HARVESTING CANBUS DATA TO IMPROVE SOIL COMPACTION MANAGEMENT

NICOLAS DUBUC1, VIJAYA RAGHAVAN2, ROBERT RECKER3

1 Department of Bioresource Engineering, McGill University, Ste-Anne-de-Bellevue, Qc H9X 3V9 Canada nicolas.dubuc@mail.mcgill.ca
2 Department of Bioresource Engineering, McGill University, Ste-Anne-de-Bellevue, Qc H9X 3V9 Canada vijaya.raghavan@mcgill.ca
3 Cedar Valley Innovation LLC, Waterloo IA 50701 USA cedarvalleyinnovation@gmail.com

CSBE101284 – Presented at Section III: Equipment Engineering for Plant Production Conference

ABSTRACT Modern tractors are equipped with electronic monitoring systems (CANbus) that can provide a wealth of information on a wide variety of operational parameters. However there is currently no simple way to access and use CANbus data by farmers. One area of interest is the monitoring and mapping of soil compaction zones using data acquired on a standard tractor. The goal of this project was to assess the accuracy of standard tractor sensors to measure soil compaction, using a cone penetrometer and a single-shank subsoiler. The CANbus data was compared to impact penetrometer compaction readings to determine which mechanized compaction measurement method is the most accurate.

Keywords: CANbus, compaction, penetrometer, tillage, site-specific tillage, controlled traffic farming.

EXTENDED ABSTRACT Soil compaction is one of the major soil degradation processes to affect arable land globally. Globally it is estimated that at least 68 million hectares of farmland suffer from excessive levels of compaction (Flowers and Lal, 1998). Soil compaction has significant economic impacts resulting from yield decrease, lower product quality and uniformity and increased energy use for soil loosening and other field operations (Raghavan et al., 1994). In addition, compaction has significant environmental impacts such as increased runoff, erosion and greenhouse gas emissions.

There are two main types of soil compaction: naturally occurring compaction and human-induced compaction. The former is the result of soil physical, chemical and mineralogical properties, whereas the latter is the consequence of heavy machinery traffic, high axle loads and excessive tire inflation pressures (Hamza and Anderson, 2005). In both cases the effects of compaction far exceed physical soil degradation; soil environment is affected as a whole, with significant perturbations of soil chemical and biological processes (Raghavan et al., 1994).
Farmers have found three main strategies to fight the negative impacts of soil compaction. The first method involves using deep tillage to break up and remove any compacted layer (Hamza and Anderson, 2005). Another method is to adjust the timing of operations to benefit from ideal soil conditions; this is highly dependent on weather conditions and it may prove difficult to achieve when time-sensitive operations such as harvest need to be conducted. Finally the last method commonly used is controlled traffic farming (CTF); the goal is to restrain field traffic to dedicated traffic lanes, so that compaction affects a limited area (~15-20%) and crops benefit from an ideal uncompacted seedbed (Tullberg et al., 2007).

Some management challenges remain even when using the compaction control strategies mentioned above: there is a need for greater energy efficiency, lower operating cost and lower impact of operations on soil structure. A major hurdle remains in order to solve those challenges: you can’t manage what you can’t measure. To manage soil compaction properly and use precision agriculture tools such as site-specific tillage, it is necessary to know the spatial distribution of compaction zones, both at the field scale and within the soil profile.

There are plenty of tools available to measure soil compaction. Three main types of sensors that have been developed for this purpose: mechanical sensors (manual cone penetrometers, impact penetrometers, tractor-mounted instrumented penetrometers, instrumented coulters, etc.), acoustic sensors (recording and analyzing the sound produced during the soil fracturing process) and radiometric sensors (ground penetrating radar) (Adamchuk et al., 2004). In order to gain wide acceptance for use in precision agriculture, compaction sensor systems must be cheap, easy to use, time efficient and accurate at detecting the depth of the compacted layer. Most of the sensors mentioned above each fail to meet one or more of these criteria.

One possible avenue of interest in the development of cheap and simple sensor systems is to use tractor CANbus systems. Most modern tractors are equipped with a multitude of sensors as well as the communication networks required for proper management of vehicle data (Darr et al., 2005). Farmers could easily gather data pertaining to soil draft and resistance by using simple data logging solutions to record information on the tractor CANbus.

The goal of this research project was to evaluate the feasibility of using CANbus-based information collection for measuring soil compaction and to evaluate which measuring method detects the depth of the hardpan the most accurately and efficiently. Two main testing methods were used: measuring hitch draft sensor forces when using a 3-point hitch-mounted penetrometer probe; measuring hitch draft sensor forces when using a straight subsoiler shank at constantly varying depth.

The site where the measurements were taken is a gently rolling field (clayey silt) located in Buckingham, Iowa. The field is under controlled traffic farming since 7 years; this allowed easy segregation of naturally-occurring compaction from traffic-induced compaction.

An initial compaction survey was done using a Jornada impact penetrometer. Soil compaction profiles were produced on three 9150 mm transects spanning across a full
CTF strip; spacing between the sample sites was 375 mm and measurement depth was 600 mm.

Following the manual data collection of compaction, measurements were taken using a 3-point hitch-mounted penetrometer designed by Robert Recker (Cedar Valley Innovation LLC). The soil resistance force was transmitted from the tip of the penetrometer cone to the hitch draft sensor (torsional deflect sensor on the top link bracket). CANbus data were recorded using ATI CANlab™ data logging software on a laptop connected to the tractor and implement buses. Parameters recorded by the logger included timestamp, GPS coordinates and elevation, navigational vehicle speed, hitch position and nominal top link force. Measurements using the tractor-mounted penetrometer were made at a distance of ~2000 mm from the impact penetrometer readings. A total of 96 tractor penetrometer readings were made to a depth of 600 mm.

The second series of tests conducted consisted in pulling a straight subsoiler shank at variable depths, parallel to the CTF traffic direction. The subsoiler was lowered at a constant rate of approximately 30 mm/s. Once it reached the maximum depth of 550 mm, it was raised out of the soil and the lowering cycle was repeated again. 14 measurements runs of ~300 m each were conducted at different positions relative to the CTF wheel tracks.

Since more than 70% of the total draft force is exerted on the tip of the shank, sudden changes of draft force tend to indicate a sudden change of soil properties at the shank tip (Stafford and Hendrick, 1988). Considering that soil properties (texture, moisture) were relatively uniform across the working depth, we can postulate that most of the variation measured with the subsoiler shank results from a variation of soil bulk density, which is a key indicator of soil compaction (Liu et al., 1996). Locating the depth at which a significant sudden increase of draft force occurs would indicate the hardpan position in the soil profile.

**CONCLUSION** Using simple soil strength measurement techniques and recording data via CANbus appears to be a promising method to map the spatial distribution of compaction. The method meets the goals of simplicity and cost effectiveness, although the accuracy of the results still has to be proved.

At the time of writing this research summary, results were not yet available. They will be presented during the World Congress of the International Commission of Agricultural Engineering in Quebec City, Quebec, June 13-17, 2010.

**Acknowledgements** The authors would like to thank Clay Mitchell (The Mitchell Farm) and Dr. Matthew J. Darr (Department of Agricultural and Biosystems Engineering, Iowa State University). Mr. Mitchell contributed to this project by allowing the use of one of his field and also supplied one tractor for this research. Dr. Darr was involved in the early planning of experiments and provided technical assistance and data logging equipment. Further we would like to acknowledge the technical support of Cedar Valley Innovation LLC and the financial support of the National Science and Engineering Research Council (NSERC).
REFERENCES