New pasture plant options to reduce P-input costs of grazing systems

G Sandral[A], R Simpson[B], A Price[A], S Hildebrand[A], C Fuller[A], Z Yang[B], A Stefanski[B], D Kidd[C], H Lambers[C] and M Ryan[C]

[A] Department of Primary Industries, 2650, Wagga Wagga, Australia: graeme.sandral@dpi.nsw.gov.au
[B] CSIRO Sustainable Agriculture Flagship / CSIRO Plant Industry, 2601, Canberra, Australia
[C] University of Western Australia, School of Plant Biology, 6009, Perth, Australia

Abstract: *The cost of phosphorus (P) fertiliser is increasing at approximately twice the rate of inflation in Australia. Consequently, there is growing interest in developing grazing systems that require less P fertiliser to reduce input costs per unit of production. This objective requires pasture plants with lower critical P requirements for growth and the ability to sustain existing production levels and stocking rates. Critical P is defined, in this case, as the soil test P (Colwell or Olsen value) or fertiliser rate that corresponds to 90% of maximum shoot growth rate in spring. In the study described here, the response of Trifolium subterraneum to applications of fertiliser P was compared with four alternative annual pasture legumes being assessed as part of a larger trial. Six levels of soil P fertility were achieved by applying triple superphosphate (21% P) to a P-deficient soil at Burrinjuck near Yass, New South Wales. The results indicate that the critical P levels for these species differed: T. subterraneum had a relatively high critical P level. However, Ornithopus compressus and O. sativus (pasture legume types) and T. purpureum and T. incarnatum (forage legume types) had lower critical P levels than T. subterraneum. Of the two pasture legumes types with a lower critical P level, only O. sativus produced an equivalent amount of dry matter at its critical P level to that of T. subterraneum.*

Introduction

Australian soils are naturally low in phosphorus (P) and pastures require P fertiliser to maintain high productivity. The cost of P fertiliser is presently increasing at approximately twice the rate of inflation in Australia. Consequently, there is growing interest in whether grazing systems that require less P fertiliser can be developed to reduce input costs.

It is estimated that it will be possible to substantially reduce P inputs and improve the P efficiency of grazing systems by using pasture legumes that have low critical P requirements (i.e. legumes that can yield well at low extractable soil-P concentrations) (Simpson *et al.* 2014).

Our hypothesis was that among the alternative pasture legume species recently developed for southern Australia (Nichols *et al.* 2012) there are likely some with lower critical P requirements than *Trifolium subterraneum*, which is the main annual legume used in the 400–750 mm rainfall zone. Figure 1 illustrates the sort of shift in legume response to soil P fertility we expected to find.

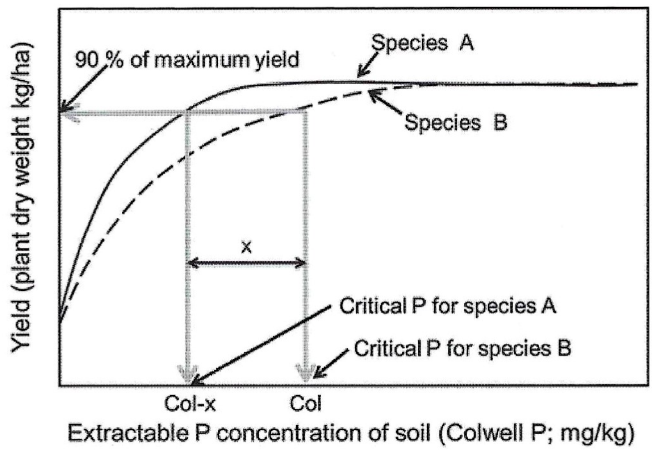

Figure 1: Diagrammatic representation of critical P (the Colwell extractable P concentration of soil that corresponds with 90% of maximum yield) for two pasture species where, species B represents the main legume used presently (*T. subterraneum*) and species A represents an alternative legume with a lower critical P requirement.

Methods

In 2013, a field experiment was started in autumn (May) near the town of Bookham in NSW, Australia. The experiment included 12 pasture species (2 grasses and 10 legumes), 6 P rates and 3 replicates in a randomised complete block design. Prior to sowing the site was limed at 2.0 t/ha and basal nutrients were applied to ensure no nutrients were limiting except P and N. The P-fertiliser rates were established by adding triple superphosphate (20% P and 1.5% S) at 0, 15, 30, 45, 60 and 80 kg P/ha. Legumes were inoculated with an appropriate rhizobia strain at sowing. At the peak of spring (early November), herbage dry matter yields were determined and soil samples (0–10 cm depth) were taken for analysis of the extractable P concentration (Colwell 1960).

Plant and soil data were statistically analysed using Genstat version 16.1 applying Linear Mixed Models (LMM) with Rep+Row.Column fitted to plant dry matter and soil Colwell P. The plant dry matter and Colwell P values generated from LMM at the plot level were subsequently used to fit Mitscherlich equations for species.

Results

Many of the pasture species that were sown proved unsuited to the soil and climate at the Bookham site. The dry matter yields (kg/ha) at critical P and Colwell P (mg/kg P) levels at critical P for five species that grew well are shown in Table 1. The critical soil test P levels were calculated from Mitscherlich equations fitted to the data (Fig. 2).

Table 1. Dry matter yield at critical Colwell P for five pasture species that established with reasonable seedling densities and grew well in the field experiment.

Species	Use	Yield at critical P (kg/ha)	Crititcal Colwell P (mg/kg)
O. sativus	Pasture	5029	16
T. purpureum	Forage	5215	19
T. incarnatum	Forage	7584	23
O. compressus	Pasture	3805	23
T. subterranean	pasture	5528	30
LSD 5%		1062	6

Among the 'pasture types' *Ornithopus sativus* and *Trifolium subterraneum* had equivalent high dry matter yields with *O. sativus* having a significantly lower critical P requirement.

The critical P requirement of *O. compressus* was also lower than that of *T. subterraneum*, but its yield was significantly lower than that of both *O. sativus* and *T. subterraneum*.

Both of the 'forage types' had lower critical P requirements and equivalent (*T. purpureum*) or higher (*T. incarnatum*) yields than *T. subterraneum*.

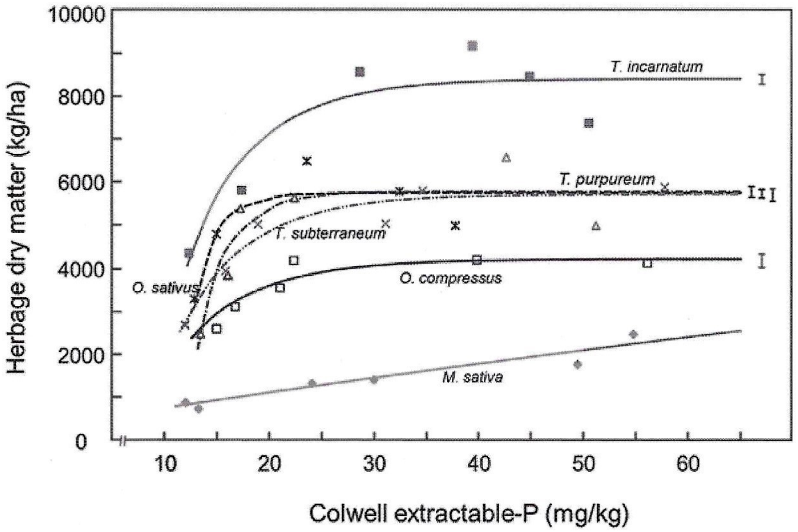

Figure 2: Peak spring dry matter yield (y axis) of pasture legumes in 2013 at the Bookham site, compared with Colwell P (x axis) soil tests (mg/kg). Fitted Mitscherlich equations explain 90% of the variance. Error bars are two times the standard error for asymptote. The legumes included: 'forage types' *T. incarnatum* (crimson clover) and *T. purpureum* (purple clover), and 'pasture types' *T. subterraneum* (subterranean clover), *O. sativus* (French serradella), *O. compressus* (yellow serradella) and *Medicago sativa* (Lucerne/Alfalfa).

Conclusions

The experiment demonstrated that there are at least some alternative pasture legumes that can yield as well as *T. subterraneum* at substantially lower soil extractable-P concentrations. The critical soil test P level for *T. subterraneum* (30 mg/kg Colwell P) is presently used as the target for soil fertility management in most pastures. Lower management targets (16–23 mg/kg Colwell P) would be feasible if pastures could be based on some of the alternative legumes.

Of the pasture types tested here, *O. sativus* showed most promise because it yielded as well as *T. subterraneum*. The forage types were also of interest, but they are not persistent and are, therefore, not used widely in southern Australia, because of the high costs of re-sowing pastures.

At this site, *O. compressus* did not yield as well as *T. subterraeum*, but there are soils and climatic conditions in southern Australia where this species yields as well or better than *T. subterraneum*. Knowledge of the lower critical P requirement of *O. compressus* may lead to better soil fertility management recommendations in areas where it is used. Fertilised grazing experiments are now planned to verify the productivity and fertiliser efficiencies associated with pastures based on alternative legumes.

Acknowledgements

This research is funded by Meat & Livestock Australia, Australian Wool Innovation Ltd, and the collaborating research organisations.

References

Colwell JD (1963) The estimation of the phosphorus fertiliser requirements of wheat in southern New South Wales by soil analysis. *Australian Journal of Experimental Agriculture and Animal Husbandry* 3, 190–198.

Nichols PGH, Revell CK, Humphries AW, Howie JH, Hall EJ, Sandral GA, Ghamkhar K Harris CA (2012) Temperate pasture legumes in Australia – their history, current use, and future prospects. *Crop and Pasture Science* **63**, 691–725.

Simpson RJ, Richardson AE, Nichols SN, Crush JR (2014) Pasture plants and soil fertility management to improve the efficiency of phosphorus fertiliser use in temperate grassland systems. *Crop and Pasture Science* **65**, 556–575.