

## Diagnosing high soil strength in sandy soils

High soil strength can be caused by compaction and/or hard setting and can severely limit plant root penetration through the soil, preventing access to deep reserves of soil moisture and nutrients. A hydraulic cone penetrometer is the simplest tool to use to measure soil strength. It measures the force required to insert a standard cone into the soil, reported as either kiloPascals (kPa) or megaPascals (1 MPa = 1000 kPa). Follow the method outlined in Table 1 to measure soil strength and use the diagnostic criteria in Table 2 to assess the severity and assign a Sandbox rank for each paddock diagnostic zone.

**Table 1. Testing methods to measure hard or compacted soil layers using a penetrometer.**

<b>EQUIPMENT</b>	<ul style="list-style-type: none"> <li>Hydraulic Cone Penetrometer</li> </ul>
<b>PREPARATION</b>	<ul style="list-style-type: none"> <li>Identify three to five distinct paddock diagnostic zones using yield maps, aerial imagery or soil sensing technologies.</li> </ul> <p><b>WET CONDITIONS</b></p> <ul style="list-style-type: none"> <li>Ideally, conduct assessments when the soil profile is uniformly wet (but not saturated), typically in the winter months.</li> </ul> <p><b>DRY CONDITIONS</b></p> <p>If the soil is dry when wanting to test:</p> <ul style="list-style-type: none"> <li>Wet up an area in each diagnostic zone</li> <li>Use a large bucket or tub with 2mm holes in the bottom.</li> <li>Trim any standing stubble back to ground level, being careful not to disturb the root system. Place a piece of coarse cloth on the ground, place the bucket on top and backfill around the base of the bucket with soil.</li> <li>Fill the bucket with water and allow to drain, leaving for a day before testing.</li> <li>After using the penetrometer, dig down to the testing depth to check that the wetting was uniform through the profile.</li> </ul>
<b>TESTING</b>	<ul style="list-style-type: none"> <li>Insert the penetrometer into the soil at a steady speed of 3 cm per second.</li> <li>Note the depth where the penetration resistance (PR) reaches 1.5 MPa and 2.5 MPa. Continue to insert the penetrometer and note the maximum PR, and the depth at which it occurs.</li> <li>Repeat several times in the surrounding area to gauge the average depths and severity.</li> <li>Repeat in 3 to 5 locations within each diagnostic zone.</li> <li>Compare readings to un-trafficked areas, such as along fence lines or in native vegetation and avoid wheel tracks and headlands.</li> <li>Penetrometers are unsuitable for use in soils with more than 10-15% gravel and may be difficult to use in dense high clay soils.</li> </ul>

**Table 2. Severity of penetration resistance**, as measured using a hydraulic cone penetrometer. High soil strength may also be detected by inspecting open soil pits, with the degree of soil consolidation and lack of roots indicating soil physical constraints.

Sandbox Rank	Severity	Penetration resistance (MPa)	Degree of consolidation	Effect on Root Growth
0	Not compacted	<0.50	Loose	Not affected
0	Mild	0.50 - 1.5	Medium	Root growth on some cereal plants in restricted.
1	Moderate	1.50 - 2.50	Dense	Root growth on most plants starts to be restricted.
2	Severe	2.50 - 3.50	Very dense	Root growth restricted to existing pores or weak planes.
2	Extreme	>3.50	Extremely dense	Significant compaction present. Root growth virtually stops.

For further information on compacted and hard setting soils, along with how to test using a penetrometer, refer to the Soil Quality: 6 Soil Compaction e-book<sup>3</sup> <https://books.apple.com/au/book/soil-quality-6-soil-compaction/id1581017530>