SHORT COMMUNICATION

A COMPARISON OF SOIL COMPACTION IN CHOPPER-HARVESTED FIELDS AND MANUALLY-CUT FIELDS AT UBOMBO SUGAR

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Abstract

Soil compaction is a challenging condition that is associated with mechanised agriculture, from land preparation to crop husbandry and harvesting operations, and the sugar industry is not immune to this challenge. The objective of this investigation was to compare the extent of soil compaction in chopper-harvested fields and those that were harvested manually by sugarcane cutters. Between 2020 and 2022, the two methods were selected for soil compaction tests from across the harvested fields on the Ubombo Sugar Estate. A penetrometer was used to ascertain the depth at which the 200 psi and 400 psi inter-row and intra-row readings were obtained, when the soil was at field capacity The study involved 119 fields, of which 37 were chopper-harvested and 82 were harvested manually. The compaction in chopper-harvested fields was significantly higher ($P<0.05$) than in non-chopper harvested fields. The findings revealed that the 200 psi penetrometer readings were found at 14.3 cm and 16.0 cm between the rows in chopper-harvested and manually harvested fields, respectively, and at the intra-row they were 21.3 cm in chopper-harvested and 23.1 cm in manually-harvested fields. The 400 psi readings were obtained at 7 cm and 9.4 cm between the chopper-harvested and cane-cutter-harvested fields, respectively. Within the sugarcane rows of the respective systems, the 400 psi readings were obtained at 11.1 cm and 14.9 cm. It was concluded that compaction is more prevalent when chopper harvesting is used; therefore, compaction mitigation measures need to be put in place in chopper-harvested fields.

Keywords: Soil compaction, chopper-harvested fields, manual cane cutters, between and within sugarcane rows, soil depth and pressure readings, Ubombo Sugar

Introduction

In Eswatini, sugarcane harvesting that is done by using machinery, popularly known as chopper harvesters, is constantly becoming a common practice, in order to replace manual cutting by labourers, as labour is projected to become scarce in the future. There are also mounting calls by environmentalists and ESG stakeholders for sugarcane to be harvested green, in order to reduce greenhouse gas emissions, which can only be achieved by machine harvesting. Sugarcane harvesting is also considered a high-risk operation for human beings, and the chopper harvesters have been identified as a mitigation measure, to eliminate the risks to human health and safety.

On the other hand, the disadvantages of chopper harvesters in sugarcane harvesting have also been documented, and these are centred around the compaction of both the topsoil and subsoil in the sugarcane fields (Afzali *et al*., 2014). Soil compaction reduces pore spaces in the root zone of sugarcane fields, resulting in poor water infiltration and retention, limited root development, and ultimately, yield losses (Shaheb *et al*., 2021). In addition to the destruction of the soil structure, chopper harvesters are also associated with poor precision in the base

cutting and topping height of sugarcane stalks, which leads to huge losses of sugar (Perez-Reyes *et al*., 2022).

For several years now, Ubombo Sugar Limited has been measuring the extent of soil compaction, on both chopper and hand-cut fields, by using a hand-held penetrometer to monitor the extent of soil compaction. However, a comparison analysis of the two harvesting methods, in terms of soil compaction, had not been done prior to this analysis. The aim of this study was to compare the extent of soil compaction in chopper-harvested and hand-cut fields at Ubombo Sugar Ltd.

Materials and Methods

Study area

The study was conducted at the Ubombo Sugar Estate, which is located in the lowveld of Eswatini at 26.75°S and 31.7°E, at an altitude of 106 m above sea level. It receives an annual average rainfall of about 625.7 mm, most of which falls between the months of October and March, which are generally outside the bulk of the harvesting period. The predominant (60%) textural soil class is clay loam (R, S and T series) with a clay content of 20-40%.

Soil compaction measurement

A hand-held penetrometer was used to measure the severity of subsurface compaction by measuring the depth of penetration required to achieve the predetermined resistance readings. Wooden pegs were used to mark the sampling points, which were gridded and spaced out at 100 m x 100 m. The data was collected in 37 chopper-harvested and 82 manually-harvested fields, totalling 119 fields, and they were all measured between the years 2020 and 2022. Minitab Software was used to statistically analyse the data. The soil penetrometer measurements were used to determine the extent and depth of subsurface compaction in, and between, the rows at all the marked sampling points. A set of four data points were collected at each sampling point. The 1.8 m tramline system was used with a spacing of 0.2 m between each row on the tramline. The spacing of the inter-row was 0.6 m from either side of the cane row, with the chopper’s rear wheels being a width of 0.48 m. The depths at which the penetrative resistance of 200 psi and 400 psi were achieved in the cane rows were measured. The same was done for the inter-rows.

Results

Figure 1 presents a summary of the penetrometer measurements obtained over the three seasons.

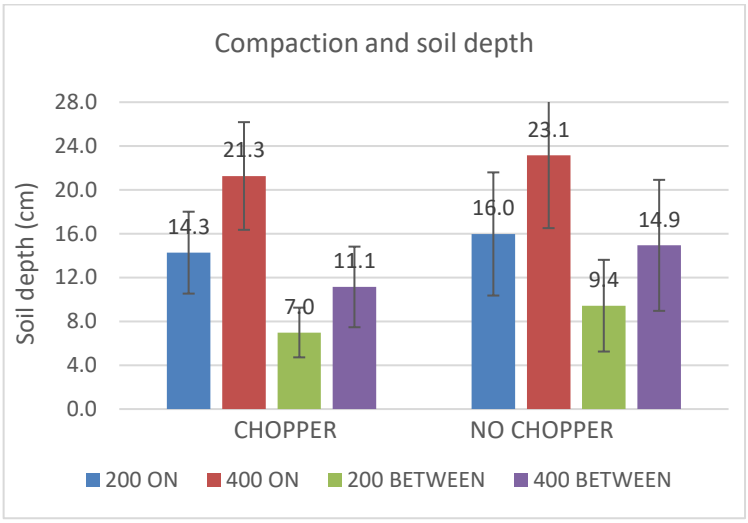

Figure 1. **The depth at which the soil compaction pressure measure of 200 psi and 400 psi were obtained between the years 2020 and 2022 at the Ubombo Sugar Estate**

The penetrometer readings on the chopper-harvested fields were found at a significantly ($P<0.05$) shallower depth than on the non-chopper harvested fields, which implies a significantly higher compaction (the analysis, which is not presented here, can be supplied on request). The findings revealed that the 200 psi penetrometer readings were found at 14.3 cm and 16.0 cm between the rows of the chopper-harvested and manually-harvested fields, respectively, and within the intra-row, it was obtained at 21.3 cm for chopper harvesting and 23.1 cm for manual harvesting. The 400 psi readings were obtained at the 7 cm and 9.4 cm inter-row of chopper-harvested and cane-cutter-harvested fields, respectively. Within the sugarcane rows of the respective systems, the 400 psi readings were obtained at a depth of 11.1 cm and 14.9 cm.

Discussion

The high level of compaction on the chopper-harvested fields, compared to the manually-cut fields, is in line with other previously-reported studies. Júnnyor *et al*. (2022) investigated the impact of different tillage practices and cover crops on soil compaction, due to mechanised sugarcane harvesting. Their investigation concluded that whatever benefits come with good tillage practices, they are countered by the mechanisation of sugarcane harvesting, in terms of soil compaction. They highlighted the fact that the soil becomes more susceptible to compaction if its structure on the surface is disrupted prior to harvesting, which is a scenario that occurs when harvesting crops such as groundnuts, if they are used as a cover crop.

In his PhD study, Tweddle (2016) recommended that losses due to sugarcane harvesting machinery should be accounted for and should be included in the standard costing methodologies of mechanisation. This should also be coupled with the cost of replanting sugarcane fields at the early ratoons, due to the accelerated deterioration of the soil structure that is caused by chopper harvesters. In a review study, Shaheb *et al*. (2021) highlighted the fact that soil compaction increases the soil's bulk density and strength, and it reduces porosity and hydraulic properties. These result in the stunted root growth of the plant, due to soil compaction which, in turn, affects the growth and development of the crop, and ultimately, the yield. Soil compaction can reduce the crop yield by up to 50%, or even more, depending upon its magnitude and severity (Shaheb *et al*., 2021).

For some decades, the benefits of mechanisation in agriculture have been documented as improving the productivity and, in some instances, reducing the costs (Júnnyor *et al*., 2022). The future projections of the reduced availability of labour and the subsequent increased costs, as well as the protection of the ozone layer and reducing the emission of greenhouse gases, have all made the mechanised harvesting of sugarcane inevitable. Therefore, despite challenges, such as soil compaction, it is imperative to put mitigation measures in place to minimise, or eliminate, the negative aspects of the practice. The issues around having the trash blanket, to enhance the ability of the soil to act like a sponge, thereby minimising the impact of compaction, as well as the operation of subsoiling, should be strategic mitigation measures to avoid soil compaction. A trash blanket will retain water in the soil for longer periods, but an adequate dry-off period of 6 to 8 weeks is necessary before harvesting, to ensure minimal compaction. The datasets of these investigations, such as those in the present study, can be crucial for simulation models, especially before engaging in highly mechanised operations. They will help to improve the preparedness of farmers, and help them to put corrective, or even preventative, measures in place before any negative results occur.

Conclusion

The study aimed to compare the level of soil compaction in chopper-harvested and manually-cut sugarcane fields. The findings revealed that soil compaction was higher in fields harvested by chopper than those harvested manually. However, the recommendation was that besides this challenge, mechanisation in agriculture is inevitable, and therefore, such mitigation and adaptation measures must be put in place. The strategic management of the trash blanket, positioning the wheel tracks, as well as subsoiling, are recommended for consideration, together with mechanised sugarcane harvesting. It was also recommended that datasets, such as those presented here, can be pivotal in the development of simulation models to reduce the soil compaction caused by agricultural mechanisation.

References

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