Assessing compaction contributions to crop losses using a soil moisture-density gauge.

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Soil Moisture-Density Gauges are commonly used in construction and roading to monitor soil density. This enables engineers to determine that sufficient compaction has been achieved to ensure foundation stability.

This article summarises results from a Sustainable Farming Fund project co-funded by the Foundation for Arable Research and LandWISE.

LandWISE cropping trials have often found yield limitations where legacy compaction is not removed prior to establishing a new crop.

A study was undertaken to see if a soil moisture – density gauge can give a valid measure of soil density in cropping fields, whether soil density is altered by cultivation practices and if it affects yield.

Fig.1 Top view of Troxler Moisture-Density Meter

A Troxler 3440 soil moisture density gauge was used to assess soil at sites in Gisborne, Manawatu and Hawke's Bay. One key advantage of the gauge is that measurements are completed quickly (a couple of minutes) in the field. Conventional sampling requires large samples to be taken, dried for several days in a lab, and then weighed to determine density and moisture.

Results showed the Troxler can give valid measures of soil density but must be calibrated for each soil type and depth. Some physical cores must be taken and processed to allow this.

The calibration curves for two Hawke's Bay soils are shown in Figure 2. These show the relationship between gauge soil density 'estimates' and soil density measured by removing, drying and weighing soil cores.

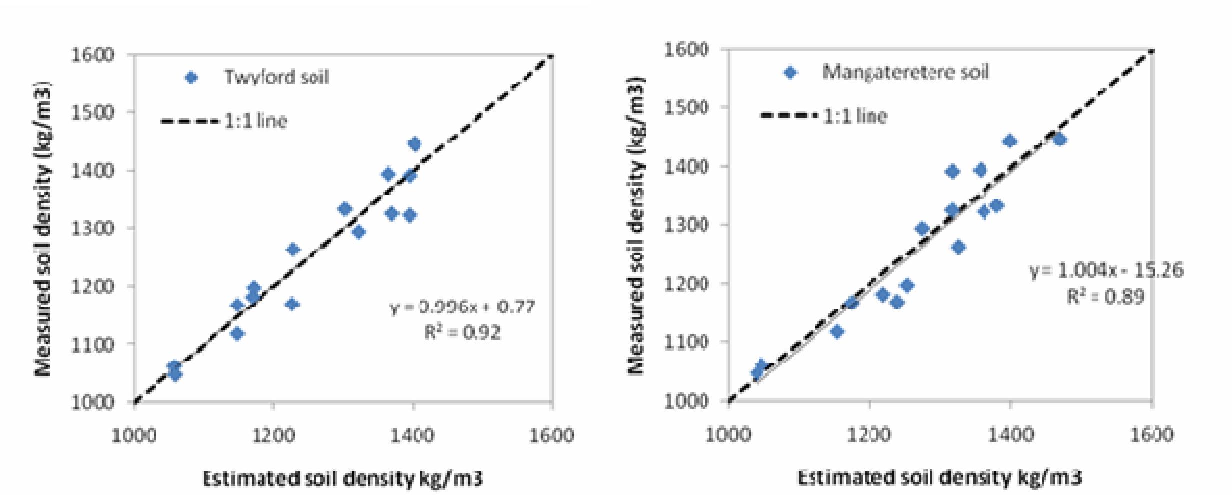

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Figure 2. Relationship between estimated soil density obtained using individually calibrated Troxler measurements and soil core measured density for Twyford and Mangateretere soils.

Once calibrated, the Troxler offers the advantage of quickly collecting a large number of soil compaction measurements at different depths, without the cost of laborious soil sampling. A draft protocol was prepared for calibration purposes

Site Assessments

The moisture-density gauge was used at four commercial cropping sites. As expected, it showed variability in soil density.

Only at one site, a maize grain trial on sandy soils, was yield limited by high soil compaction. At other sites, there was no effect of soil density on yield, but in some cases this may have been because factors other than soil density were more limiting.

Comparisons of maize silage grown under conventional cultivation and under strip-till showed conventional cultivation tended to decrease soil density in the 150-300mm soil depth. However, this decrease in density did not result in increased yields.

In a maize grain field, where deep ripping was practiced to address compaction, the same things were found; decreased soil density in the 150-300mm soil depth did not result in increased yields.

Methods Used

In the trials conducted in this project, separate density-moisture measurements were made in the in-row and inter-row positions.

Fig. 4. Position of Gauge for in-row (left) and inter-row (right) Soil Density-Moisture measurements in a strip tillage versus full cultivation trial growing maize for silage.

Comparative soil density measurements were made using a standard soil bulk density corer, taking 85mm diameter cores 150mm long. Some difficulty was experienced determining the exact depth for coring using this method, including assessing the degree of surface distortion when the corer was hammered into the soil.

Fig. 5. Sampling using bulk density soil corer: Installation (left) and extracted core (right)

How do these results compare internationally?

One overseas trial showed that soil compaction reduced maize silage yield by 13% and nitrogen uptake by 23% when penetration resistance was up to 1.5MPa (Nevens and Reheul, 2003). The yield loss was very significant and reduced nitrogen uptake left suboptimal nitrogen content in silage.

Another study used the Troxler technology to assess in-field compaction and measured yield losses of 38% from tractor compaction of no-till soya fields (Botta et al 2004). This suggests that less vigorous plants lose a greater percentage of yield, so crops such as sweetcorn and kabocha might be assumed suffering significant yield loss in compacted fields.

Soil densities at the sandy maize site were not significantly higher than at other sites. Determining how density limits yields and under what conditions is necessary for an understanding of when mitigation options will be beneficial to yields. A major factor is likely to be soil moisture content – with penetration resistance rather than density the factor controlling root development.

How does the soil moisture density gauge work?

The Troxler Moisture-Density Gauge contains two separate radioactive sources. These enable the equipment to rapidly determine both soil density and soil moisture content. While it does contain radioactive isotopes, if used correctly, no significant hazard exists from the equipment in normal operation.

The equipment uses gamma radiation emission from a cesium-137 source for soil density measurement. Detectors in the base of the gauge measure the radiation.

Gamma photons released by the source collide with electrons in the soil. This reduces the number of photons reaching the detector, and thus allows the density of the material to be calculated.

It also contains Americium 241:Beryllium which is a source of neutrons and allows determination of volumetric soil moisture content – exactly the same technology as used in agriculture to monitor moisture for irrigation.