SHORT COMMUNICATION

SOIL COMPACTION DECISION SUPPORT

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Abstract

Soil compaction caused by in-field vehicles poses a threat to optimal cane production and overall soil sustainability. Complex soil mechanics regulate compaction, and a wide range of factors, such as axle loads, soil texture and soil moisture, determine the severity of a compaction event. As a result of the complexity and sensitivity of soil compaction, managing soil compaction is difficult and few operators in South Africa base their day-to-day decisions on an estimate of damage to the soil under the current conditions. Recent research provided a modelling tool to assist in understanding the different processes and impacts that occur during soil compaction. The model, named SOCOMO, has been verified in different countries, including South Africa, and is based on sound mechanistic principles. The aim of this short communication is to demonstrate the use of this model with respect to decision support in the South African sugar industry. Users may choose to run the model on regular intervals to estimate the potential damage posed by soil compaction, or they may use static look-up tables as a quick reference. The authors make some suggestions on how to move towards operational soil compaction management. These include the use of climate forecasts and prioritising different operations.

Keywords: soil compaction, SOCOMO model, decision support, management, model, modelling

Introduction

Soil compaction caused by in-field vehicles poses a threat to optimal cane production and overall soil sustainability. Complex soil mechanics regulate soil compaction and a wide range of factors, such as axle loads, texture and soil moisture, eventually determine the severity of a compaction event. Managing in-field transport to minimise soil compaction is therefore a difficult task, and few growers adjust their practices based on a dynamic near real-time estimate of compaction.

Marx (2006) verified the accuracy of a well recognised soil compaction model, *viz* SOCOMO (van den Akker, 2004; Trautner and Arvidsson, 2003), in a KwaZulu-Natal soil. Although further research has been recommended, the performance of the model, especially in relative terms, may already posess information valuable to sugarcane growers. As a result, Marx (2006) produced a decision support system (DSS) that could be used by non-scientists to evaluate potential soil compaction scenarios using the SOCOMO model.

The objectives of this short communication are to (i) briefly present the SOCOMO DSS, (ii) demonstrate a typical application of the model outputs and (iii) make recommendations with respect to the use of the SOCOMO DSS for different management decisions.

Model description and application

SOCOMO was developed as a research tool for agricultural engineers and scientists to investigate ways of preventing subsoil compaction and hence enhance decision making. This pseudo-analytical model, based on the soil mechanics principles of Boussinesq (1885), Fröhlich (1934) and Söhne (1958), calculates whether the subsoil will be over-stressed by a particular tyre size, axle load, inflation pressure, soil strength, bulk density and moisture conditions (van den Akker, 2004). Marx (2006) developed a user-friendly Excel interface for SOCOMO, shown in Figure 1.

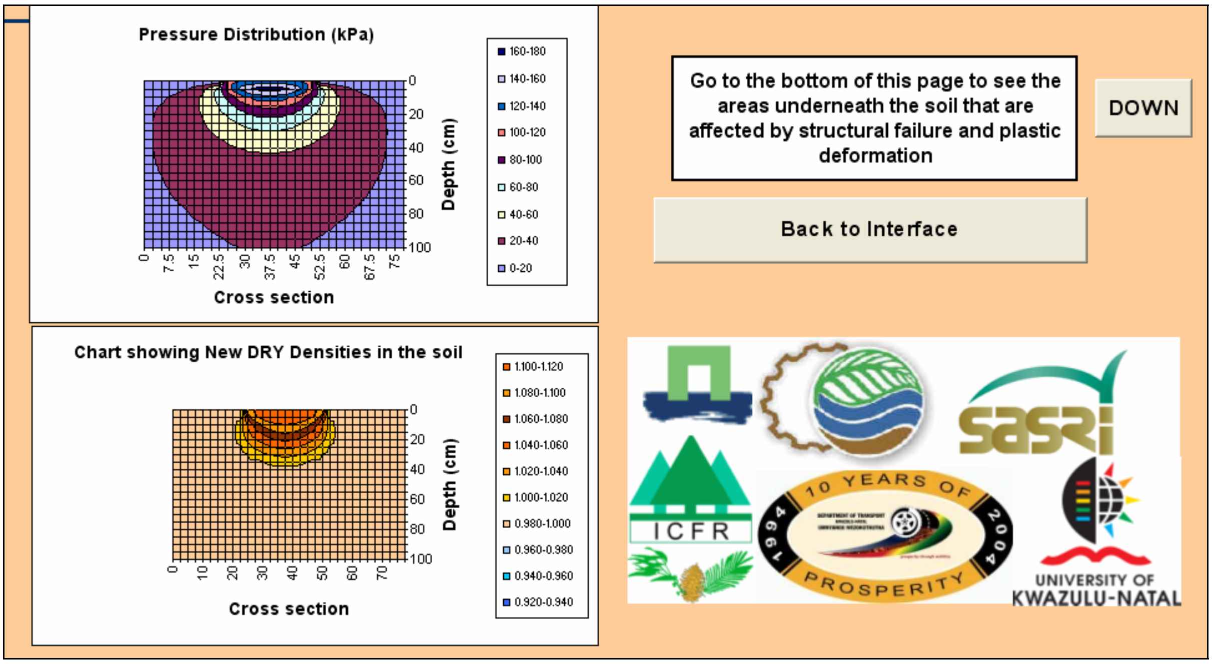

Figure 1. Example of an output screen of the Excel-based SOCOMO Decision Support System.

SOCOMO simulates the propagation of pressure into a soil profile with reasonable accuracy (RMSE = 48 kPa). Although the model does not at present account for the influences of organic matter (Marx, 2006), simulations of different situations can be compared with confidence. Figure 2 illustrates different depths of soil strength failures, and hence compaction damage, for different soils and different conditions of soil moisture content and tyre pressure. It is noteworthy that structural failure results in severe damage that will significantly reduce productivity. Plastic deformation is less serious, but should be evaluated since it often propagates deeper into the soil profile.

Growers who intend to base in-field traffic decisions on estimates of possible soil damage can use look-up tables, as shown in Figure 2, in order to select the least damaging practice for a given scenario. Based on the estimates provided, growers may decide to reduce tyre pressures, maintain lower axle loads or postpone an activity until the soil has sufficiently dried out. Estimates of soil moisture content can be measured or simulated using models and near real-time weather data, such as the www-based Canesim system (Singels and Smith, 2004). Short lead-time climate forecasts can also be used to predict whether soils are expected to become dryer or wetter during the following weeks.

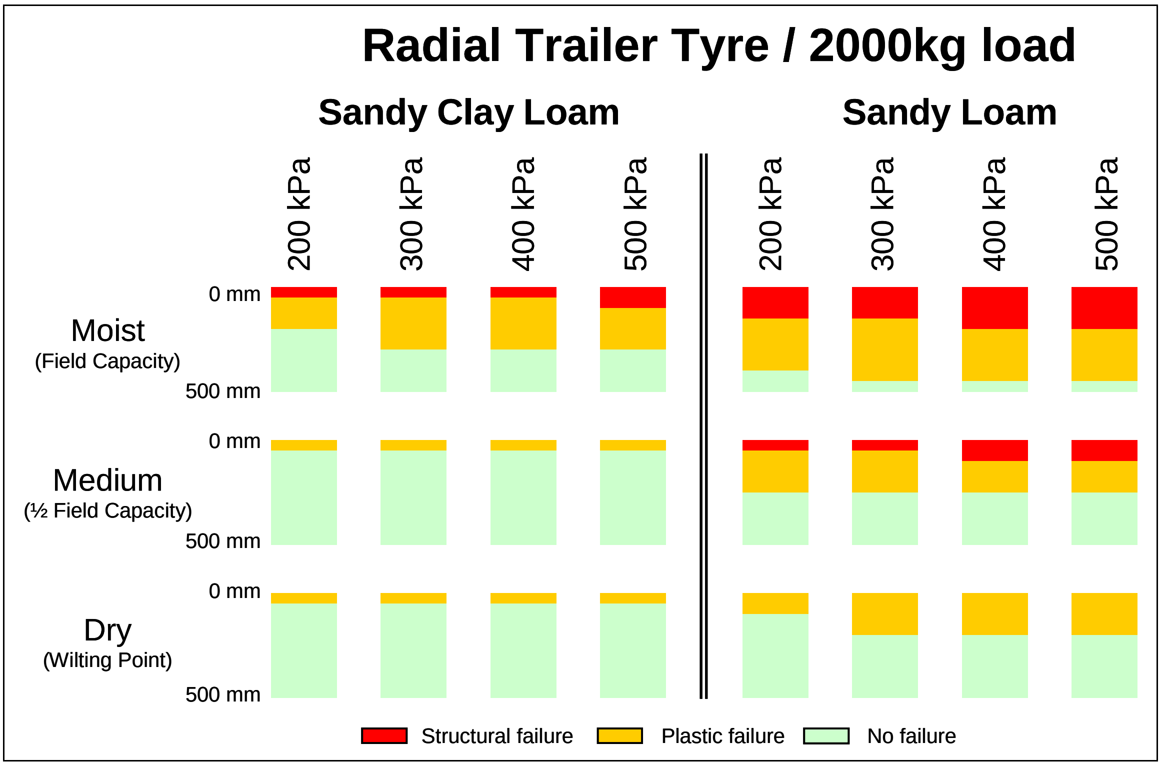

Figure 2. Soil damage profiles for permutations of different SOCOMO input variables (soil texture, moisture content and tyre inflation pressure).

Linking the depth and severity of soil compaction damage to crop productivity remains a topic for future research, and growers may need to subjectively choose certain threshold depths beyond which they wish to rather not disturb the profile. One such rule of thumb is to not allow plastic failure to occur deeper than 375 mm. The most suitable way to manage soil compaction is to follow an integrated approach that requires operating at the correct tyre inflation pressure, using the correct vehicles, choosing to operate at reasonable axle loads and using climate forecasts to tactically schedule different in-field operations.

Discussion and Conclusions

Managing in-field transport to prevent severe soil compaction remains complex. The SOCOMO model can be used to provide a reference of damage, but the impact of this damage on future crops remains unknown. Similarly, although the impacts of compaction on crop production have been proven, it remains difficult to estimate the precise economic significance of compaction preventing practices. The authors sustain their opinion that soil compaction may severely impact sustainability and that conservative measures may yield large benefits in the long term. Managing soil compaction requires an integrated approach of the correct practices in trashing, in-field vehicle manoeuvring, using less damaging vehicles and tyres and timing operations correctly with respect to soil moisture contents.

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