2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

COTTON YIELD RESPONSE TO SOURCES, RATES AND PLACEMENT OF P FERTILIZERS IN TROPICAL AUSTRALIA

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Abstract

Locations throughout tropical northern Australia are being evaluated as potential winter cotton production areas. The response of cotton to several different phosphorus fertilizers was recorded over two years in the Ord River Irrigation Area of north-western Australia. In 2000, when the starting soil P levels were low (bicarbonate extract 14mg kg^{-1} in the 0-30cm zone of the soil profile), there was a yield response to both source and placement of P. However in 2001, when starting soil P levels were much greater (32mg kg^{-1} in the 0-30cm zone of the soil profile), yields were higher than those in 2000 and there was no yield response to source or placement of P. It was concluded that source and placement of P fertilizer significantly affected cotton yield under conditions of low starting soil P. Deficiency levels appear to be substantially higher than indicated in the literature from temperate cotton growing areas.

Introduction

Unlike other areas of Australia, cotton in the Ord River Irrigation Area (ORIA) is being evaluated as a winter/'dry season' crop. The ORIA is located in tropical northern Australia (Fig 1) with the dry season occurring from April to November. Soils in the region are inherently low in P. Applications of P fertilizers to other crops over the last 30 years has seen an increase in P concentration in some fields, although levels at depth remain low. This stratification of phosphorus may affect the ability of deep rooted crops, such as cotton, taking up phosphorus. Interactions may also exist between source and placement of phosphate fertilizers and affect the ability of the plant to take up phosphorus. The relative isolation of the ORIA as well as the need to apply high rates of nitrogen and phosphate fertilizers (Yeates *et al*, 1996) has made diammonium phosphate a popular choice with local growers. However, this can lead to problems with seedling emergence if the fertilizer is placed too close to the germinating seed (Yeates, personal observation). The soil type on which cotton is predominantly grown on in the ORIA is classified as a Cununurra clay (Montmorillinitic Typic Haplustert) which is dark gray to dark gray-brown, medium clay content with a pH of approximately 8 (Gunn, 1969). Current estimates for deficient levels of P for cotton in temperate environments range from 5mg kg^{-1} (Rouse, 1968) to 12mg kg^{-1} (Hibberd *et al*, 1990), although this has never been examined for a tropical, dry season production system. The purpose of this research was to investigate the yield response of cotton to various sources, rates and positioning of P fertilizer in the soil and identify at what level phosphorus becomes deficient under a tropical dry season production system.

Materials and Methods

The 2000 experiment was sown on May 15 and consisted of eight fertilizer treatments organized as a randomized complete block. Seeds were sown two rows to a 1.8m bed with 0.9m between rows. Six of these treatments were combinations of three sources of P (diammonium phosphate (DAP), monoammonium phosphate (MAP) and double superphosphate (DS)) and two placement methods ('root placement' - 50% of the fertilizer placed 30cm below the plant line and 50% placed 10cm inside the plant line, 15cm deep; and ‘shallow' - 100% of the fertilizer placed 10cm below the plant line (see Table 1 for treatment descriptions). All six treatments consisted of 50kg ha^{-1} of P and 150kg ha^{-1} of N with the balance of the N fertilizer made up with urea. The remaining treatments were zero nitrogen (i.e. 50kg ha^{-1} P, as double superphosphate) and zero phosphate (i.e. 150kg ha^{-1} N, as urea). Pre-season soil analysis (Colwell bicarbonate extraction (Colwell, 1963)) indicated that there was 14mg kg^{-1} of P in the 0-30cm zone of the soil profile, 3mg kg^{-1} in the 30-60cm zone and 1.5 mg kg^{-1} in the 60-120cm zone. There were no differences in establishment counts between treatments with an average of 8.0 plants m^{-1} of row. The experiment was picked on October 26, with a single row picker.

The 2001 experiment was sown on May 5 and consisted of five treatments arranged as a randomized complete block. Seeds were sown two rows to a 1.8m bed with 0.9m between rows. This experiment included the most commonly used mix DAP (45kg ha^{-1} N and 50kg ha^{-1} P placed 15cm below the plant line), which was compared with MAP (25kg ha^{-1} N and 50kg ha^{-1} P placed 30cm deep, 5cm outside the plant line), 0.6 MAP (16kg ha^{-1} N and 33kg ha^{-1} P placed 30cm deep, 5cm outside the plant line), DAP placed at two depths (200kg ha^{-1} N and 50kg ha^{-1} P 50% placed 30cm below the plant line, 50% placed 15 cm deep, 10cm inside the plant line made up for DAP and the balance of N from urea) and zero phosphorus (55kg ha^{-1} N placed 30cm deep, 5cm outside the plant line). The balance of N applied to all plots was brought up to 200kg ha^{-1} with urea which was sidedressed at the fourth leaf stage (39 days after sowing). Pre-season soil analysis indicated that there was 32mg kg^{-1} of P in the 0-30cm zone of the soil profile and 3mg kg^{-1} in the 30-120cm zone. There were no difference in establishment counts between treatments with an average of 10.6 plants m^{-1} of row. The experiment was picked on November 9, with a single row picker.

Results

In 2000, the 'root placement' method of applying fertilizer resulted in a significantly increased lint yield ($P<0.001$) while treatments using MAP as their source of P yielded more than the other sources of P fertilizer (Fig 2A). However, in 2001 neither the source nor placement of fertilizer affected lint yield (Fig 2B).

Discussion

The yield response to P fertilizer appeared to depend more upon the pre-season level of soil P than on the source or placement of P fertilizer. In 2000, when surface P levels were relatively low, there was a yield response to placement of P fertilizer in the root zone ($P<0.001$). This may be the result of the shallow placement burning young roots. Certainly the effect for MAP was not as strong as it was for DAP. There was also a greater response to MAP over all other sources of P fertilizer. However, in the 2001 season when the average lint yield was almost double that of the 2000 season (1574 *c.f.* 985kg ha^{-1} respectively), there was no significant difference in yield between any of the treatments. This would appear to be the result of the relatively abundant P available to the plant in the top 30cm of the soil profile. Form, rate or position to which the P fertilizer was applied had no bearing on yield. It appears then that the rate, source and placement of P fertilizer only impacts upon yield in cotton when yield is severely P limited. Why a soil phosphorus concentration of 14mg kg^{-1} is yield limiting in this environment is unclear. It may be that there is a high degree of P fixation associated with the Cununurra clays, or some other soil property, even mycorrhizal levels. Further research is required to clarify causes of these differences, as that knowledge would assist with fertilizer programs. Unpublished research suggests that phosphorus levels are deficient for maize grown on Cununurra clay soils at 10-15mg kg^{-1} (Sherrard, unpublished data). Alternatively, it may be that phosphorus requirements are greater when plants are grown in this climate with temperatures exceeding 40^{o}C during vegetative growth compared to summer conditions in temperate environments.

Conclusion

P source, rate and placement affected cotton yield but only when surface soil P levels were 14 mg kg^{-1} and limited yield. When surface soil P was 32 mg kg^{-1} there was no yield response to various sources or placement of P fertilizers. Yield limiting P concentrations for cotton appeared to be higher on these soils than others reported in the literature. This may be due to soil characteristic (e.g. high rate of P fixation), or to the fact that the cotton is grown during the winter/dry season, with very high temperatures during summer and during early vegetative growth.

References

Colwell J.D. (1963). The estimation of the phosphorus requirements of wheat in southern New South Wales by soil analysis. *Aust J Exp Ag and Anim Husb* **3**, 51-61.

Gunn R.H. (1969) Soils of the Kimberley Research Station, Kununurra, Western Australia. CSIRO Australia, Division of Land Research Technical Memos. **69**:21

Hibberd, D.E., Ladewig, J.H., Hunter, M.N. and Blight, G.W. (1990). Response in cotton yields to nitrogen and phosphorus fertilizers in the Emerald irrigation area of central Queensland. *Aust. J. Exp. Ag.* **30**, 661-667.

Rouse, R.D. (1968). Soil test theory and calibration for cotton, corn, soybeans and coastal bermudagrass. *Alabama Agric. Exp. Station Bulletin.* **375,** 1-27.

Yeates S.J., G.A. Constable, G.R. Strickland, and G.P. Fitt 1996. Development of agronomic and varietal options for dry season cotton production in NW Australia. P. 577-584. *In:* Proceedings of the 8^{th} Australian Cotton Conference, Broadbeach Qld. The Australian Cotton Grower's Research Association.

Table 1. Description of various treatments involved in the P fertilizer trials, 2000 and 2001

	2000				2001		
Treatment	Pre-sowing fertilizer	Placement	P (kg ha^{-1})	Treatment	Pre-sowing fertilizer	Placement	P (kg ha^{-1})
1	DAP+urea	Root	50	1	DAP+urea	15cm deep, below plant line	46
2	DAP+urea	Shallow	50	2	MAP+urea	30cm deep, 5cm inside plant line	52
3	MAP+urea	Root	50	3	MAP+urea	30cm deep, 5cm inside plant line	33
4	MAP+urea	Shallow	50	4	DAP+urea	50% 30cm deep; 50% 15cm, 10cm inside plant line	51
5	D.S.+urea	Root	50	5	Urea	30cm deep, 5cm inside plant line	0
6	D.S.+urea	Shallow	50				
7	D.S.	Shallow	50				
8	Urea	Shallow	0				

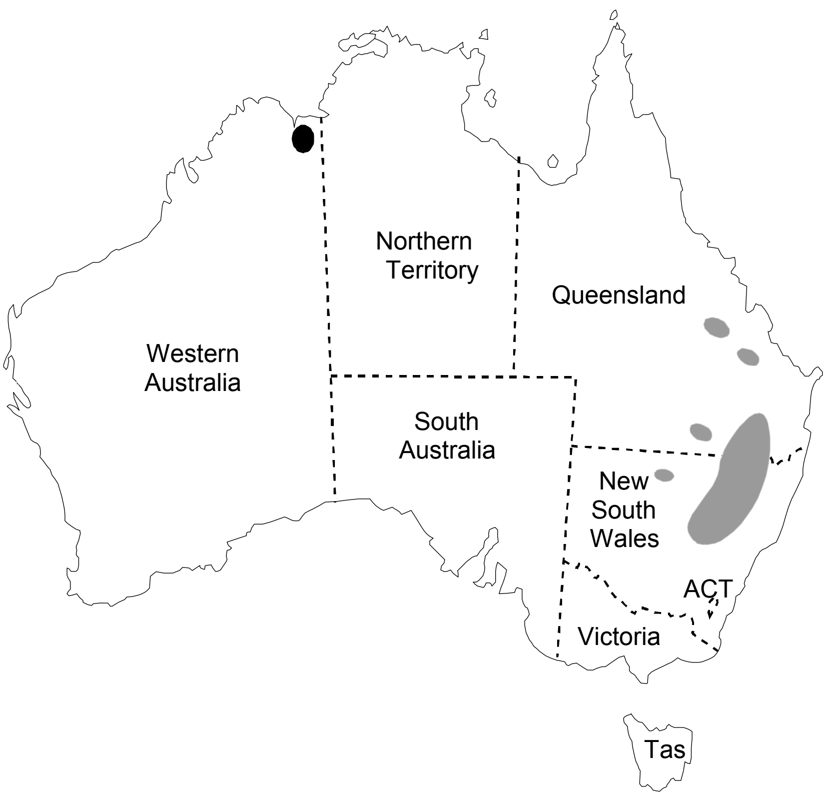

Figure 1. The Ord River Irrigation Area (black) in relation to the traditional cotton growing areas of Australia (gray).

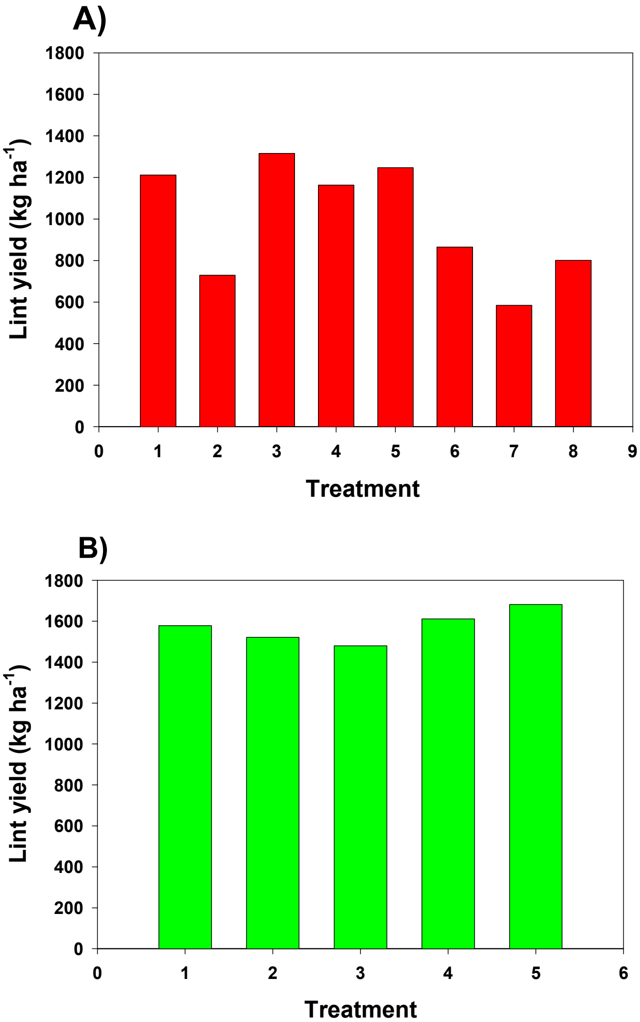

Figure 2. Lint yield (kg ha^{-1}) for the various fertilizer treatments in A) 2000 and B) 2001