Soil Compaction Survey and Sampling of Dairy Farms in the Goulburn Valley

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Abstract
The objectives of this survey and sampling were to quantify the levels of soil compaction in Goulburn valley loams and identify if these levels may have be reducing pasture growth in 2017. The survey also sought to find the extent of soil compaction caused by high stocking rates of cattle on dairy pastures in 2016. Eleven farms across the Goulburn valley were selected to be representative of differing areas in the valley. These farms were selected because they had a paddock(s) which had been severely impacted by large numbers of cattle where pasture had been destroyed and the soil structure damaged. Soil Bulk density (BD) in g/cm^3 was measured to indicate the level of soil compaction in the paddocks with severely impacted soil and compared with areas of the same or similar soil type where there had been little or no effect on the soil from cattle. These paddocks were analysed for soil fertility, pH and salinity. The paddocks were identified by soil type and group. Typically the soils tested were loams or sandy loams which were able to withstand high stocking rates. On average these soils had low calcium to magnesium ratios and low levels of sodium. The BD levels were measured at two depths, 0-10 cm (surface soil) and 10-20 cm (root zone). This study found that for 80% of the farms sampled, BD in the 10-20 cm zone was 1.6g/cm^3 or greater. According to Taylor and Brar (1991) at this level of BD plant root growth can be severely inhibited because the soil is so tightly compacted. Analysis of the relationships between BD and calcium, sodium, soil type, soil texture and soil organic carbon (SOC) found that the correlation of BD with SOC was reasonably strong while all the other correlations were weak. This meant that where the SOC content was high the BD levels were low. When BD was plotted against SOC for both the compacted and non-compacted soils a difference of around 8% was consistently found which is attributed to the effect of the cattle.

A phone survey was undertaken to sample fifty dairy farmers in the Goulburn valley to investigate the methods used to prevent damage to pasture and remediate the soil from damage caused by cattle. The survey also sort to find the level of understanding on the impact of soil compaction on pasture production. Prevention of soil damage by the cattle was by far the most popular method using feed pads, sacrifice paddocks and non-arable land. Prevention methods were regarded as the best method of moderating lost production from excessively wet conditions. Very little work was done to remediate soil and the farmers' understanding of the impact of soil compaction was low.

Keywords
BD, SOC, Field Capacity

Introduction
This research project was undertaken following field observations by the author of slow and restricted pasture growth on several dairy farms during the winter of 2017. The fertility of these impaired paddocks was measured and found to be sufficient for good growth but soil compaction was unknown and may have been a factor in reducing pasture production.

The winter of 2016 recorded 192 mm of rain in excess of the seasonal average of 260 mm for this region. This additional rain meant that farmers had to prevent damage to pastures as soils were at field capacity. A common method was to use a "sacrifice paddock" where one paddock is highly stocked and the cattle hand fed to prevent damage to the rest of the pasture. These paddocks appeared to be structurally damaged and the soil compacted by the stock. Soil compaction not only effects root development but reduces water infiltration which in turn means lower pasture production and increased water use which has a major impact on the productivity of the farm.

Northern Victorian dairy farmers often measure soil fertility and acidity of their soils but they rarely measure BD which may have as great an impact on pasture production as fertility according to Greenland (1991). Therefore measuring BD may enable dairy farmers and agronomists to gain an insight into how it effects pasture production and also how irrigation water may be used more efficiently through amending soil structure.

This project set out to establish the levels of soil compaction in farms where there had been high stocking rates in 2016. These levels would be compared to the same soil type that was not compacted to establish at what level the cattle attributed to the soil compaction. Measuring BD levels would also indicate if pasture root development was being impeded. A phone survey of the farmers would indicate the level of understanding of the impact of soil compaction on pasture production and management strategies used during 2016.

Methods

Eleven farms were chosen across the Goulburn valley to be part of the soil survey. Each farm was selected on the basis of having a paddock which had been used as a "sacrifice paddock" and also an area with the same soil type where stock had no impact.

Three BD measurements were made on the 0-10 cm depth and at the 10-20 cm depth in the areas of high and low impact cattle traffic, making a total of 12 BD samples for each farm. A volumetric ring was driven in to the soil and dry weight recorded to obtain the g/cm^3 BD.

The soils sampled were mostly loams as clay soils were not used as sacrifice paddocks due to their delicate structure which is easily damaged by stock in wet conditions. Sand is ideal for sacrifice paddocks as it can resist structural damage from high stocking rates because it resists compaction. Loams were used for high stocking rates where sandy soil was unavailable. They can resist compaction to a degree but will lose structure under high stocking rates when the soil is at field capacity. The loams surveyed were; Moira, Shepparton Fine Sandy, Waaia, Lemnos, Naring, Goulburn, Congupna and Boosey (McKenzie et al. 2002). All the sampled soils were analysed for nutrients, pH and SOC to establish a relationship between these attributes and soil compaction.

A phone survey consisting of nine questions was conducted to examine methods used by fifty Goulburn Valley dairy farmers to prevent and remediate soil compaction during the winter of 2016. The results would indicate which methods were most successful. The survey also sort to ascertain the farmers perception of which factors were most important in obtaining maximum pasture growth in winter.

Results

Figure 1 shows the location of the sampled farms across the Goulburn Valley. These farms were selected because they had a paddock or paddocks that had been severely impacted by stock during the winter of 2016.

Figure 1. Location of the dairy farms chosen to measure BD at 0-10 cm and 10-20 cm depths

Figure 2 shows the BD levels of all the soils sampled. It can be noted that in nine of the eleven sites the BD levels in 10-20 cm zone were above the level of 1.6g/cm^3 which according to Taylor and Brar (1991) is at levels which impede root growth in loam soils. There were some anomalies where the compacted soil (high stocking rate) had lower levels of BD than the good soil (no stock). In these instances the SOC was higher in the compacted soil.

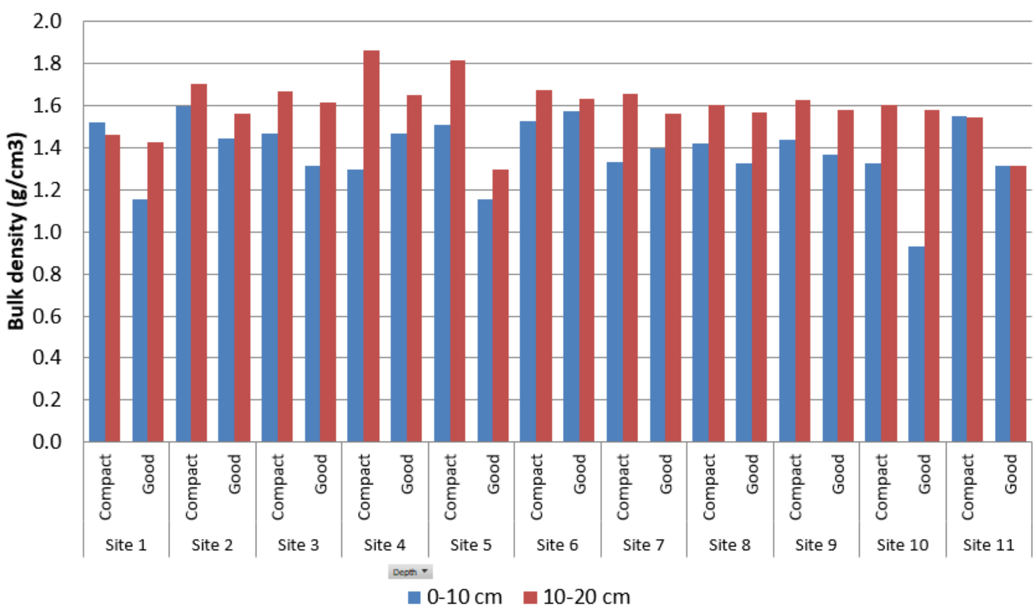

Figure 2. Bulk density (0-10 cm and 10-20 cm) for the eleven farms sampled in the Goulburn Valley

In Figure 3 the BD is plotted against SOC for both the compacted and the good (non-compacted) soil. This negative correlation between SOC and BD where the higher the SOC the lower the BD has enabled the difference between the compacted and "good" soil to be established. This difference is around 8% overall and represents the impact of the cattle on the sampled soils.

Discussion/Conclusion

This survey found that 80% of the farms surveyed had BD levels of 1.6g/cm^3 or more in the 10-20 cm zone which is where the roots develop according to Taylor and Brar (1991) this would reduce root development which in turn may impact on pasture yield. Cockcroft and Dillon (2004) state that BD and therefore soil compaction increases with depth which is supported by the findings (Figure 2). It can be seen that only in Site 2 were the BD levels high in the 0-10 cm zone. The 10-20 cm zone was higher than the 0-10 cm zone in most cases except Site 1 in the compacted soil and in Site 11 where it was equivalent. The question raised by the findings of high compaction levels in the root zone of these soils is how much does this impact on water infiltration and root development?

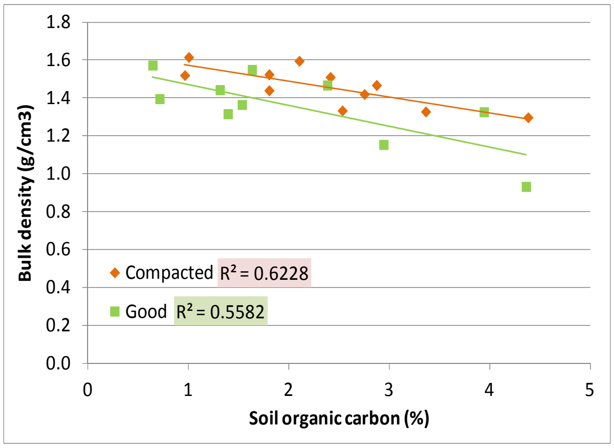

Figure 3. The relationship between BD and SOC and the difference between the compacted soil and the non-compacted/good soil is the impact of the cattle on BD

This survey also discovered the high negative correlation between BD and SOC (Figure 3) in these soils which is supported by Greenland (1981) and Cockcroft and Dillon (2004) and suggests that even with these soils at field capacity and high stocking rates of cattle, compaction can be mitigated by using organic matter. At least one of the 50 farmers surveyed was aware of this relationship and had used “green waste” to lessen the effect of high stocking rates in the sacrifice paddocks. The use of the negative correlation between SOC and BD enabled the calculation of the compaction effect on these soils by the cattle. This has been rounded up to 8% which is surprising given the weight of these animals which average about 500kg/cow, the levels of soil moisture and the visual appearance of the paddocks. However Bell et al. (2011) found with their work on sheep grazing cereal paddocks that the impact of the sheep was minimal and that the levels of compaction were limited to some ponding of soil.

The phone survey found that although the farmers used strategies that reduced compaction such as removing animals from grazing the pasture with sacrifice paddocks, feed pads and non-arable land, these strategies were about saving the plants from destruction by the hooves of the cattle. Few farmers equated the relationship between SOC and BD and none had measured BD or were aware of the impact of soil compaction on root growth.

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