Improving phosphorus (P) fertiliser decisions for cotton

Chris Dorahy[1], Ian Rochester[2] and Graeme Blair[1]
Australian Cotton Cooperative Research Centre
[1]Division of Agronomy and Soil Science, The University of New England, Armidale.
[2]CSIRO Plant Industry, ACRI, Narrabri.

Keywords: phosphorus, soil testing, fertiliser efficiency, critical limits, P deficiency symptoms.

Introduction

Phosphorus (P) fertiliser usage in the cotton industry has increased six-fold in the period between 1981 and 2000. This has been the result of growers being concerned with maintaining soil P fertility levels so that long-term cotton production is sustainable. However, response to P has been variable which has raised the following questions:

- What are the symptoms of P deficiency?
- When is soil P limiting to cotton growth?
- Are current P fertilisation practices efficient? and
- What are the economics of P fertilisation?

These issues have been investigated over the past three years as part of a project that was initiated by the Australian Cotton Cooperative Research Centre. The objective of this paper is to present some of these findings so that interpretation of soil tests and confidence in making P fertiliser decisions can be improved.

P deficiency symptoms

The 1998/99 and 1999/2000 cotton growing seasons were characterised by cool, wet, early season conditions, which caused some crops to exhibit symptoms of P deficiency. This included poor early season crop vigour and plant stand development, which limited early season root development and the crops ability to access larger P pools within the soil. Later in the season, the leaves of these P deficient plants became dark green on the margins and exhibited purple, interveinal, discolouration. These symptoms can result in yield reduction due to a reduction in the number and size of bolls produced, particularly on the lower fruiting branches.

The P requirements of cotton

Depending on crop yield, P uptake by cotton varies between 20-30 kg P per hectare. Typically, 80% of this is removed from the field in the seed and so application of 22 kg P per hectare (100 kg MAP/ha) is generally required to replace the P removed in the crop (Table 1). Higher application rates are needed to increase soil P fertility levels over time.

Table 1. Phosphorus removed in the seed in comparison to cotton lint yield from various sites throughout the Macquarie, Namoi, Gwydir and MacIntyre Valleys between 1997-1999. At the low P sites Colwell P concentrations ranged from <5-25 mg/kg. At ACRI, Narrabri available soil P is high (Colwell P 50-70 mg/kg).

Lint Yield	P Removal (kg/ha)	
(bales/ha)	Various low P Sites	ACRI, Narrabri[a]
6	12	15
7	14	17
8	16	20
9	17	23
10	20	26

([a] Rochester and Peoples, (1998)).

Cotton response to P and soil P test interpretation

In order to determine cotton response to P fertiliser application, 17 response experiments were established throughout the Macquarie, Namoi, Gwydir and MacIntyre Valleys during the 1997/98-1999/2000 cotton growing seasons. Of these, only three demonstrated a significant ($p< 0.05$) lint yield response to P fertiliser, which indicates that cotton was able to meet its P requirements from the soil, despite low extractable soil P levels.

The results from these trials have been useful to draw relationships between soil P and relative lint yield (-P Lint Yield / +P Lint Yield x 100) for different soil P tests (0-30 cm). Of the tests which are most commonly used by the cotton industry, the Colwell test has been found to be better correlated with Relative Lint Yield, than the Lactate test (Figures 1 and 2).

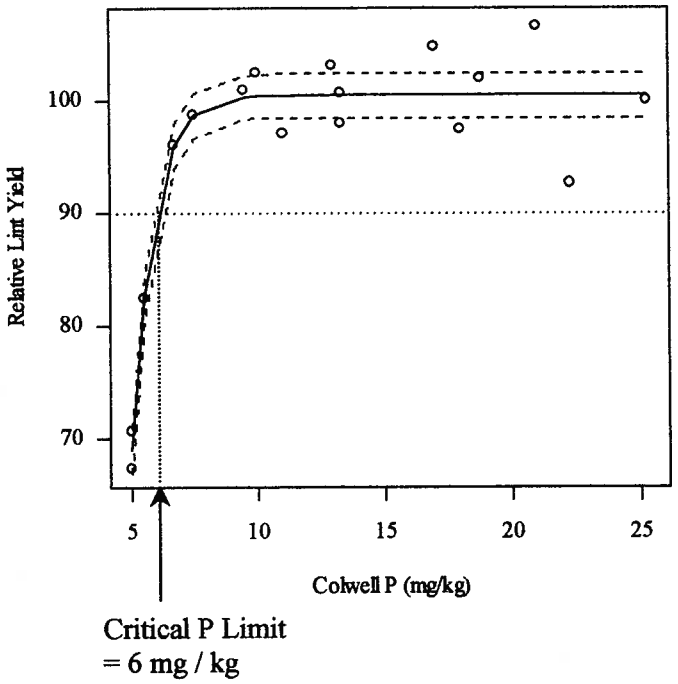
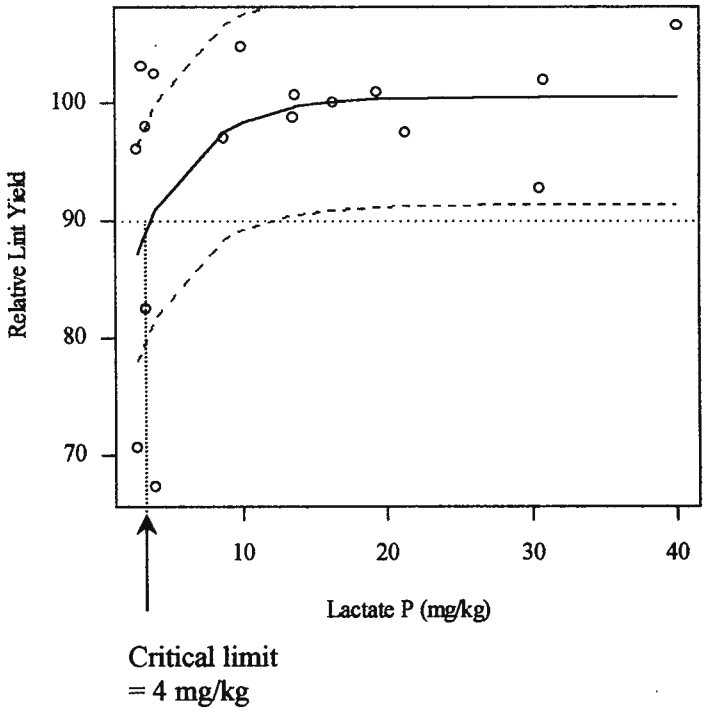


Figure 1. The relationship between Relative Lint Yield and Colwell Available Soil P (The curved dashed lines represent the 95 % confidence limits for the regression equation).

The critical soil P limits for each test are determined by calculating the level of phosphorus that corresponds to 90 % of maximum Relative Lint Yield. Below this level, crop response to P fertiliser is likely. For the Colwell test, it is suggested that the critical P limit is < 6 mg/kg (0-30cm).

Figure 2. The relationship between Relative Lint Yield and Lactate Available Soil P. The wider range of confidence limits indicate that this test is less suitable for determining when soil P is limiting to cotton lint yield.



Timing and method of P fertiliser application

When P fertiliser is added to the soil, up to 50 % is quickly rendered unavailable to the plants since it is precipitated as insoluble inorganic soil phosphorus (Figure 3). However, after this time equilibrium appears to be established in the soil solution which means that sufficient amounts remain available for subsequent crop uptake. Application of 20-40 kg P per hectare, one to two months prior to planting should ensure this.

Banding the P fertiliser reduces the amount of contact between the soil and fertiliser and provides a concentrated zone of P which plant roots grow towards and feed from. Early season, this is an important source of P for the developing plants. However, this will only provide a significant lint yield benefit if soil P is limiting in the bulk soil.

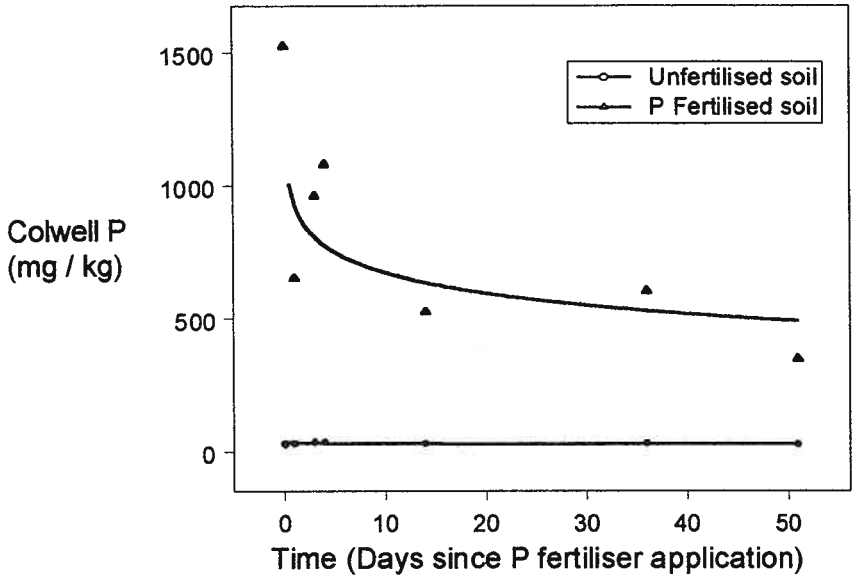


Figure 3. Comparison of P availability with time in P fertilised and unfertilised alkaline cotton soil at ACRI, Narrabri during the 1998/99 cotton-growing season.

Economics of Applying P

Table 2. Net profit / loss from applying P fertiliser to the fields used in the P response trials. These figures are based on applying bulk MAP at 100 kg / ha at a cost of $430 / tonne including freight. Income is based on receiving $ 450 / bale.

	Colwell P	Lint Yield (bales/ha)			Gross Profit	Cost	Net Profit
Field	(mg/kg)	Control Plot	P fertilised Plot	Increase	$/ha	$/ha	$/ha
1	5	6.1	8.6	2.5	1128	43	1085
2	5	3.8	5.7	1.9	837	43	793
3	6	8.6	10.4	1.8	821	43	778
4	7	8.3	8.6	0.3	155	43	111
5	22	3.2	3.5	0.3	115	43	72
6	18	8.8	9.0	0.2	105	43	62
7	13	10.3	10.5	0.2	93	43	50
8	11	6.0	6.2	0.2	81	43	38
9	8	5.6	5.7	0.1	32	43	-11
10	25	9.2	9.2	0.0	0	43	-43
11	13	8.6	8.5	-0.1	-24	43	-67
12	10	8.6	8.5	-0.1	-34	43	-77
13	19	8.9	8.7	-0.2	-79	43	-122
14	13	7.8	7.6	-0.2	-81	43	-124
15	13	8.1	7.9	-0.2	-109	43	-152
16	17	6.7	6.4	-0.3	-135	43	-178
17	22	11.2	10.5	-0.7	-313	43	-356

As can be seen from Table 2, there are substantial financial benefits from applying P fertiliser when Colwell P levels are lower than 6 mg / kg. However, above these levels the economic benefit is variable. In order for growers to be certain they are receiving benefit from applying P fertilisers, it is suggested that 2-3 nil strips be left in the field to see if any differences are apparent. This is particularly true where soil tests indicate that available P is approaching the critical limit *i.e.* within the range of 6-10 mg / kg Colwell P.

Conclusion

Despite low extractable soil P levels, cotton was able to meet its P requirements on the majority of soils studied. It can be suggested that the Colwell (bicarbonate) test gives the best indication of when soil P is limiting to cotton growth on alkaline soils. Below Colwell P levels of 6 mg / kg, significant economic benefits from P fertilisation are likely.

If P fertiliser is required, it should be banded at a rate of 20-40 kg P per hectare 0 - 2 months prior to planting. Although up to 50 % of the P which is applied is likely to be rendered unavailable to the plants, sufficient amounts should remain available in the soil to increase early season P uptake.

Acknowledgements

The Australian Cotton Cooperative Research Centre is gratefully acknowledged for providing funding for this project. Thanks are also extended to the many growers and consultants whose cooperation have made this research possible; Chris Dowling, Incitec, for his assistance with soil analyses; Bob Murison for assistance with statistical analyses; and Judi Kenny, Leanne Lisle and Greg Roberts for their technical assistance.

Reference

I. Rochester and M. Peoples (1998). Optimising cotton nutrition. *Proceedings of the 9th Australian Cotton Conference*. August 12th -14th, Broadbeach, Qld. pp. 139-144.