Soil compaction is a major issue operating against the development of sustainable sugarcane cropping systems

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Abstract

The harvesting and hauling of sugarcane from the field is carried out by heavy machinery that passes down every inter-row at least twice during the harvesting operation. Once established, a sugarcane crop is grown for a number of years (5 – 6) but is harvested on an annual basis. The combination of heavy machinery and non precision driving results in severe compaction by the end of a sugarcane cycle. The compaction is usually removed by numerous tillage operations at the end of a cycle in order to provide good tilth for the planting of the next crop. As many growers don't fully appreciate the severity of the compaction caused during a cane cycle and the potential productivity losses, tests were run to measure the effect of compaction. Sugarcane experiments incorporating different row configurations were established in Mackay and Ingham in 2001 and harvested on an annual basis until terminated in 2005. Plots were then split into permanent beds (no tillage) or reformed beds following cultivation with disc, ripper and rotary hoed. Cane was then re-planted across the whole experimental area. Cane yield was enhanced by up to 86% by removing the compaction. The results have important implications for the development of a new sugarcane farming system which is attempting to combine controlled traffic and minimum tillage. It is concluded that harvesting precision will need to be improved, probably through guidance systems, and row spacings adjusted if reduced tillage is to be adopted without productivity losses.

Key Words

soil compaction, tillage, penetrometer, water stress, mechanical harvesting

Introduction

The Australian sugar industry is the most highly mechanised sugar industry in the world. Where many other countries still resort to hand harvesting and loading the Australian industry has been mechanically harvested for the past 40 years. The large biomass harvested in sugarcane (cane yields between 100 – 200 t/ha) has restricted the rate at which the cane can be harvested. Harvesting and haul-out machinery are designed to harvest and collect one row at a time. Thus every inter-row receives at least two passes of both the harvester and haul-out equipment, which weigh 16 – 20 t and up to 30 t (loaded), respectively (Robotham 2000). Both the harvester and haul-out have wheel spacings of 1.8 – 1.9 m, yet sugarcane is traditionally grown in rows 1.5 m apart. The larger wheel spacing on the machinery is to improve stability in undulating fields (Robotham 2000). With this mixture of configuration 70% of a field is trafficked during the harvesting operation with no driver error. Invariably, driver error occurs, increasing the area trafficked to 90% of the field (Robotham and Garside 2004). Given these heavy weights and mis-matched wheel and row spacings soil compaction becomes a major issue when a plant and several ratoon crops are grown over a cycle.

The Sugar Yield Decline Joint Venture has been developing a "new" sugarcane cropping system based on the three principles of breaking the sugarcane monoculture, minimising tillage and controlling traffic (Garside *et al.,* 2005). Controlling traffic is aimed largely at reducing the adverse effects of soil compaction. However, many growers don't appreciate the seriousness of compaction in terms of productivity loss.

Thus it was decided that long-term sugarcane experiments should be utilised to demonstrate the detrimental effects that compaction, caused by the heavy machinery, can have on potential productivity. To effectively do this, it was necessary to compare productivity of plant cane crops established on permanent beds with those established on fully cultivated re-formed beds in experiments at Ingham and Mackay. Permanent beds are likely to be a feature of the new farming system.

Method

Large scale experiments evaluating the growth of sugarcane in 1.5m single rows, 1.8 m single rows and 1.8 m dual rows were established in Ingham and Mackay in November 2001. Soybeans were sown on beds formed into the various row configurations. Sugarcane was planted on these beds in August 2002 and plant, first ratoon and second ratoon crops were harvested mechanically in 2003, 2004 and 2005, respectively. After the 2005 harvest all plots in both experiments were split to permanent beds (beds were not tilled) or reformed beds (beds were disced, ripped and rotary hoed) and re-planted to soybean. At the end of the soybean crop similar land preparation procedures were adopted with the permanent and re-formed beds. Basically, the permanent beds received no tillage after the cane was planted in the first experiment in 2002 while the re-formed beds received tillage after the end of the cane cycle in 2005 and again after the end of the soybean crop in mid-2006. Sugarcane varieties Q200[A] at Ingham, Q208[A] at Mackay were planted in August 2006 using double-disc opener planters and the plant crop was harvested in August 2007.

Results and discussion

Cane Yields

There was a highly significant effect of tillage on cane yield in both experiments regardless of row spacing (Table 1) but there was no overall effect of row spacing in either experiment.

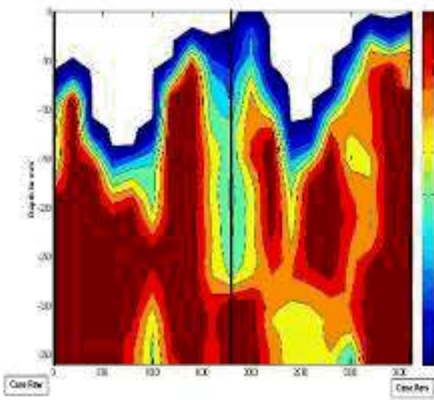
The responses were larger at Ingham than at Mackay. We investigated plant nutrient status several times during the growing period, and although there were differences in the concentration of various nutrients, which mainly favoured the re-formed beds, third leaf tissue levels were always above the critical level for each nutrient. Therefore, nutrition is most unlikely to have been the reason for the yield differences.

Following biomass samples at 4 and 8 months of age at Mackay and Ingham, respectively, the hydraulic cone penetrometer developed by BSES Ltd. (Kidd 2006) was used on selected permanent and re-formed beds with 1.8 m row spacing to measure soil strength. The data from this exercise (Figs. 1 and 2) along with soil moisture data (Table 2) measured at the same time readily explained the yield differences between the permanent and re-formed beds.

Experiment	Bed Treatment	Row Spacing			Mean
		1.5 m	1.8 m single	1.8 m dual	
Ingham	Permanent	107	78	86	90
	Re-formed	135 *(21%)*	145 *(86%)*	142 *(65%)*	141
	Mean	121	112	114	
	Level of signif.		*Nsd*		*p<0.001* *17*

	Lsd 5%				
Mackay	Permanent	113	108	119	113
	Re-formed	129 *(14%)*	128 *(19%)*	136 *(14%)*	131
	Mean	121	118	127	
	Level of signif.		*Nsd*		*p<0.001*
	Lsd 5%				*8*

Table 1. Cane yield (t/ha) from permanent and re-formed beds where cane had been grown in the previous cycle on 1.5 m single rows, 1.8 m single rows and 1.8 m dual rows. Percent data in the re-formed bed rows indicate the yield increase over the permanent beds.



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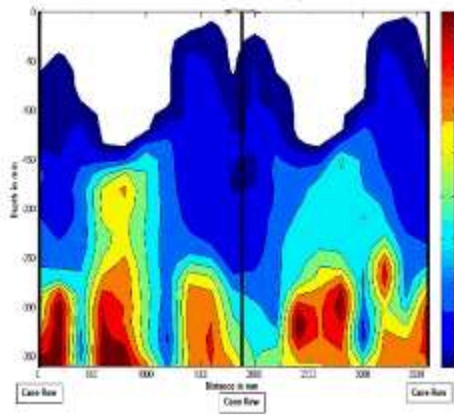

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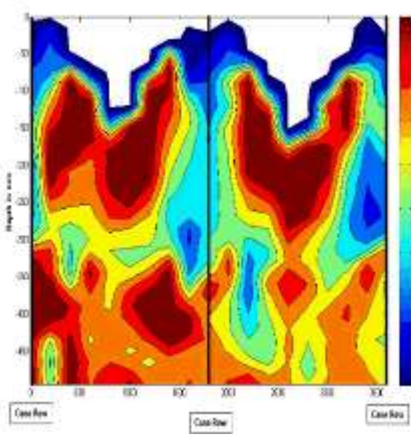

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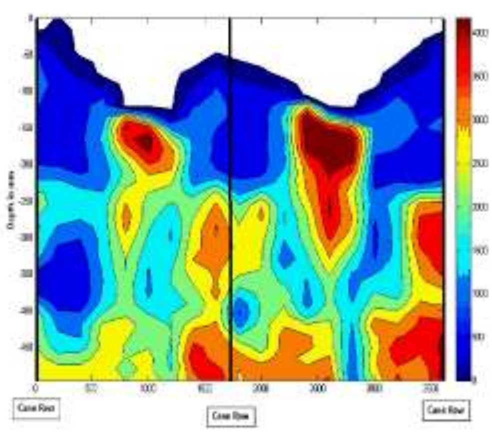

2b

Figure 1 and 2. Cone index (kPa) vs soil depth for 1.8 m single rows for the Ingham (Fig.1) and Mackay (Fig.2) experiments for permanent beds (1a, 2a) and re-formed beds (1b, 2b).

Basically, soil strength as measured by the cone penetrometer was higher in the permanent beds at both sites but the difference in soil strength between re-formed and permanent beds was greater at Ingham than in Mackay. These soil strength differences resulted in differences in soil water content (measured on the same day as the penetrometer measurements) (Table 2) which in turn produced the yield differences. The smaller response at Mackay compared with Ingham can probably be related to a smaller differential in soil strength between the permanent and re-formed beds. Unfortunately, the relevant soil water data for the Mackay experiment was not collected.

Table 2. Gravimetric moisture (%) in the top 40 cm of the permanent and re-formed beds at Ingham

Soil Depth (cm)	Bed Type	
	Permanent	Re-formed
0 – 10	23.4	26.5
10 – 20	21.4	25.7
20 – 30	20.3	25.9
30 - 40	20.2	25.0

Conclusions

Compaction has a major effect on the yield of sugarcane through limiting the availability of soil water. Tillage between cane cycles can remove the compaction accumulated during the previous cycle but such intensive tillage operate against the development of the “new” reduced tillage farming system. In both of these experiments, but more so in Ingham, the compaction with the 1.8 m single rows was more wide spread and severe than was expected with matched wheel and row spacing. However, these data clearly suggest that the driving of the equipment was not as precise as it should have been. Unfortunately 1.5 m single row data with the penetrometer is not complete, but the data we did get indicated that compaction in the permanent beds was as bad or worse than with the 1.8 m single rows.

It appears that if the sugar industry is to move to minimum or zero-tillage it will only occur successfully with wider inter-row wheel spacings (*viz.* 2 – 3 m) and/or the utilisation of guidance systems to overcome driver error. The suitability of 1.8 m spacing to limit compaction is questionable without guidance. Further research is required to evaluate the extent of compaction when guidance is used on 1.8 m row spacings.

References

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