Phosphorus: the current global situation, P-efficiency in Australian agriculture, and the threats and opportunities that this may pose for grazing businesses.

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Phosphorus (P) fertiliser is a significant input cost for farming systems in southern Australia because of the low P status of most soils. In a majority of grazing businesses, P is used to ensure high production per hectare because this allows the business to reduce overhead costs per DSE and improve profitability and return on investment. However, even in farms run intentionally with low inputs, it is wise to at least replace P removals to protect the sustainability of production. Presently, P-fertiliser inputs account for about 10% of all expenses (including wages), and amounts to about 21-26% of enterprise costs on "average" grazing farms (Holmes and Sackett 2010).

The cost of P-fertiliser has been very volatile in recent years (e.g. 2007-08), but P has remained a profitable investment for grazing businesses. However, increases in P-fertiliser cost directly reduce profitability, and significantly increase the business risk associated with fertiliser investments. This can substantially reduce the attractiveness of applying fertiliser.

In 2009, it was forecast that "peak P" could occur within 25-30 years (Cordell et al. 2009). This is the point at which global supply cannot keep up with demand for P and the cost of P-fertilisers would escalate dramatically. This grim analysis prompted the International Fertiliser Development Center to re-assess the size of global P "reserves" and "resources" and it is now thought that world P reserves are probably 4-fold larger than estimated previously (Van Kauwenbergh 2010). If correct, this means that the risk of peak P in the foreseeable future is low. However, the debate about the sustainability of P-resources is unlikely to dissipate because global food security is dependent on fertiliser use, high-quality rock P reserves are a finite resource, and the data underpinning estimates of the longevity of the reserves are of variable reliability. What is certain is: (i) the price if P fertiliser has doubled over the last 10 years and (ii) that as the world moves to mine new P-reserves, which are of lower quality or harder to extract, the cost of P fertiliser will continue to increase.

Presently, Australia sources about half of its annual P requirements domestically and half from overseas. The majority is used in agriculture with a P-balance efficiency of only 25% (i.e. 4 units of P are applied as fertiliser to produce only 1 unit of P in products). About 90% of the P in agricultural products is exported, the rest is consumed domestically. In some countries, global P-shortages would result in increased emphasis on recovery and recycling of P from waste streams and for some countries, this would go close to covering P needs. However, in Australia the amount of P available for recycling will cover only 5-10% of the annual P requirements of agriculture. While there is no doubt that there will be an increasing role for P-fertilisers derived from waste streams, the major avenue for addressing increases in P-fertiliser costs in Australia will be through improved P-use efficiency in agriculture. Significant opportunities exist to improve profitability and sustainability of production and to improve the environmental credentials of farming, if the P-efficiency of agriculture can be improved.

Threats: Estimates of the farmgate P-balance of the major southern Australian broadacre farm enterprises vary from extremely poor (5-15%, some horticultural enterprises), through poor (20-40% for grazing industries), to average (45-60% in cropping enterprises) (McLaughlin et al. 1992). Only very low-input, low-production systems or enterprises on very low P-sorbing soils (such as sands) approach 100% efficiency. In each case they do so at a cost (e.g. low productivity, or nutrient-leaky and environmentally problematic). The P-balance of extensive northern Australian grazing systems are usually slightly negative (i.e. they extract P at a very slow rate). Rising P-costs present substantial potential threats to management of southern Australian grazing systems through the impact on profitability and business risks and will also make attempts to balance P-use in northern grazing systems even more difficult.

In addition, a number of commentators believe that human diets need to change to rationalise P use globally. Simple calculations of the P costs of meat-based diets indicate that meat production can require ~2-3 times as much P as a vegetarian diet and it is suggested that the consumption of meat should, therefore, be reduced. Unfortunately, these calls ignore many aspects of meat production in Australia that would mitigate the P-costs of production. Nevertheless, they highlight the fact that in a P-constrained world the image of meat as a sustainable product would come under scrutiny. Because the scrutiny would not be confined to meat production, grazing industries as a whole could potentially face the dual threats of high prices for an input essential to productivity, and loss of market share.

Opportunities: The large inefficiency associated with P use in agriculture and the grazing industries in particular, also represents a substantial opportunity to reduce costs by promoting a targeted approach to soil fertility management and by researching and developing P-efficient farming systems. There is relatively little data about the nature and lability of the P that is accumulating in Australia's agricultural soils and consequently it is very difficult to estimate the magnitude of savings that can realistically be made by moving agriculture towards improved P-efficiency. However, examples of farming systems managed to maintain plant-available soil P at sensible levels, have inputs in the range 9-12 kg P/ha/year and accumulate between 4-8 kg P/ha annually depending on enterprise and soil type.

Recent research indicates that P-efficiencies may be obtained if farming systems can be operated at lower plant-available soil P concentrations than are presently necessary. This would slow the rate of P accumulation in sparingly-available P compounds in soil (a process sometimes called P "fixation") (Simpson et al. 2010). Low-P grazing systems will require pasture legumes with root systems that can explore soil more effectively, as this lowers the concentration of P in soil that is needed for maximum plant growth rates. From this research, it appears feasible that fertiliser inputs could be reduced by 25%-30%, in the first instance. It is possible that further savings in P-fertiliser may be made if novel plants are also developed with traits that also enable solubilisation or extraction of P already accumulated in soil (e.g. plants that secrete organic acid secretion from their roots can solubilise P in soil and phosphatase enzyme release can sometimes improve access to organic P). There are naturally-occurring examples of plants that can extract P from soils in this way but, presently, there are few examples of agricultural species with these desirable P-extraction traits.

There is some evidence to suggest that some farm businesses are not following "best practice" fertiliser recommendations and are operating at soil fertility levels in excess of the level necessary for maximum production. On these farms, immediate savings of a similar magnitude can also be achieved simply by correctly using soil testing and managing soil P fertility in a targeted way that is informed by critical P values that are suited to the farming system and soil type.

Achieving substantial improvements in the P-balance of Australian agriculture will not be an easy task despite the clear imperative and obvious production and environmental benefits that could be realised. P is such a universally important input in Australia that changes would already have been implemented were there easy solutions available. Despite this, there are some very obvious immediate goals that will deliver benefits with relatively little effort and there are a variety of potential options for improving the efficiency with which P fertilisers are used, for developing lower-P farming systems, and for reducing the rate at which P is accumulated in agricultural soils. The latter options, however, will take a committed RD&E investment.

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