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Physics

SOIL COMPACTION—TASMANIA

Key points

- In agricultural soils, compaction is caused by compression from machinery traffic or stock trampling.
- Poor root growth and swollen root tips can indicate a compacted layer, usually between 10 and 40 cm.
- Nearly 70 percent of the compaction caused by wheel traffic occurs on the first pass. This is the basis for adoption of controlled traffic farming.
- Prevention of compaction is better than treating it.

Background

Soil compaction is the process of increasing the density of soil by packing the soil particles closer together causing a reduction in the volume of air. Soil water acts as a lubricant increasing compaction when a load is imposed on the soil. If near saturation, however, the load is likely to exceed the soil strength and bearing capacity, resulting in excessive wheel slippage and rutting as well as soil mixing and smearing. It has been estimated that, given conventional tillage practices and other planting-harvesting farm operations, as much as 90% of a paddock will be wheel tracked on an annual basis and that much of the area receives 4 or 5 wheel passes.

Compaction usually results in less plant root proliferation in the soil and lowers the rate of water and air movement. Because of the root restriction the amount of water available to the crop is often decreased. Slower internal drainage results in poorer subsurface drain performance, longer periods of time when the soil is too wet for tillage following rainfall or water application, increased denitrification and decreased crop production. Increased compaction also adds to the energy consumption by tractors for subsequent tillage.

Most effects of compaction are detrimental. However, in some cases, slight compaction near seeds can aid germination and improve plant growth in times of low soil moisture caused by low rainfall or low water-holding capacity soils.

Deep soil compaction

Deep soil compaction is excessive soil compaction below the normal annual tillage depth, usually 15–20 cm. It is of greater concern than near surface compaction because it is a difficult problem to solve and may take many years, or even decades, under vigorous pasture to rehabilitate.

Research on Tasmanian soils has shown that deep sandy soils are prone to deep soil compaction at 20–40 cm depth (figure 1). This has been associated with the use of heavy pea and potato harvesters when the soils are moist or wet. Near surface compaction (0–5 cm) occurs on other soils, which results in the formation of clods and restricted root growth. Near surface compaction can be relieved relatively easily and is likely to be short lived.

The volume of soil compacted by a wheel pass varies with soil type, soil moisture, tire size, pressure and total load. Pressures are transmitted deeper into wet soil than in dry soil by the same tyre size and wheel load.

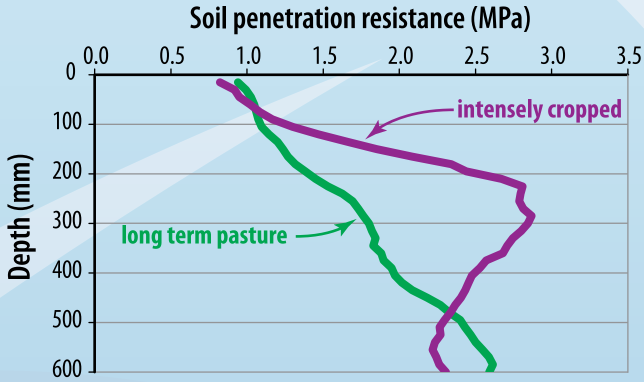


Figure 1: *Plot showing the difference in penetration resistance between a long term pasture (green) and an intensely cropped (purple) deep sand.*

Detecting soil compaction

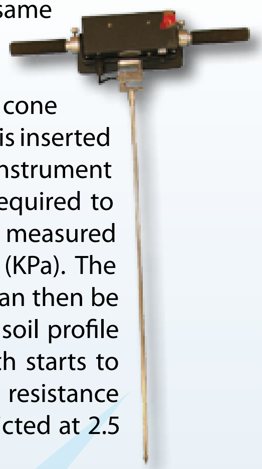
Visual observation

Dig a small pit crossing the crop root zone, use a knife to examine the rooting pattern and test the resistance to penetration. Note denser zones of soil and see if they coincide with a reduction in root growth. By examining the soil profile it is possible to identify a compacted soil layer because it is physically stronger (harder) and more dense than the soil above or below it. Compacted layers often have distinct massive or blocky appearance and are a clearly defined horizontal layer that occurs between 10 and 40 cm.

Hand probe or shovel

This method measures compaction by the resistance encountered as you push down through the soil. It is useful for detecting dense soil layers that may resist root penetration or growth. Hand probes are basically steel rods that are pushed into the soil by hand. Compacted layers are more difficult to push through, and easier once past the compacted zone. Hand probes can be made from steel rod (about 8–10 mm diameter) or heavy gauge (3 mm) fencing wire about 40 cm long with one end looped to make a handle. Depth increments can be added.

Cone penetrometer



A cone penetrometer works by the same principle as the hand probe except that it measures and records the force required to insert a standard sized cone into the soil profile. The penetrometer is inserted at a steady speed by hand and the instrument uses a gauge to measure the force required to penetrate the soil at a given depth, measured in megapascals (MPa) or kilopascals (KPa). The data are stored in a data logger and can then be downloaded and the strength of the soil profile assessed. In general, crop root growth starts to be restricted when the penetration resistance exceeds 1.5 MPa and is severely restricted at 2.5 MPa or more.

All three methods above are relative tests, and should be compared to areas with similar soils and where compaction is known not to be a problem.

Higher bulk density

Bulk density is measured with constant volume rings (see Bulk Density—Measuring fact sheet). The significance of bulk density depends on the soil texture (table 1).

Table 1: *Rough guidelines for the minimum bulk density at which a root restricting condition will occur for various soil textures.*

TEXTURE	BULK DENSITY (g/cm³)
Coarse, medium, and fine sand and loamy sands	1.80
Sandy loams	1.75
Loam, sandy clay loam	1.70
Clay loam	1.65
Sandy clay	1.60
Clay	1.40

Management of subsoil compaction

Varying the annual tillage depth

This will deal with tillage-induced compaction layers occurring just below the normal working depth of the primary tillage implement. The tillage depth is decreased in a wet year and is increased in a year when soil is dry enough to shatter a compacted layer.

Crop rotation and growing vigorous pasture

This is normally a long-term method of reducing compaction. A diverse rotation is essential to stabilise and build soil aggregates. Crops should include both deep rooted and fibrous rooted crops.

Deep ripping

Deep ripping involves breaking up the hard pan using strong tynes usually to a depth of 30–40 cm. This should be attempted only when soil is moist to dry and crumbles at the depth you are ripping. Operating depth should be no more than a few centimetres below the zone of compaction because operating any deeper uses more energy and risks the potential of deeper compaction. Yield benefits resulting from ripping have been measured for various soil types ranging from sands to clay loams but in heavier textured soils benefits can sometimes be short lived due to re-compaction by machinery.

Ways to reduce and prevent compaction

Since compaction problems are likely to persist for a prolonged period of time, the best defence is avoiding the problem altogether.

- Schedule farm operations, such as spreading fertiliser, to avoid working paddocks when wet. The soil should break easily and crumble at the deepest depth as it is being tilled. Dry soil will compact less than moist soil.
- Reduce secondary tillage passes as each additional tillage pass destroys aggregates and increases bulk density. Ideally, adopt minimum or zero tillage systems.
- Control traffic patterns using tramlines, as under conventional tillage systems as much as 90% of the land area can be tracked at least once.
- Remove excess weight on machinery and use only enough ballast to reduce slippage.
- Reduce surface pressure by reducing tyre pressure or by using lighter axle loads. Subsoil compaction increases dramatically with axle loads of greater than 5 tonnes.
- Traction versus compaction. A long narrow footprint is preferable to a short wide track (i.e. dual wheels). This can be accomplished by: using larger diameter tyres; replacing bias tyres with radials; using tandem axles; using 4-wheel drive or tracked vehicles.
- Avoid loaded trucks on paddocks and overloaded crop wagons.
- Improve drainage as this reduces the risk of being forced to work wet fields.

Further reading and references

Delroy ND, Bowden JW (1986) Effect of deep ripping, the previous crop, and applied nitrogen on the growth and yield of a wheat crop. *Australian Journal of Experimental Agriculture* **26:** 469-479.

Greacen EL and Williams J (1983) Physical properties and water relations. In 'SOILS an Australian view point.' CSIRO/Academic Press pp 499-530.

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