On-farm research

Soil phosphorus fertility for broadacre organic cropping systems

By JEFFREY EVANS

Phosphorus (P) is an essential component of plant and animal tissue, hence harvesting of plant and animal products for agricultural production depletes the soil of its P reserve. Australian soils are inherently deficient in P, and it has therefore been necessary to replenish or improve soil P reserves to optimise and sustain agricultural productivity.

Establishing whether a soil is deficient in P for optimal crop and pasture production has been defined by calibration of various soil P tests with known plant responses to P fertilisers. In this manner 'critical soil P levels' have been developed for different P tests, plant species and soil types. Although these are approximations, they nonetheless provide reasonable benchmarks as to whether soils require improving in P fertility. This article refers to the Olsen P test and a benchmark 'critical' Olsen P level of 15ppm P (ie., mgP/kg soil) for cereals and pastures in central and south-west NSW.

In a small survey of organic or biodynamic properties in south-west NSW the author has found Olsen P levels frequently less than 6ppm P. This is perhaps a warning for organic and biodynamic farmers to regularly monitor levels and trends in their plant available soil P. As P is an essential plant nutrient, worsening soil P levels below the benchmarks will eventually lead to the collapse of sustainable, productive, cropping systems.

Managing to correct P deficiency on a broad-acre organic farm is the next question. Soil addition with reactive rock phosphate (RPR) is probably the only practical strategy for the broad-acre organic farmer. However, in a national project on the role of RPR in Australian agriculture it was generally concluded to be ineffective, except in areas of acidic soils in environments with at least 700-800mm of rainfall; ie. atypical of the southern Australian cropping zone. Should farmers in the southern cropping zone therefore expect to abandon organic cereal production systems? Perhaps not.

Rock phosphate is only slowly soluble but solvation is essential to release the phosphate that is necessary to increase soil P fertility. The more reactive the rock phosphate (% P soluble in citric acid) the greater its potential for solvation. Solvation should be enhanced when a greater surface area of the RPR is exposed to soil: so granulating RPR and not incorporating RPR with soil work against this. Solvation is ultimately highly dependent on reaction of the RPR with H^+ ions (acidity), hence soil acidity is important for effective use of RPR. To illustrate this, consider Figure 1, for which the pH values are those measured in $CaCl_2$ solution. In the strongly acidic soil (pH 4.4, $CaCl_2$) maintained at a high moisture level (the moisture level immediately following drainage of free-water by gravity, ie., so called field capacity moisture content (FC)), incorporation of RPR with soil resulted in a substantial increase in plant available P (Olsen P). For the soil of less acidity (pH 5.3, $CaCl_2$), the increase was less.

Under field conditions, however, soil is only briefly sustained at high moisture content. When soil moisture is less than FC, the effectiveness of RPR is reduced, as can be seen in Figure 2. Therefore, under field conditions in the southern cropping zone (< 600mm rainfall), the use of RPR alone may have only a minimal effect on Olsen P, as can be seen in Figure 3 when the nil soil treatment is compared with RPR soil treatment. (Note: these results refer to RPR of only moderate reactivity: 1.2% citric acid soluble P.) Nevertheless, the data in Figure 2 suggest that farming practices that maintain soil moisture should help solvation of RPR: however, research is required on this issue.

Solvation of RPR, though, may be increased by its co-treatment with elemental sulphur (S), ie., the yellow powder form of S. Some soil micro-organisms use this element. This natural process generates acidity, which can be used to enhance phosphate release from RPR. Figure 3 shows the 'added' effect of co-treatment of RPR with S on Olsen P, at the strongly acidic and less acidic sites referred to in Figure 1. These results were achieved with both the RPR and S in ground form to increase reaction, with a one-off application in 2001, and following incorporation with soil. Agronomically significant increases in Olsen P have been sustained for at least three years following soil treatment.

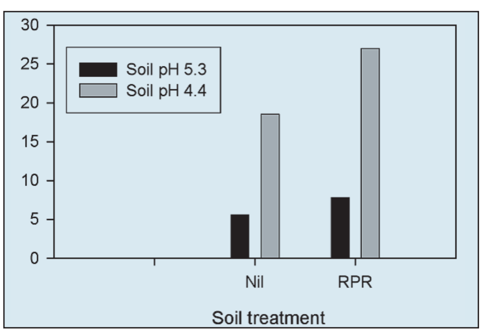

Figure 1: influence of ground-reactive phosphate rock (RPR) and soil pH on increase of plant-available soil phosphate (Olsen P) at sustained high soil moisture.

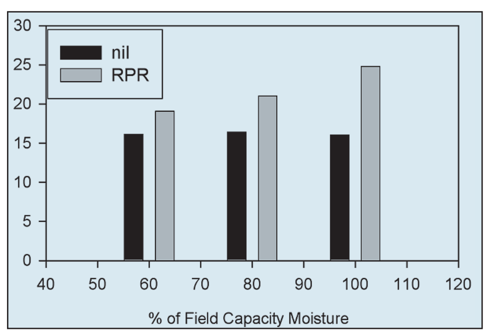

Figure 2: influence of soil moisture level (% of field capacity) on the effect of ground-reactive rock phosphaic (RPR) on plant-available soil phosphate (Olsen P).

The rates used in these field experiments were high for experimental reasons, especially the sulphur rate. These are not general recommendations, for example, recent experiments have shown that the sulphur rate may be optimal at a ratio of RPR : S of 2:1). Although high rates may be needed to rapidly recover soils already strongly depleted in available P, ie., Olsen P well below critical levels, management for incremental recovery of plant available soil P may be a more economically optimal solution, but more research is required on this aspect. Where only maintenance of plant available soil phosphate is required, substantially lower rates will presumably apply.

CONCLUSION

Although more research is required, co-treatment of reactive phosphate rock with elemental sulphur, both in ground form, pre-mixed and incorporated with soil, may offer a strategy for effective use of phosphate rock under the relatively dry conditions of the southern cropping zone. Farming practices that help preserve soil moisture should be useful, and avoiding liming soil during recovery of soil P fertility would also be judicious. Agricultural production usually leads to soil acidification so farmers could select the more acidic paddocks for treatment with rock phosphate – sulphur mixes.

During this 'acidic' phase of a rotation, when phosphate would be released from the rock phosphate into soil solution and into organic P (via plant uptake), acid tolerant crop and pasture species could be used to maintain productivity. The soil may be subsequently limed to promote mineralisation of the organic P.

To avoid the need for large fertiliser rates, organic farmers should be watchful of their soil P fertility and consider using rock phosphate – sulphur mixes as a strategy for maintenance of soil P fertility.

Studies are continuing.

WARNING

In the dry state, ground sulphur is potentially explosive. However, this hazard can be eliminated provided that the amount of sulphur relative to rock phosphate is controlled. The proposed RPR-S product should therefore be developed at the industry level.

Recent developments in applying fertiliser in a moist or 'sludge' form, will allow safe application of RPR-S even at high S rates. ■

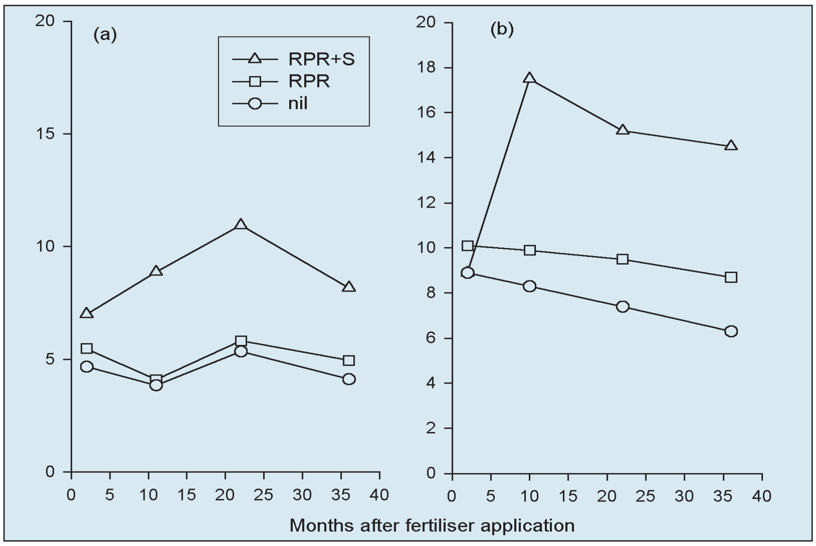

Figure 3: influence of a one-off soil application of ground-reactive rock phosphate (RPR: 500kg/ha) without and with elemental sulphur (S: 500kg/ha) on plant-available soil phosphate (Olsen P) at (a) a mildly acidic site (pH = 5.3, $CaCl_2$) and (b) a strongly acidic site (pH = 4.4, $CaCl_2$) under field conditions.

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Green Grove a magnet for researchers

Alan Druce, of Green Grove, Kamarah, NSW, has attracted much attention from researchers, students, lecturers, consumers and all those interested in organic farming. This is mainly due to the extensive scientific research conducted on the farm and interest generated by a profile on ABC TV's *Landline* last winter.

Research includes work by DPI scientist Jeffrey Evans to establish a strategy for replenishing phosphorus through co-treatment of reactive phosphate rock with sulphur.

More than $1,000,000 in research was conducted on the property by David Dumaresq of ANU comparing organic and conventional practices and their effectiveness.

CSIRO scientist Steven Wakelin has also found the farm to be invaluable for soil samples, assisting him in his research on the effects of the Penicillium fungi, of which some strains may be of immense value as plant growth promoting agents.

Alan comments: "Research has recently discovered that there is a whole range of mineral and trace element deficiencies in soil. The soil life manufactures nutrients from sterile dirt and feeds it into the plant roots. Conventional farming, through the use of poisons, inhibits soil ecology. As certain minerals and microbes die, this in turn makes others suffer and nutrient delivery is seriously compromised.

"Organic farming relies on soil ecology for soil and plant health. In the long run it provides the benefits of higher and better quality production. For a conventional farmer planning to go organic, economics of course are very important to consider. There are three years of transition required to become fully certified organic. During this time production is generally less as soil ecology takes time to rebuild. However, if you can survive through the transition period the hard work will pay off with higher returns than a conventional farm."

More on the results of the research and a profile of Green Grove is to come in the next edition of *AOJ*.