THE EFFICACY OF FOLIAR FERTILISERS ON BOLLGARD II® COTTON

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Introduction

The salts of many essential plant nutrients are soluble in water and may be applied to plant leaves directly as a foliar fertiliser. This practice has become widespread in the American and Australian cotton industries over the past 20 years as a means of correcting crop nutrient deficiencies and supplying nutrients to plants during peak demand when root uptake may not be adequate (Oosterhuis 2003). Foliar fertilisation has many advantages over traditional soil fertilisation including:

- low cost of application
- plant response is fast and therefore deficiencies may be rectified quickly
- no soil fixation
- independent of root uptake and so may be applied when root functioning is declining or impaired and
- may be incorporated with other agrochemicals.

Foliar applications of micronutrients can overcome short-term deficiencies, since the amounts applied are small and the nutrients themselves can be applied directly to the tissues showing signs of deficiency (Fernandez and Ebert 2005). The risks of foliar fertilisation are phytotoxicity and leaf burn, insolubility of some nutrient compounds, high solution pH, difficulty in application of a high volume of nutrient and inefficient plant absorption due to leaf age, crop stage, water stress or climatic conditions (Oosterhuis 2003).

Correct nutrition of a cotton crop is essential for ensuring high yields and high quality fibre. Newly released transgenic cotton varieties are reported to have higher boll numbers, higher boll retention rates and larger bolls than conventional varieties. It is speculated that these varieties have a higher overall nutrient demand, particularly during the boll development stage, making adequate nutrient supply to these crops a significant factor in achieving high yields. At cutout, translocation of nutrients from leaves to bolls intensifies at the same time as production of assimilates and photosynthates slows and sometimes stops. This halt in photosynthesis is attributed to the translocation of nitrogen to developing bolls (Pettigrew *et al.* 2000) so it follows that if nutrients are applied to leaves to prevent their senescence and decline in photosynthesis, can photosynthesis and carbon fixation be extended resulting in higher seed cotton yields?

Variable and inconsistent plant responses to foliar fertilisers have been recorded. A study conducted at twelve sites across the American cotton belt showed yield increases with foliar applications of potassium at only 40% of the sites (Oosterhuis *et al.* 1994). Similarly yield responses to foliar applications of micronutrients have ranged from an increase of 140kg/ha in response to foliar zinc (Sawan *et al,* 1998) to a decrease of 160 kg/ha in lint yield (Heitholt 1994).

Inconsistencies in yield and fibre quality benefits obtained from foliar fertilisation have been linked to environmental conditions (Zhu and Oosterhuis 1992), crop physiological characteristics (Wullschleger and Oosterhuis 1989) and chemical properties of the foliar sprays (Howard *et al.* 2000).

This pilot experiment at Carroll and Narrabri investigated the yield and fibre quality benefits of application of foliar potassium, phosphorus and micronutrients to a high yielding Bollgard II ® and Roundup Ready ® variety.

Methodology

Seven foliar fertilisers (six treatments and a control) were applied to Sicot 71BR cotton in a randomised complete block design with four replications, at two sites in north-west NSW at ACRI, Narrabri and on ‘Longacres’, Carroll. Sprays contained one essential plant nutrient (Table 1) mixed with rainwater and a non-ionic wetting agent (ChemWet 1000). Agrodex K50 and Agrodex Fe were supplied by Agrobest Chemicals.

Table 1 Forms and rates of foliar fertilizers

Element	Form	Rate of element application per spray	PH of spray
K	AGRODEX K50	2 kg/Ha	10.21
P	NaH_2PO_4	2 kg/Ha	5.31
Fe	AGRODEX Fe	33 g/Ha	4.28
Zn	$ZnSO_4.7H_2O$	75 g/Ha	5.93
Cu	$CuSO_4.5H_2O$	16.9 g/Ha	5.64
B	$Na_2B_8.7H_2O$	0.14 kg/Ha	8.72

Three sprays were applied manually to the Narrabri site and two at Carroll. The three sprays at Narrabri were applied at 1184, 1423 and 1736 day degrees from sowing. The two times of application of the sprays at Carroll were January 13th and February 7th, 2006.

Results

There was no statistically significant difference in yield between treatments at either site (*P*=0.05). Figures 1 and 2 show average yield comparisons between nutrient spray treatments at both sites.

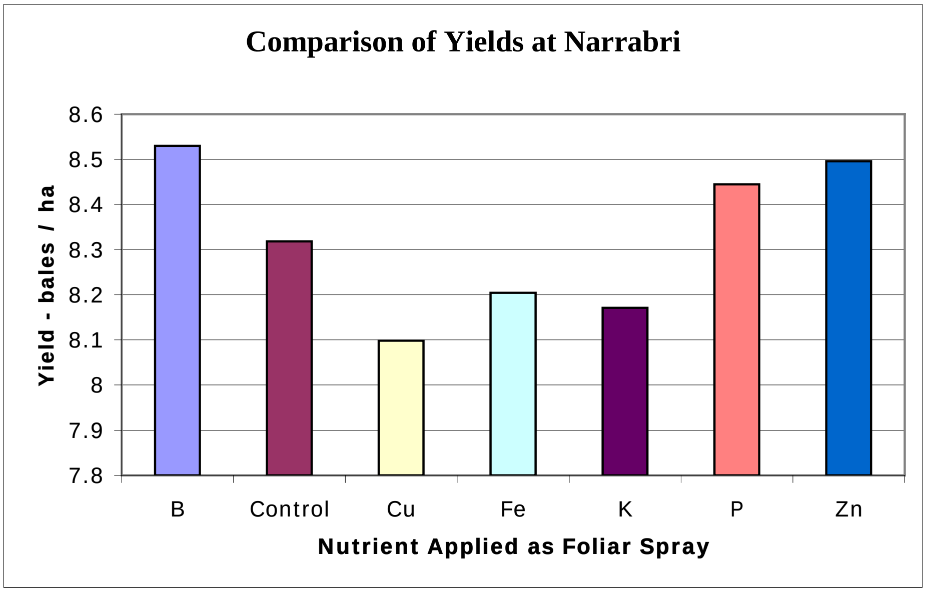

Figure 1 Yield of Bollgard II ® cotton at Narrabri in response to applied foliar fertilisers.

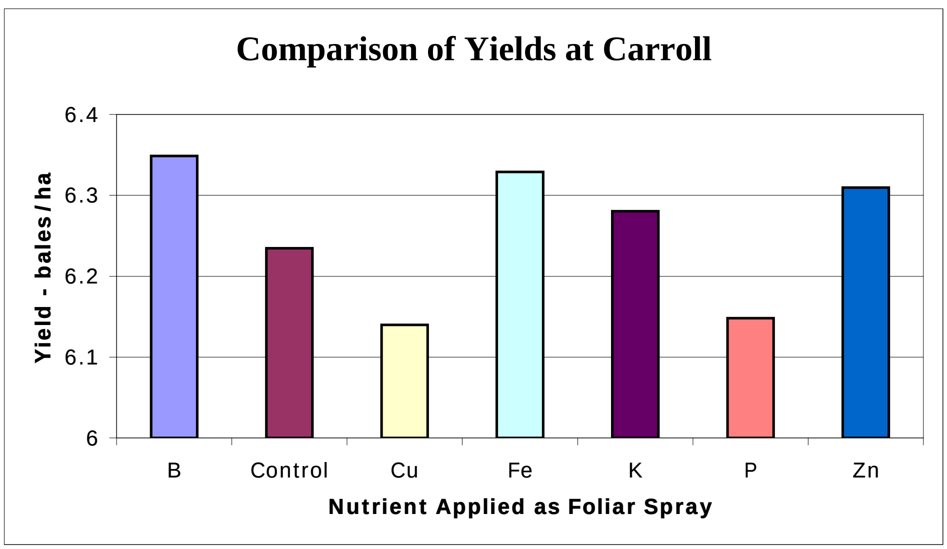

Figure 2 Yield of Bollgard II ® cotton at Carroll in response to applied foliar fertilisers.

Discussion

Although similar patterns of response occurred at both Carroll and Narrabri (Figures 1 and 2), there were no yield differences between nutrient treatments (P>0.05). Data on fibre quality are not yet available. As with other studies on the efficacy of foliar fertilisers, the reasons for the lack of yield response to foliar sprays are unclear. Possible reasons include the lack of nutrient deficiencies at the experiment site, impediments to leaf absorption of the chemicals by physiological and environmental factors or incorrect timing of nutrient applications.

The soil nutrient levels at both Narrabri and Carroll were not limiting to plant growth. Foliar potassium uptake has been linked to soil potassium status, with poor yield responses observed on soils containing adequate potassium for crop development (Oosterhuis 2003). This factor may have contributed to the lack of yield response in this experiment. Future experiments should be located at sites where deficiencies exist to investigate the effect of soil deficiencies on foliar uptake of nutrients. In situations where root growth is restricted or inadequate for nutrient uptake, foliar application could provide an economic and environmentally beneficial way to provide these nutrients. Foliar fertilisation may be especially useful in situations where root growth and nutrient uptake are restircted (Howard *et al.* 2001). Likewise in higher yielding crops where the soil uptake and supply of nutrients is insufficient for plant demand, foliar application may supply the nutrients needed effectively (Pettigrew *et al.* 2000).

Physiological characteristics of both cotton crops may have affected nutrient uptake and assimilation of the chemicals. The penetration of foliar applied compounds, and subsequent incorporation into plant metabolic pathways, occurs via the leaf cuticle through cuticular cracks and imperfections and also through stomata, leaf hairs and other specialised epidermal cells (Fernandez and Ebert 2005). These leaf characteristics can be altered by crop water stress and leaf age which increase the thickness of the leaf cuticle and impede absorption of foliar applied chemicals (Bondada *et al.* 1997). Hot and dry conditions in the 2005-2006 season may have contributed to this.

Another factor that may explain the lack of yield response could be the incorrect timing of nutrient application in terms of the age and crop growth stage. Asynchronous movement of nutrients to developing seeds has been recorded in soybean (Sale and Campbell 1980) and wheat (Adjetey and Campbell 1998). If nutrient translocation to cotton bolls occurred in the same way, application of nutrients at the correct developmental stage could increase uptake, and yield or quality benefits obtained from nutrient application. Conversely, application at the wrong developmental stage could reduce the efficacy of the fertilisers. An experiment measuring the timing of nutrient translocation to developing bolls was carried out at ACRI, but data are not yet available. Knowledge of the timing of nutrient movement to bolls, in terms of the crop developmental stage could enhance the effectiveness of fertiliser applications. Measurement of nutrient translocation and demand with respect to day degrees will allow comparisons between sites and, more importantly, be applicable industry-wide.

The effectiveness of foliar fertilisers could be further enhanced and understood through a greater understanding of the distribution or micronutrients throughout the cotton plant and the source of nutrients which are finally removed in seed and lint. At physiological maturity, root absorption of nutrients declines (Wright 1999) and the demand for nutrients from bolls is supplied through translocation of nutrients from vegetative structures (Pettigrew *et al.* 2000). If the decline in leaf function is due to nutrient translocation to bolls, yield benefits may occur from foliar application of nutrients.

While no yield responses to foliar fertilisation were observed, several questions about factors affecting the efficacy of this practice remain unanswered. Further research into nutrient accumulation in bolls based on developmental stages and measured in thermal time may enhance the effectiveness of this practice and increase the ability of growers to apply timely and appropriate quantities of nutrients for yield or quality benefits.

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