Management of the interface between sugarcane cycles in a permanent bed, controlled traffic farming system.

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Abstract

Legume breaks, controlled traffic and minimum/zero-tillage have all been shown to individually benefit the profitability and sustainability of the sugarcane production system. The research reported here discusses how these three basic components can be integrated into a practical sugarcane farming system to provide enhanced benefits. Once permanent beds were established on a row spacing suitable for controlled traffic (1.8 m) sugarcane and legume breaks were planted with double-disc opener planters with or without any soil disturbance. Substantial yield improvements were measured with no tillage compared with surface tillage of the beds and these yield improvements were further enhanced when a legume crop, such as soybean, was included between sugarcane cycles. The combination of direct planting of sugarcane into a non-tilled permanent bed following a soybean break out-yielded a tilled permanent bed that did not have a soybean break by 47% in the plant crop.

Key Words

Permanent beds, controlled traffic, legume breaks, sugarcane, monoculture.

Introduction

The Sugar Yield Decline Joint Venture (SYDJV) has been developing a “new” sugarcane cropping system which incorporates the principles of minimum/zero-tillage, controlled traffic and legume breaks. Component research into each of these areas has shown the benefits that can be achieved by: legume breaks and how they are managed (Noble and Garside, 2000; Garside and Bell, 2001; Garside and Berthelsen, 2004), controlling traffic (Braunack and Peatey, 1999; Braunack and Hurney, 2000; Robotham, 2003) and reduced tillage (Braunack and McGarry, 1998; Braunack *et al.,* 1999; Garside *et al.,* 2004). However until now, little research has been carried out into combining these three principles into the sugarcane cropping system. Bell *et al.* (2003) reported on initial studies under irrigation in a sub-tropical environment at Bundaberg, but no research in combining these three principles has been reported from north Queensland. The marked soil and climatic differences between the wet tropics of north Queensland and Bundaberg presented different challenges for the new cropping system to be tested against.

The research reported here was conducted at the BSES Ltd Tully Experiment Station (TES) between September 2003 and July 2005. It involved different types and timing of cane trash management, different management of legume residues, and different rates of nitrogen fertiliser application under tillage and direct planting in an established permanent bed, controlled traffic system. The main aim of the work was to identify whether there were likely to be any adverse effects of the different management options.

Methods

TES is located on the wet tropical coast of north Queensland (17? 58' 40”S, 145? 55’ 38.7”E), where the mean annual rainfall is of the order of 4000 mm. Soil type was a medium to heavy clay of the Coom Series (Cannon *et al.,* 1992). The site was acquired by the SYDJV in September 2001 when it was prepared into 1.8m raised beds and planted to sugarcane during the initial testing of a double disc opener dual row cane planter. Plant (PC) and first ratoon (R1) cane crops were harvested from the site in September 2002 and 2003, respectively. Standard fertilizer practices (150, 28 and 80 kg/ha of N, P and

K, respectively) were used with the plant crop but no nitrogen was applied to R1. All cane, except for six designated plots, was removed by herbicide (Glyphosate @ 7 l/ha) after R1 without disturbance of the permanent beds. The six designated plots were taken into a second ratoon (R2) and fertilized with 28 and 80 kg/ha of P and K, respectively. A soybean crop was established across the remainder of the site in December 2003 with the same fertilization as R2. The sugarcane trash remaining after R1 was incorporated into the bed tops at various times prior to planting the soybean in order to measure the effect of time of trash incorporation on soybean growth. As there was no effect of time of trash incorporation, data from the various times of trash incorporation have been pooled in this paper.

The cane taken through to R2 was not grown as a standard crop but was regularly slashed with the tops left on the plot surface between the end of R1 and the end of the soybean crop in April 2004. At the end of the soybean crop, the soybean was either incorporated into the surface of the permanent bed with a light rotary hoe or left as a standing crop (soybean was not harvested for grain). At the same time the cane trash in three of the R2 plots was incorporated into the bed surface while it was left on the surface in the other three R2 plots. The maintenance of R2 through until this stage simulated a sugarcane monoculture as it retained the sugarcane root stock. Volunteer sugarcane was controlled with herbicide. Sugarcane variety Q187[A] was planted in June 2004 into all plots with a dual row double disc opener planter. At 90 days after planting all plots were split to 0 or 150 kg/ha N applied as urea to the centre of each of the dual rows.

The resultant experiment consisted of permanent beds with a factorial combination of either continual sugarcane or a soybean break and soybean break/cane trash incorporated or soybean break/cane trash surface managed as main plots. Each main plot was split to 0 N or 150 kg/ha N. There were three replications and the final plot size was 3 x 1.8 m beds x 12 m.

Measurements and data collection

Soil sampling

Soil samples to measure mineral nitrogen were taken on April 20, 2004 (end of soybean phase), June 16, 2004 (cane planting), November 18, 2004 and February 8, 2005 to coincide with biomass samples; and after harvest of the plant crop on September 29, 2005. After collection and storage in a cool room, samples were air-dried, ground, extracted with potassium chloride and analysed using an automated calorimetric method.

Soybean biomass

Soybeans were sampled on April 4, two weeks prior to physiological maturity, to measure biomass production. Samples were cut at ground level, fresh weight recorded, sub-sampled, mulched, dried at 70^0C for 72 h or until a stable dry weight was recorded. Sample dry weight was calculated from these data and a sub-sample was then ground and analysed for plant nitrogen concentration to allow plant nitrogen content of the tops to be calculated.

Sugarcane production

Crop harvest was carried out by hand during the week July 4 – 7, 2005. Harvest area was 7 m x 1.8 m (12.6 m^2) from the centre bed of each plot. All stalks were counted and weighed. Fifteen stalks were then randomly selected and divided into millable stalk and leaf and cabbage by separation between the 5th and 6th leaf below the top visible dewlap. These data were then used to calculate the percent millable stalk which was applied to each harvest area to calculate millable stalk yield. Four stalks were set aside from each plot to measure CCS.

Statistical Analysis

All data were subjected to analysis of variance using the Genstat? Statistical program. The model used to analyse the cane data was a split-plot design with soybean or cane x post soybean/cane tillage as main plots and nitrogen rates as sub-plots.

Results and Discussion

Soybean

As there was no significant difference in biomass and nitrogen concentration between any of the soybean plots only the mean data is presented. Biomass of Soybean tops was 6 373 kg/ha and had a nitrogen concentration of 3.19% resulting in a nitrogen contribution from the tops of 203 kg/ha. The concentration in the roots was not measured.

Sugarcane

As CCS (sugar concentration) was not affected by any of the treatments, and sugar yields are related to cane yields only cane yields are discussed (Table 1).

Table 1 – Effect of crop rotation (cane monoculture or soybean breaks), tillage and nitrogen fertiliser on plant cane yields of Q187[A] at Tully.

Land Management	**Cane Direct Planted**		**Cane Planted after Surface tillage**		**Mean**
	0 N	150 N	0 N	150 N	
Cane Monoculture	81	88	57	74	75
Soybean Break	92	102	87	101	96
Mean	87	95	72	88	0 N = 80 150 N = 92
	91		80		

Significant effects: Rotation (p=0.003, lsd 5% = 10), N (p<0.001, lsd5%=3.37),
Rotation X N (p=0.07, lsd5%=11.2), Rotation x Tillage(p=0.10, lsd 5% = 16).

Overall the inclusion of a soybean break increased cane yield by 21 t/ha or 28%. However, there were also positive responses *($p<0.10$)* to the removal of tillage from the cropping system, particularly in the cane monoculture. The yields under cane monoculture with and without tillage were 69 and 81 t/ha, respectively. However, when a soybean break was included there was no difference in cane yield between direct planting into standing soybean and planting into a bed that had soybean tilled into the surface.

There was a significant nitrogen response *($p<0.001$)* across the experiment. However, there were also strong trends towards a rotation x N effect and a rotation x tillage x N effect. These trends reflected a large response to N when the cane monoculture was tilled but a much smaller response under direct planting. Thus it could be concluded that there was probably more N available in the direct planted system. However, sequential sampling of mineral N from the 0 N plots in the cane monoculture failed to show any difference in mineral N between the direct planted treatment and the surface tilled treatment to depth in the profile (data not presented). Some other soil health factors would appear to be operating. Conversely, there were similar responses to N following the soybean break, whether the soybean residue was tilled into the surface or left standing. This is the first experiment in a whole range of studies conducted in the sugarcane cropping system where a response to N has been recorded following a soybean crop (Garside *et al.,* 1997*,* Bell *et al.,* 2003). It is suspected that the rundown of N in the R1 cane crop (an unlikely practical scenario) was a major reason for this response.

The major positives to emerge from this experiment are that cane yield can be increased in a sugarcane monoculture by the adoption of direct planting into established permanent beds, while the inclusion of a legume break provides a further yield increase. The results also support previous studies (Garside and Berthelsen 2004) that showed that it was not necessary to incorporate legume residue, thus clearly promoting a move towards zero-tillage in the sugarcane cropping system. Significantly, the combination of zero-tillage and a soybean break out-yielded a tilled sugarcane monoculture by 47%, although the effect was greater in the absence of nitrogen fertiliser (61%) than when fertiliser was applied (38%) (Table 1). This lends support to previous observations (Garside *et al.,* 2001) that adverse effects of a sugarcane monoculture can be masked to a certain extent by high rates of inputs like nitrogen fertiliser, especially with plenty of available water. However, with excessive use of nitrogen fertiliser likely to come under increasing environmental scrutiny such a strategy should not be relied upon to maintain yields in the long-term.

Conclusion

The results of this experiment support the move towards a sugarcane cropping system that incorporates controlled traffic, permanent beds, minimum/zero-tillage and legume breaks. Such a system is likely to reduce production costs, be more sustainable and environmentally responsible and result in yield increases.

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