SHORT NON-REFEREED PAPER

ESTIMATING CROP PRODUCTION LOSSES FOR VARIOUS INFIELD SUGARCANE EXTRACTION SYSTEMS

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Abstract

Infield traffic is understood to negatively impact crop yields. For high biomass crops such as sugarcane, the amount of infield traffic when removing the crop from the field is substantial compared to other crops. In the South African sugar industry there are a range of systems that are used to harvest and remove the cane crop, each with varying amounts of infield traffic. Surveys were conducted to determine the extent of traffic that occurred infield and the position of the traffic with respect to the crop row and inter-row areas. Yield losses differentiating between row and inter-row traffic were synthesised from local and international literature. These yield losses were used to estimate field based crop production losses for a range of systems that are typically found in the South African sugar industry. The estimated yield losses ranged from approximately 1-9%, depending on the loading system and the associated intensity and extent of traffic through the field. The results from this study provide an indication of the impact that infield traffic is having on yields and crop sustainability for different systems, and the benefits that may be available through the adoption of better infield traffic practices and systems. This study provides the basis for the economic benefit of better infield traffic practices to be quantified, and in certain cases may provide sufficient incentive for the changing of infield traffic equipment and systems.

Keywords: compaction, harvesting systems, extraction systems, infield traffic, sugarcane, stool damage, yield losses

Introduction

Estimating the amount of crop yield loss that results from infield traffic systems is particularly important because it allows system costs to be compared more equitably by including the cost that infield traffic would cause on subsequent crop yields. It also may provide an indication of the benefit that better management practices such as controlled traffic could provide.

The objective of this short paper is to report on a combined project between the South African Sugarcane Research Institute (SASRI) and the Bioresources Engineering department of the University of KwaZulu-Natal (UKZN), where the traffic from a range of sugarcane loading and extraction systems typically found in the South African sugar industry were surveyed, analysed and compared. The systems analysed included a range of cut and stack operations and cut and windrow operations.

Materials and Methods

A literature review gathering and synthesising sugarcane yield responses to infield traffic treatments was conducted (Tweddle, 2014). The results obtained confirmed that wheel traffic on the crop row (row traffic) typically causes far more crop damage than wheel traffic confined to the inter-row (inter-row traffic). Traffic treatments for higher soil moisture conditions and for higher traffic intensity also showed greater yield losses, as would be expected. The results provide a yield loss (%) linked to row or inter-row field position for a particular point in a field, referred to as 'point of impact' yield loss. These results were further split into vehicle impact categories, namely low, medium and high impact. Due to large yield differences between categories, intermediate categories of low-medium and medium-high were defined.

Field work to determine the extent and location of infield traffic for a range of typical cane loading and extraction systems was conducted. This consisted of conducting Global Navigation Satellite System (GNSS) surveys to determine the location of wheel tracks through the field.

The data from the GNSS field surveys were then processed and analysed on AutoCAD Civil 3D® (CAD) and Quantum GIS® (GIS) software to determine the location and extent of infield traffic associated with each system independently. This provided a field-based area of traffic impact. The results provide a distinction between different equipment components for each system. The field area was analysed using GIS analytical tools to determine the proportion of the field where row, inter-row and no traffic had occurred during the extraction of cane from the field. A crop row width of 0.4 m was used in the analyses.

Figure 1 provides an indication of the maps that were produced following the integration of field maps and traffic movements through the field. In this case, the map represents traffic for a particular cut and stack system.

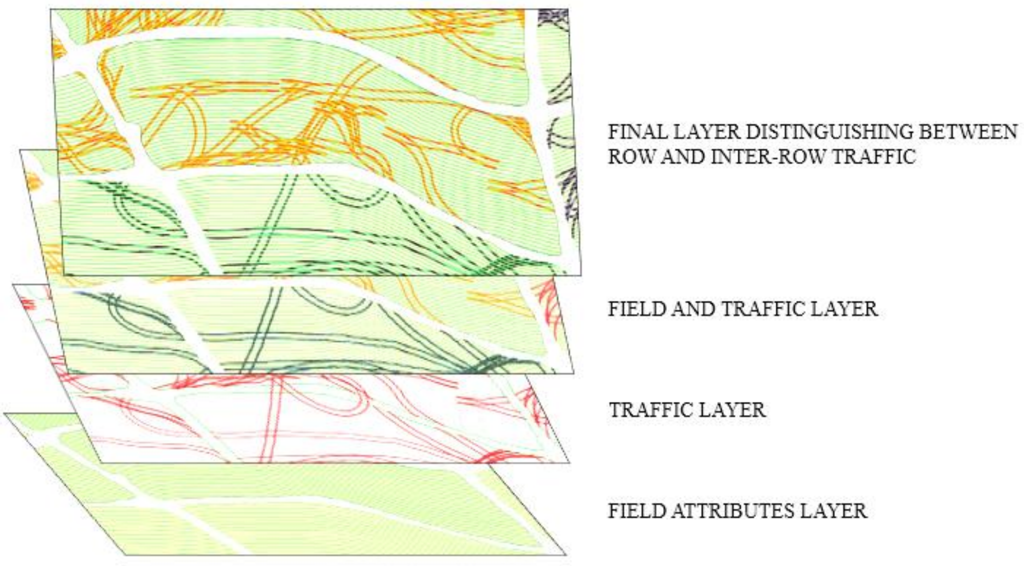

Figure 1. Integration of field attributes and traffic paths to determine the extent of row and inter-row traffic within a field for a particular loading and extraction system.

Yield losses were estimated by attributing the point of impact yield loss in terms of row or inter-row field position (as derived from the synthesis of literature linking traffic to yield loss) to the proportion of the field areas trafficked. The product of these factors was used to determine the field productivity yield loss estimates apportioned to row traffic and inter-row traffic.

This procedure was conducted on field survey data gathered from the following commercial loading and extraction operations:

1. Cut and stack system: single stack self-loading trailers
2. Cut and stack system: double stack self-loading trailers
3. Cut and windrow system: non-slewing loader (gathering from 1 windrow) and box trailer
4. Cut and windrow system: non-slewing loader (2 windrows) and box trailer
5. Cut and windrow system: non-slewing loader (3 windrows) and high capacity trailer
6. Cut and windrow system: slewing loader (1 large windrow) and high capacity trailers.

Results and Discussion

The results from the field studies are given in Table 1. The various systems can be compared in terms of the extent of the entire area that was subjected to row traffic, inter-row traffic and the remainder of the field that was not trafficked during the loading and extraction operations.

Table 1. Extent of infield traffic classified by row traffic, inter-row traffic and no traffic for a range of systems typically found in the South African sugarcane industry.

Equipment	Extent of traffic on a field basis (%)		
	Row traffic (%)	Inter-row traffic (%)	No traffic (%)
1. Single stack self-loading trailers	4.8	7.7	87.5
2. Double stack self-loading trailers	5.5	10.8	83.7
3. Non-slewing loader (1), box trailer	20.4	29.2	50.3
4. Non-slewing loader (2), box trailer	26.2	39.0	34.8
5. Non-slewing loader (3), high capacity trailer	37.7	58.4	3.9
6. Slewing loader (1), two high capacity trailers	8.8	13.9	77.4

By attributing point of impact yield loss estimates to the extent of the fields that were trafficked, an estimated yield impact for the various systems can be determined. The estimated yield losses for the different systems are indicated in Table 2. Five impact categories were defined and rated as low (L), low-medium (L/M), medium (M), medium-high (M/H) and high (H). These categories were based on mean axle weight (partially loaded) and were classified accordingly. Vehicles with low flotation tyres were down-rated to a lower category impact.

Table 2. Estimated field yield loss based on equipment impact rating classifications.

System description (subjective impact rating)	Estimated field yield loss (%)
1. Single stack self-loading trailers (L/M)	1.0
2. Double stack self-loading trailers (L/M)	1.2
3. Non-slewing loader - 1 windrow (L/M), box trailers (L/M)	4.7
4. Non-slewing loader - 2 windrows (L/M), box trailers (L/M)	6.0
5. Non-slewing loader - 3 windrows (L/M), tri-axle trailer (H)	9.2
6. Slewing loader (L/M), 2x tandem-axle trailers (H)	3.2

The above results indicated that the lowest impact systems are the cut and stack systems, with relatively low impact equipment and low extent of traffic. These systems, however, do not typically track the same paths in subsequent ratoons and may accumulate higher long-term yield losses than a system where controlled traffic principles are practised. The controlled traffic system, although having a high impact combination of traffic, was estimated to perform better than the uncontrolled traffic cut and windrow systems using non-slewing loaders. The type and management of infield vehicles for the cut and stack systems with non-slewing loaders seemed to have a large influence on the estimated yield loss impact, with the least impact being attributed to the lower axle loads of smaller infield trailers. However, the choice of system would need to be carefully planned from a machinery cost and field productivity aspect. This work aims to address the previously unaccounted for aspect of field production yield loss, and allow advisors and machinery purchasers to be aware of this aspect.

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