

Nutrient uptake by dry season cotton in the Ord River Irrigation Area

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Uptakes of phosphorus, potassium, calcium, magnesium, sulphur, zinc, manganese, iron and copper were measured in an experiment evaluating nutrition of cotton in a newly developed field. Uptake amounts of each nutrient were similar to reported values, although the pattern of uptake varied in some cases, possibly as a result of different temperature patterns experienced by cotton in a dry season winter production system. This data will assist with developing fertiliser programs.

Introduction

Although cotton nutrition has been reviewed and studied extensively little is known about nutrient uptake when it is grown as a dry season crop. Dry season cotton is currently being grown as an experimental crop in the Ord River Irrigation Area (ORIA) as it is a candidate crop to be grown in the proposed further development of Ord Stage II. Given the differences in rates of development between cotton grown in the tropical dry season compared to traditional temperate cotton growing areas nutrient uptake may differ considerably. This study was undertaken to observe the uptake of several macro and micro-nutrients by cotton grown under conditions where nutrients were non-limiting during the dry season.

Materials and methods

Experiments were conducted on cotton grown on soils similar to those in Ord Stage II at the Frank Wise Institute of Tropical Agriculture, Kununurra, WA, Australia in the 2002 and 2003 dry seasons. The soil is predominantly a uniform dark brown medium to heavy clay with swelling and shrinking characteristics. Soil analysis was conducted on the field during the 2001 dry season and analysed by at the Waite

Institute, Adelaide. Results are displayed in Table 1. Prior to sowing in 2002 and 2003, five rates of phosphorus (0, 40, 80, 120 and 160 kg ha⁻¹) were applied as double superphosphate 20 cm deep and 2 cm outside the proposed plant line, although only the 80, 120 and 160 kg ha⁻¹ were sampled for nutrient uptake. Sulphur (51 kg ha⁻¹), zinc (40 kg ha⁻¹) and nitrogen (200 kg ha⁻¹) were balanced across the experiment using ZnSO₄ and urea. In 2003 each plot in the area on which the 2002 experiment had been conducted was further divided into five sub-plots and each randomly allocated one of the five rates of phosphorus fertiliser. However, only plots that received at least 80 kg ha⁻¹ phosphorus fertiliser in 2002 and 40 kg ha⁻¹ phosphorus fertiliser in 2003 were sampled. This area will from here-on be referred to as the 'old area', while the area which was sown to cotton for the first time in 2003 will be known as the 'new area'. The 'new area' had been left fallow during the 2002 dry season. The crops were sown into dry soil on the 28th of April 2002 and on the 28th of March 2003. The cultivar chosen in 2002 was Sicot 289i while in 2003 the cultivar was Sicot 289B. In the 'new' area experiment in 2003 plants displayed a pronounced lack of vigour and 1 kg ha⁻¹ of ZnSO₄ hepta-hydrate was applied as a foliar fertiliser. Shortly after plants appeared to recover somewhat from their deficiency symptoms. Dry weight samples of 1 m² of crop were taken three to four times throughout the season. A sub-sample was then ground to pass a 1 mm screen. These samples were analysed for P, K, Ca, Mg, S, Zn, Mn, Fe and Cu using an Inductively Coupled Plasma Optical Emission Spectrometer (ARL, Switzerland). Nutrient uptake was then determined by multiplying the concentration in the plant by the dry weight at time of sampling. First flower and 'cutout' (i.e. when nodes above white flower = 4) were recorded as occurring at 900 and 1400 growing degree days (GDD) after sowing respectively for 2002 and 2003 'old' season, although it was delayed by approximately 100 GDD for the 2003 'new' experiment, possibly due to the early zinc deficiency. In both years yields were taken using a small plot picker. In 2002 the average yield was 5.3 bales ha⁻¹, for the 2003 'new' experiment the average yield was 3.8 bales ha⁻¹ while for the 'old' area it was 4.1 bales ha⁻¹.

Results and Discussion

Soil tests determined that phosphorus and sulphur were below critical concentrations for growing cotton, based on NUTRIpak recommendations (Table 1).

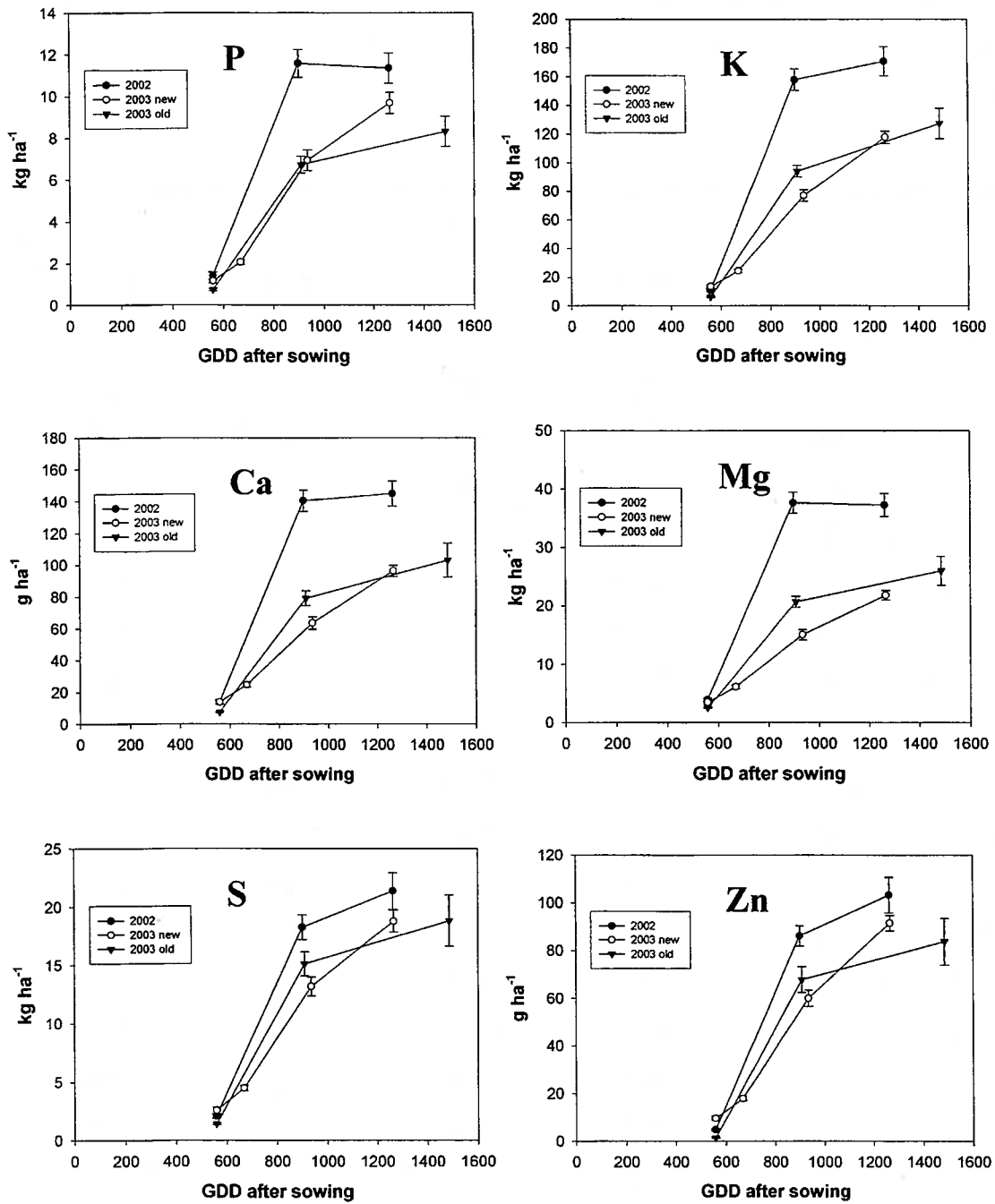
Zinc and manganese were adequate in the top-soil but deficient in the sub-soil. It is anticipated that the levels of fertiliser applied to the soil would overcome these deficiencies. All other nutrients appeared to be at levels that would not induce a nutrient deficiency. Magnesium levels tended to be high throughout the soil profile and while sodium levels increased with depth.

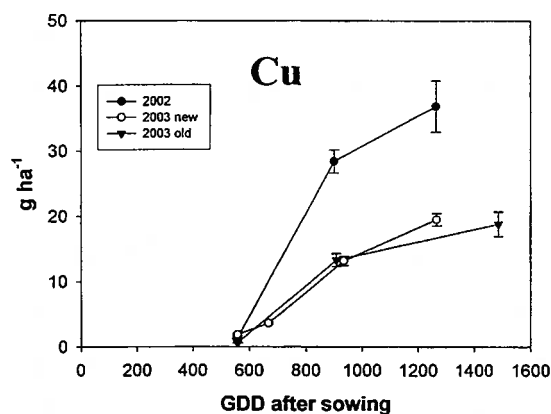
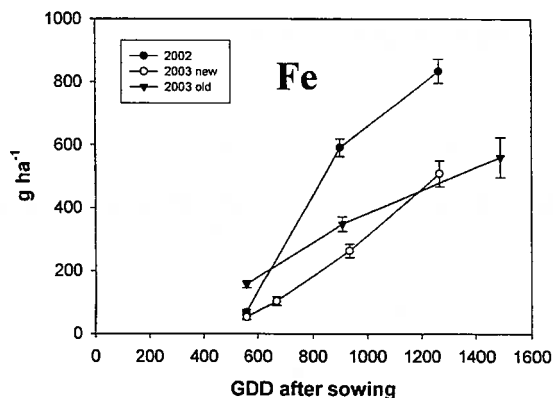
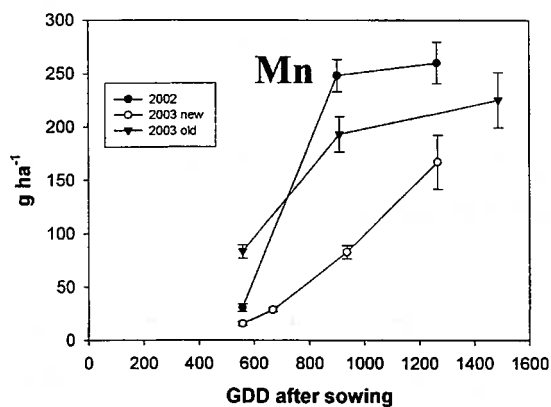
Table 1. Nutrient analysis from soil taken at four depths during the 2001 dry season

	Soil depth (cm)			
	0-15	15-30	30-80	80-130
Avail P (mg kg ⁻¹)	3	3	1	1
Total P (mg kg ⁻¹)	29	32	24	21
Colwell K (mg kg ⁻¹)	295	239	225	247
Sulphate (mg kg ⁻¹)	4	3	3	4
Ext Ca (meq 100g ⁻¹)	22.5	23.5	21.2	19.8
Ext Mg (meq 100g ⁻¹)	14.0	14.6	15.2	15.9
Ext Na (meq 100g ⁻¹)	0.22	0.53	1.92	3.66
Ext K (meq 100g ⁻¹)	0.74	0.61	0.57	0.62
Boron Hot (mg kg ⁻¹)	0.40	0.39	0.51	0.98
DTPA Cu (mg kg ⁻¹)	0.75	0.69	0.60	0.65
DTPA Zn (mg kg ⁻¹)	0.82	0.33	0.27	0.38
DTPA Mn (mg kg ⁻¹)	8.64	3.63	1.97	2.86
DTPA Fe (mg kg ⁻¹)	11.7	13.1	11.1	11.5
Reactive Fe (mg kg ⁻¹)	585	673	574	584
Conductivity dS m ⁻¹	0.04	0.03	0.04	0.07
pH CaCl ₂	6.7	7.1	7.5	7.6
pH H ₂ O	7.6	8.0	8.6	8.7

In the 2002 and 2003 'old' area experiments the majority of nutrient uptake was completed by the plant prior to first flower (Fig 1). In 2003 however, considerable amounts of all nutrients, with the exception of copper and zinc, were still being taken up by the plants between first flower and cutout. For all nutrients except sulphur and zinc there was more uptake in the 2002 experiment followed by the 2003 'old' and then the 2003 'new' experiments.

Figure 1. Nutrient uptake of P, K, Ca, Mg, S, Zn, Mn, Fe and Cu by cotton throughout the 2002, 2003 'new' and 2003 'old' growing seasons





Phosphorus – In reviewing phosphorus uptake, Hearn (1981) determined that between 3.6 and 6.8 kg uptake was required per bale of cotton. However, data from these experiments indicate that the number was between 2.0 and 2.6 kg of phosphorus per bale. Total uptake by the crops was comparable with crops with similar lint yields (Hearn 1981). NUTRIpak claims that phosphorus uptake on a daily basis is greatest between mid-flowering and boll filling, although the data presented here would indicate that uptake was greatest prior to first flower. This may be due to temperatures being warmer earlier in the season in the ORIA encouraging more rapid growth.

Potassium – Potassium uptake was comparable to other crops which produced similar lint yields (Hearn 1981). Compared to high yielding crops however the crops reported in this experiment took up greater amounts of potassium per bale of cotton produced.

Calcium – Hearn (1981) determined that calcium uptake by cotton crops is between 14 and 33 kg per bale of lint and this is comparable with the results reported here.

There is little data in the literature to indicate when calcium is taken up although data from these experiments would indicate that most occurs prior to first flower.

Magnesium – The uptake of magnesium by the crops reported here is similar to that reported for similar yielding cotton crops reviewed by Hearn (1981).

Sulphur – Sulphur uptake differed little between the experiments reported here despite the range of yields. Crop uptake was within the range identified in the literature (Hearn 1981). The generous application of sulphur in the superphosphate and zinc sulphate appeared to overcome any deficiencies that may have occurred due to the low levels of sulphur in the soil in its natural state. Most sulphur uptake appeared to occur prior to first flower.

Zinc- An understanding of the uptake of zinc for dry season cotton production is important as Joham and Rowe (1975) reported an interaction between zinc and temperature in controlling the fruiting pattern of cotton. Zinc uptake also differed little between experiments. Zinc uptake was slightly less than that reported in NUTRIpak for cotton in traditional cotton growing areas in Australia although it did appear to be taken up in a similar manner with a consistent rate being taken up until cutout.

Manganese – The uptake of manganese was almost half that reported for cotton in NUTRIpak, although similar levels, and in a similar manner, to that reported in Constable *et al* (1988). Soil manganese levels were marginal and this may have been part of the reason for the low lint yields. Although plants reported in this paper did not show the characteristic signs of leaf cupping and interveinal chlorosis associated with manganese deficiency (NUTRIpak), there have been reports of yield responses to manganese without plants displaying any obvious deficiency symptoms.

Iron – Crops in the experiments reported here took up 700g ha⁻¹ of iron and this is comparable with the findings of Constable *et al* (1988). However, unlike Constable *et al* who found most of the iron was taken up first flower, in the experiments reported here it was not until cutout that maximum levels of iron uptake were achieved. This may be due to cooler temperatures coinciding with increasing boll load.

Copper – Despite being relatively abundant in the soil in its natural state uptake of copper was 25 to 50% less than that suggested in NUTRIpak. Constable *et al* (1988) reported copper uptake throughout the season with up to 80 g ha⁻¹ taken up by the end of the season. Why such low levels were taken up by crops reported here is unclear.

Conclusion

Some nutrient uptake differed considerably compared to what is expected in temperate cotton growing areas. Yield levels were low compared to traditional cotton growing areas in Australia and this may explain some of the lower uptake levels reported in this experiment, however some amounts and patterns of nutrient uptake were different compared to traditional cotton growing areas. Iron was taken up over a period longer while there appeared to be a greater requirement for both phosphorus and potassium per bale of cotton lint, or conversion efficiency of nutrients to yield is reduced. Uptake of copper and manganese were considerably lower than expected, although for manganese this could be explained by the marginal levels found in the soil.

Acknowledgments

This project was funded by both the Cotton Research and Development Corporation and the Australia Cotton Cooperative Research Centre.

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