SUBSURFACE COMPACTION—NEW SOUTH WALES

Key points
- Soil compaction is caused by compression from machinery traffic or stock trampling.
- Poor root growth and swollen root tips can indicate a compacted layer (hardpan), usually between 10 and 40 cm.
- Prevention of compaction through adoption of controlled traffic farming can minimise yield penalties.

Background
The majority of agricultural soils in Australia have developed subsoil physical constraints, in particular compaction (Greacen & Williams, 1983). Subsurface compaction is caused by compression from agricultural machinery traffic with the compacted layer forming between 10 and 40 centimetres. In contrast, compaction from stock trampling is confined to the surface 15 cm of soil. In addition to compaction, hard layers can form as a result of natural soil packing and chemical cementation processes and these may occur throughout the soil profile. These hard layers slow or in extreme cases prevent root growth and restrict root access to water and nutrients.

Detecting soil compaction

Visual observation
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 (figure 1) and are clearly defined horizontal layer that occurs between 10 and 40 cm.

In loam, sandy clay loam and clay soil, a hardpan will often fracture into large clods when dug up which can only be broken with some force. Plant indicators include; poor root growth, swollen root tips and horizontal root growth as roots try to force their way through compacted soils. Roots growing through compacted soils can be confined to macropores, soil fractures or be at a reduced density.

Hand probe
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. This needs to be done when the soil is wet to depth (preferably the upper drained limit) as many soils become hard when dry regardless of compaction status. 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 mega- (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.

Penetration resistance has been related to crop root growth in wet soils close to the drained upper limit. 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. In spring when the soil surface layers have been re-wet, the soil may still contain dry subsurface layers that resist a probe or penetrometer. Soils can be wet up before using a probe or penetrometer but it is essential to make sure the soil is wet deep enough to detect the compaction layer.

Management of subsoil compaction
Some cropping soils in NSW have strong shrink–swell characteristics. These deep cracking clays (vertosols) have some capacity to recover from compaction through natural wetting and drying cycles. Managers of other cropping
soils need to consider techniques to remediate existing compaction as well as reducing further compaction in the future.

Deep ripping involves breaking up the hard pan using strong tynes usually to a depth of 30–40 cm (figure 3). Removal of these compacted layers by ripping has been shown to increase root growth rate from 0.5–1.5 cm/day through the compaction pan of yellow sandy earths (Delroy and Bowden, 1986). This allows the roots to better utilise nitrogen and water as it moves down the soil profile. In high and medium rainfall areas this has proven very successful with average yield increases of 22–37% for wheat (Davies et al., 2006; Jarvis, 2000). However it should be noted that negative responses to deep ripping can occur when there is a dry finish to the season and the bigger deep ripped crops have used the available soil water faster, leaving little water for grain filling.

Other methods of removing the compaction, such as the use of deep tillage points and deep working at seeding, can also be successful and cost less as they don’t involve a separate operation. Subsurface clay in shallow duplex soils and gravel layers can resist a penetrometer or probe but these soils are less likely to respond to ripping.

Deep working of sodic subsoils requires caution, in some circumstances it can be beneficial, but can also lead to collapse and worsening of soil structure. Gypsum can be applied at the time of working to reduce this risk.

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 (Hamza & Anderson, 2003). On a heavy clay soil in central NSW soil under wheeltracks showed evidence of recompaction within 1 year, and compaction returned to it’s previous extent within 4 years following deep ripping (Dear et al. 2005).

Prevention of compaction by restricting traffic to tramlines increases the duration of benefits of ripping, and can increase yields. Most of this is attributed to reduced compaction with some additional benefits from reduced crop damage.

**Crop sensitivity**
The yields of some crops are more affected by compacted subsoils than others. Table 1 shows a comparison of the effects of compacted conditions in canola and wheat in a heavy clay soil.

<table>
<thead>
<tr>
<th>CANOLA</th>
<th>WHEAT</th>
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<tbody>
<tr>
<td>WHEEL</td>
<td>NON-WHEEL</td>
</tr>
<tr>
<td>Bulk density (mg/m$^3$)</td>
<td>1.58</td>
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<tr>
<td>Air filled porosity (cm$^3$/cm$^3$)</td>
<td>0.07</td>
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<tr>
<td>Root mass (g 10$^6$/cm$^3$)</td>
<td>9.2</td>
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<tr>
<td>Crop biomass (t/ha)</td>
<td>4.7</td>
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<tr>
<td>Grain yield (t/ha)</td>
<td>1.1</td>
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</tbody>
</table>

**Further reading and references**

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