Determination of the Critical Soil and Plant Phosphorus levels for Cotton

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Introduction

In cotton, phosphorus (P) is important for early seedling vigour, plant establishment and root development. Deficient plants are usually stunted, dark green in appearance and exhibit a delay in flowering, boll set and maturity (Hodges, 1992). The main role of P in plant metabolism is to allow energy transfer to occur (Mengel and Kirkby, 1987).

Research by Macleod *et al.* (1997) has shown that P may also be involved in the onset of premature senescence. When cotton plants are subjected to environmental stresses such as waterlogging late in the season, the rates of translocation of P and K from leaves and other organs to the filling bolls, is greater than the rate of uptake from the soil solution, which in turn leads to a reduction in the efficiency of these supply organs and causes the plants to senescence prematurely.

With the removal of up to 30 kg of P/ha in the cotton seed (Rochester, paper in this proceedings), the introduction of higher yielding varieties, and the optimisation of inputs such as nitrogen and water, the use of phosphatic fertilisers as another means by which soil fertility can be maintained and yield potential met, is becoming popular. Responses to applied P, however, have been variable and little is known of the fate of applied phosphorus, since the high clay content and alkaline nature of Australian cotton soils (Typically Vertisols with pH 8.0- 8.5), tends to favour the formation of calcium phosphates of low solubility, whilst the form of phosphorus in the soil solution (HPO_4^{2-}), at this pH (Mengel an Kirkby, 1987), is less readily taken up by plants (Blair *et al*, 1970).

In addition, soil and plant tissue tests have been available to the industry for many years, but inconsistency exists regarding the levels of P in the soil and plant, below which yield reduction is likely.

Objectives

The main objectives of this project are to:

1. Determine the critical soil and plant P levels, by relating soil P levels to rates of plant nutrient uptake and lint yield.

2. Calibrate or modify existing soil tests, to make them more accurate predictors of the likelihood of cotton response to applied P.

3. Explain the variability in plant responses to applied phosphorus.

4. Demonstrate how an understanding of soil P processes may help growers in making decisions on fertiliser management to overcome reduced seedling vigour or late season crop stress, through providing technical input to the nutriLOGIC/NUTRIpak decision support program.

Field Experiments

The 1997/98 growing season was the first year of research and involved the establishment of 8 field experiments on commercial farms in the Gwydir, Namoi and Macquarie Valleys, on soils of low to medium P status (6 to 33 mg/kg Colwell (Bicarbonate) Extractable P). Typically, these experiments were rate response trials with rates of 0,10,20,40 kg P/ha banded pre-plant as MAP (10:22:0) or Starter Z (9:21:0 + 2.5% Zn).

In addition to these field trials, an experiment was established in Field B4 at ACRI Narrabri, to determine the optimum timing and method of application of P in cotton. This involved applying phosphorus pre-plant and at planting as well as looking at the potential for using seed P coating, phosphoric acid and foliar sprays as alternative means by which phosphorus may be supplied to cotton.

Laboratory Procedures

Soil samples were taken pre-plant across all sites and post picking from selected sites. Analyses were performed by Incitec Brisbane, on the pre-plant soil samples for Colwell, Bray-1 and Lactate available P, as well as for other chemical and physical properties. Plant samples were taken early, mid and late season, to gauge the rates of nutrient uptake and

relate them to lint yield and nutrient removal. Lint yield was measured by hand and machine picks. In the Field B4 experiment, maturity picks were also performed to determine if any of the treatments affected the earliness of the crop. The plant samples were ground, ginned and delinted in preparation for complete nutrient analyses.

Results

Preliminary analyses have been performed on the yield data with no significant differences between treatments at any site. Nutrient analyses have been performed on the early season plant samples from all sites with no obvious trends evident. In Field B4 at ACRI, Narrabri, pre-plant application of P alone, as well as supplemental P in mid-January and foliar application in February, did however, improve crop earliness.

This highlights the problem of variability in response to P application, since applications of up to 40 kg of phosphorus per hectare did not increase lint yield nor early season P uptake, even on soils with a Colwell P as low as 6 mg/kg. Similarly, the trials on which Starter Z was applied, did not respond to zinc applications of up to 3 kg per hectare.

The lack of observed response could be attributed, in part, to the ideal early and late growth conditions experienced in most areas, which differed from seasons where cool, wet starts, or early finishes, would be more likely to show a response to P application on soils with low P levels . Conversely, it could be said that the ideal growth conditions experienced, might increase plant nutrient demand and exacerbate any soil nutritional deficiencies. This was not observed, even though lint yields from the control plots were moderate, ranging from 7.8-9.2 bales/ha (3.2-3.7 bales/ac), indicating that the rates of mineralisation of organic phosphorus in the soil were sufficient to meet plant demand.

Differences between sites were observed, but it was difficult to ascertain the nature of the relationship between Soil P, early season P, K and Zn uptake in the tops, and lint yield. Lint yield tended to decline where the Bray and Colwell P soil tests fell below 5 and 10 mg/kg of extractable P, respectively. The lactate soil test was more difficult to interpret. However, in order for a more reliable assessment of the critical soil test values, more observations need to be made, especially at sites with very low levels of soil P (less than 5ppm bicarbonate extractable P). Closer examination of the standard tests used to determine soil available P, is also needed, since these results highlight the inconsistencies which exist between them.

As with the soil test values, we are unable to suggest improvements for the critical plant P levels for cotton because of the lack of consistent relationships observed between plant P uptake, soil P and lint yield. However, the data in Fig. 1 suggest that early season crop P uptake was limited where available soil P was low. In addition, higher lint yields were positively associated with early season P uptake by the crop, as is demonstrated in Fig. 2.

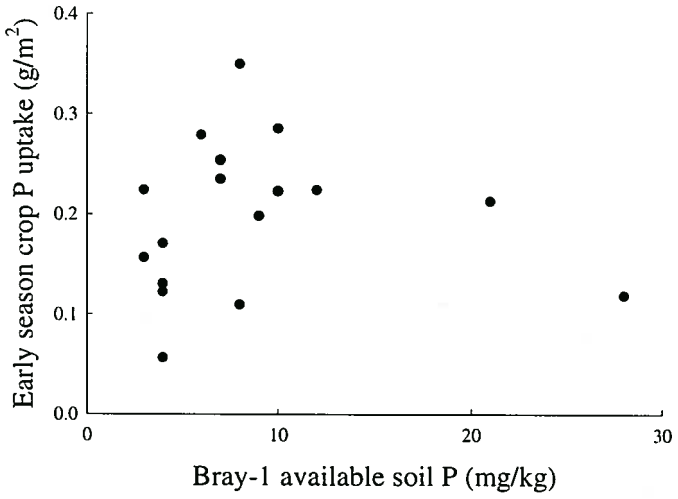

Fig. 1. Early season crop P uptake tended to be limited where available soil P was low.

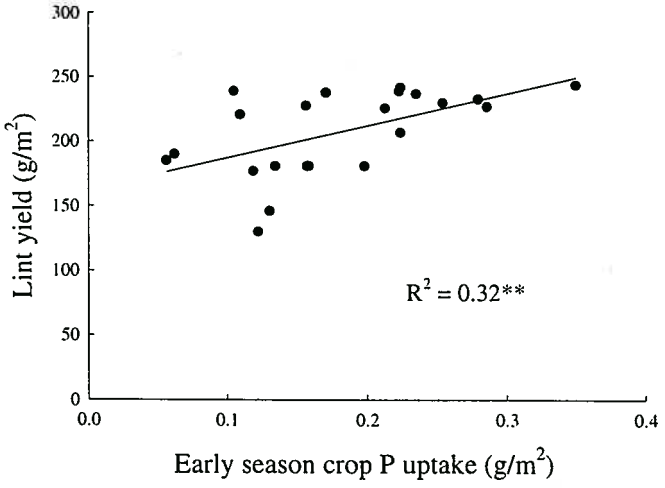

Fig. 2. Higher lint yields were associated with greater early season crop P uptake.

Future Research

During the 1998/99 and 1999/2000 cotton growing seasons, further field experiments will be conducted to determine the critical soil and plant P levels. This will involve establishing field trials on a range of sites with low to high soil P levels, so that the nature of the

relationship between soil P, plant P and lint yield can be more accurately predicted. In addition, experiments at UNE during the off season will be conducted to more closely examine the soil tests currently used, so that a more reliable predictor of P response in cotton can be established. This will be achieved by examining the effects of soil properties such as pH and buffering capacity on soil nutrient availability, and possible mechanisms by which cotton is able to extract adequate P supplies from the soil, even though it may appear to be limiting.

Acknowledgments

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