richard J Simpson [A], Graeme A Sandral [B], Richard A Culvenor [A], Megan H Ryan [C], Hans Lambers [C], Phillip GH Nichols [CD] and Richard C Hayes [B]

[A] CSIRO Sustainable Agriculture Flagship / CSIRO Plant Industry, Canberra, ACT, 2601, Australia
[B] NSW Department of Primary Industries, Wagga Wagga, NSW, 2650, Australia
[C] Faculty of Natural & Agricultural Sciences, University of Western Australia, Crawley, WA, 6009, Australia
[D] Department of Agriculture Western Australia, South Perth, WA, 6151, Australia

Contact email: richard.simpson@csiro.au

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Introduction

Phosphorus (P) is a key input necessary for high production in many temperate, grass-legume pasture systems in Australia because the pastures are situated on P-deficient and moderate to highly P-sorbing soils. A consequence of P-sorption in these soils is that much more P must be applied as fertiliser than will be exported in animal products. The P balance efficiency (PBE=100*P_{export}/P_{inputs}) of grazing enterprises (*e.g.* wool, meat, milk and live animal export) is about 10-30% and compares poorly with some other agricultural enterprises (e.g. 45-54% for grain production; McLaughlin *et al*. 1992; Weaver and Wong 2011). P accumulates in these soils when they are fertilised as a result of phosphate reactions with Ca and/or Al and Fe oxides, and P incorporation into resistant organic materials (McLaughlin *et al*. 2011). Some P in grazed fields is also accumulated in animal camps. The net rate of P accumulation in soil (and in grazed fields as a whole) is related to the concentration of plant-available P in the soil. Operating grazing systems at lower plant-available P levels should help to slow P accumulation and result in more effective use of P fertiliser (Simpson *et al.* 2010; Simpson *et al*. 2011). Because the P requirement of grass-legume pastures is usually set by the high P requirements of the legume (Hill *et al*. 2005), we commenced a study to quantify the P requirements of a range of legumes to determine whether productive, lower P-input grazing systems can be developed. We are also screening subterranean clover, the most widely used pasture legume in temperate Australia, for root traits related to P efficiency. Here we report early findings from the establishment year of a field experiment to determine the P requirement of several alternative temperate legumes.

Methods

Pasture species were sown into a cultivated seedbed (Colwell P [0-10 cm depth] = 8 mg/kg) on 20 May 2012 at a field site near Yass, NSW. Legumes were sown at 15 kg seed/ha and inoculated with appropriate rhizobia, while the perennial grasses were sown at 10 kg seed/ha. Basal applications of lime, K, S, Mg and micronutrients were applied prior to sowing to ensure that no nutrients (other than P and N) would be limiting for pasture growth. P was applied to the soil surface at sowing at: 0, 15, 30, 45, 60 and 80 kg P/ha (n = 3) as triple superphosphate (20.7% P; 1% S). The pasture species were either widely used, had potential as alternative legumes for pastures, or had known or anecdotal P-efficiency attributes as follows:

Perennial legumes: *Medicago sativa* (lucerne) - widely used with unknown P requirement; *Lotus corniculatus* (birdsfoot trefoil) - reputed to be adapted to low nutrient soils; *Trifolium tumens* (talish clover) - novel pasture species with unknown P requirement; *T. ambiguum* (Caucasian clover) - reported as “less dependent” on P than white clover; *Bituminaria bituminosa* ssp. *abomarginata* (tedera) – a novel pasture species considered likely to be adapted to low nutrient soils.

Annual legumes: *T. hirtum* (rose clover) **-** has a low internal P concentration, possible half that of *T. subterraneum*; *Onithopus compressus* (yellow serradella) **-** has a low external critical P requirement; possibly half that of *T. subterraneum*; *T. spumosum* (bladder clover) - novel species with unknown P requirement; *Biserrula pelecinus* (biserrula) - considered likely to be adapted to low P soils; *T. subterraneum* (subterranean clover) - widely used species with a high P requirement.

Perennial grasses: *Phalaris aquatica* (phalaris) - persistent but relatively unproductive in low P soils; *Dactylis glomerata* ssp. *hispanica* (cocksfoot) - productive species used widely on low P soils.

Results

Success in establishing the alternative legumes was varied reflecting, in part, the novelty of the species as pasture legumes in the area they were being trialled. Tedera and biserrula seedlings succumbed to severe frosts, bladder clover appeared to show a hypersensitive response to Rutherglen bug (*Nysius vinitor*) and some of the perennial species were slow to reach canopy closure. The range of responses to P-fertiliser by species that had established well by the first spring is shown in Figure 1. The main observations for the annual legumes were that the relatively high P requirement for maximum growth by subterranean clover was confirmed, the external P requirement of rose clover was similar to that of subterranean clover despite its low shoot P concentration (Pinkerton *et al*. 1997) and a

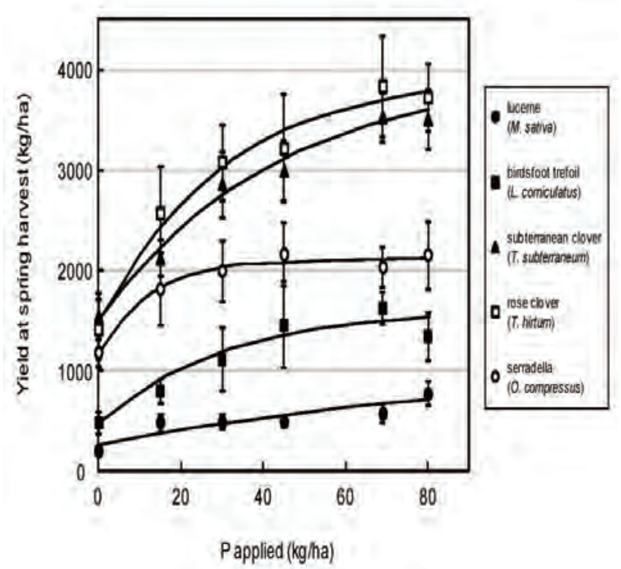

Figure 1. Dry matter yield (November 2012) of five legumes grown in response to increasing rates of P application. Lines are Mitscherlich regressions fitted using Genstat. Bars = 2xSE

lower critical external P requirement for yellow serradella compared with subterranean clover was confirmed (Paynter 1990). Birdsfoot trefoil appeared to also have relatively low P requirement. However, it will be important to confirm that the ongoing P requirement of this perennial legume is low once it has established fully. The critical requirement of lucerne could not be determined reflecting its slow establishment. Comparisons of the P requirements in relation to herbage yield are difficult to make at this stage while the swards are still becoming established.

Conclusion

This project is assessing whether productive pastures can be grown with lower available-P concentrations. At least two legumes with lower critical P requirements relative to high requirement of subterranean clover are potentially indicated at this early stage. The high P requirement of subterranean clover also confirmed the need to investigate variation in P efficiency traits in this keystone pasture legume.

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