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Effect of harvest traffic position on soil conditions and sugarcane (*Saccharum officinarum*) response to environmental conditions in Queensland, Australia

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Abstract

Field trials were conducted for a period of 5 years at two locations in north Queensland and with four sugarcane varieties to quantify the effect of harvest traffic on soil physical properties and sugarcane growth. The trials were conducted under rain-fed conditions. Treatments consisted of wheel traffic directly over the planted row, 0.1 m from the row and down the middle of the inter-row, by fully laden haulout equipment immediately after harvest. The equipment varied between sites, with low ground pressure tyres being used at one-site and high ground pressure tyres being used at the other site. This reflected commonly used harvesting equipment for each area. Gravimetric soil water content was 23–29 and 26.5–33% at the time of treatment application, which corresponds, to 0.7–0.9 and 0.8–1.0 of the plastic limit for the respective soils. Undisturbed cores were extracted for determination of bulk density and saturated hydraulic conductivity. Soil cone resistance was measured in the field. All measurements were made before and after impact on the plant crop and after impact on each ratoon crop. Stalk numbers, heights of stalks and number of gaps in cane rows were recorded to assess treatment effects, and final yield was measured. Experimental design was split-plot, with the main plot being position of wheel impact and the plot being split by varieties.

Saturated hydraulic conductivity decreased and bulk density increased and soil cone resistance was variable in the row after traffic over the row compared with the near- and inter-row positions.

Stalk numbers and heights and yield indicated little difference with respect to treatment, but there was a significant varietal difference. The varieties Q138 and Q124 were taller and had greater yield than Q117 and Q115. The effect of traffic appeared to be cumulative, as the degree of soil compactness and bulk density increased, with treatment differences becoming significant with each additional year of traffic. Traffic over the row resulted in a yield loss compared with traffic near-the-row and down the inter-row.

To predict crop response to machinery traffic in the Australian sugar industry the model of Arvidsson and Håkansson [Arvidsson J., Håkansson, I., 1991. A model for estimating crop yield losses caused by soil compaction. Soil Tallage Res. 20, 319–332] was modified. Several changes were necessary, since the original model was developed for a

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cropping system based on annual cultivation, whereas sugarcane is a perennial crop grown in rows with no annual cultivation. The modified model was validated using data from the trials described in this paper. Agreement between measured yield loss and predicted yield loss was reasonable. This is the first attempt to provide the Australian sugar industry with a tool to assess the yield loss due to harvesting traffic and the economic cost of that loss. The model has the potential to provide, with further development, an indication to growers as to the benefit of restricting traffic to the inter-row area, restricting the number of passes by haulouts, harvesting under drier soil conditions and using high flotation haulout equipment. This should aid in more informed management decisions with respect to harvesting equipment or to the consequences of harvesting under adverse soil conditions.

Keywords: Harvesting traffic; Soil physical conditions; Sugarcane; Soil compaction; Modeling; Yield loss; Bulk density; Hydraulic conductivity; Cone resistance

1. Introduction

Sugarcane is grown as a monoculture in tropical and sub-tropical, coastal regions of Australia. The crop is largely grown under rain-fed conditions, with supplemental irrigation in some districts and full irrigation occurring in two regions. Effective rainfall under rain-fed conditions ranges from 28–87% of the annual rainfall. The commercial crop is planted in rows spaced at 1.5 m and is propagated vegetatively. The crop grows for 12–18 months before mechanical harvesting by cutting stalks at ground level. A ratoon crop regrows from material underground and is again mechanically harvested after a period of between 12 and 14 months. Several harvests are taken from the initial planting, thus a crop cycle consists of a plant crop and on average four ratoon crops, cut annually. A single row is harvested at a time with a haulout unit tracking alongside the harvester collecting the cut cane for transportation out of the field. The traffic at each harvest is intense. Each inter-row is trafficked with a minimum of four passes, two by the harvester and two by the haulout. Some inter-rows are trafficked more depending on row length and crop yield. A proportion of each inter-row is trafficked by empty, partially loaded and fully loaded haulouts. Since the harvesters weigh up to 20 tonnes and fully loaded haulouts up to 30 tonnes, and since harvesting traffic is often applied under wet soil conditions, there is great potential for soil compaction on an industry wide basis. To reduce soil compaction, wider tyres, tracks and tandem axles are utilised. The subsoil compaction effect of the traffic is unknown. Under the current cane growing system there is a mis-match between crop row spacing (1.5 m) and track width of the harvesting equipment (1.83 m). Therefore, some traffic occurs very close to the row and occasionally directly over the row.

In mechanised agriculture, soil compaction reduces crop yields (Lindstrom and Voorhees, 1994). Mechanical harvesting, by increasingly larger harvesters and haulout equipment, has been linked circumstantially with the yield plateau in the Australian sugar industry since 1975. The below ground cane stool and soil structure can be damaged during harvest by hauling equipment, especially under wet conditions (Torres and Villegas, 1993). Poor crop growth, attributed to traffic damage (‘wheels disease’), is identified annually by growers, but overall yield losses have not been quantified. Previous studies, in Columbia, under wet conditions resulted in yield losses of up to 40% (Torres and Villegas, 1993) while, in South Africa, under drier soil conditions losses were up to 30% (Swinford and Boevey, 1984) when traffic occurred directly over the row. When traffic was restricted to the inter-row area yield losses of 10% were reported. It was suggested that the major cause of yield loss was direct damage to the stool. Under dry harvesting conditions in Australia, no yield loss was recorded due to harvesting traffic (Braunack et al., 1993).

Changes in soil properties have been recorded in the inter-row, with bulk density increasing, soil strength increasing and cumulative infiltration decreasing after in-field traffic with air-filled porosity being reduced to less than 10% (Swinford and Boevey, 1984; Torres and Villegas, 1993). The reduction in air-filled porosity in combination with the increase in