Soil compaction

Compacted soils cannot function healthily, resulting in poor crop establishment and lower crop yields. There is also less infiltration of rainfall, increased runoff and soil erosion.

Solutions are available to reduce compaction—resulting in a healthier soil with greater biological activity and improved yields.

Causes of soil compaction

Soil compaction occurs when soil density is increased by an energy input into moist or wet soil. The force may be exerted by tyres, tillage tools or animal hooves (Figure 1).

In conventional tillage systems, most of the surface area of a paddock receives at least one wheel pass during a fallow. The first pass of a tractor wheel can create 90 per cent of the damage caused by five passes. Most compaction occurs in the top 20−30 centimetres of the soil.

Repeated tillage at the same depth can form a hardpan—a dense, impenetrable layer beneath the tilled soil.

The most important factor determining the extent and severity of soil compaction is the moisture content at the time of tyre or implement passage. Other factors like implement design and tyre-inflation pressures are important although secondary to soil moisture content.

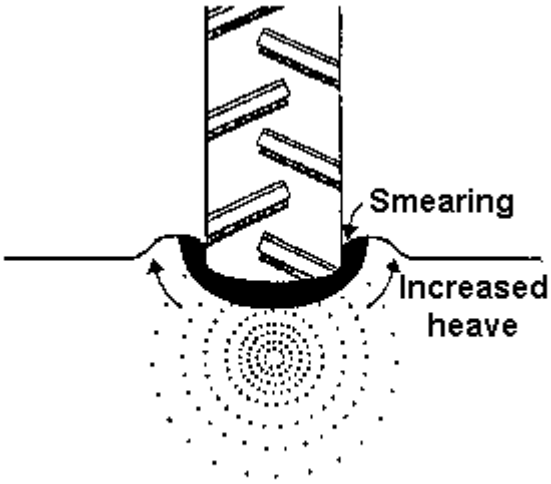

Figure 1. Soil reaction to the forces exerted by a tractor tyre

Impact of soil compaction

Compacted soil lacks the interconnected air spaces that are essential to the movement of water, gases and plant roots, and critical for a biologically healthy soil.

In dry years, crop yields are most affected when plant roots are unable to penetrate compacted layers to enable access to much needed subsoil water. Water-use efficiency is greatly reduced as rain or irrigation water is unable to penetrate the compacted layers of soil to re-fill the subsoil. This results in more run-off and evaporation.

Compacted soil requires more horsepower (and fuel) to cultivate. Planting implements are less effective in compacted soil and poor germination is the result. Fertiliser efficiency is also reduced as the large blocks of compacted soil provide few surfaces to retain and release fertiliser for crop growth.

Most degradation in grazing lands occurs when surface cover is removed as a result of high grazing pressures. This exposes soils to raindrop impact, runoff and soil loss by erosion.

Animal hooves are often blamed for causing soil compaction, however, animals such as rabbits can cause extensive damage when they remove all of the surface cover in a concentrated area. In a well-managed pasture, animal hooves will not have an adverse impact on soils.

Evidence of compaction

On the soil surface

Symptoms to look for include:

- increased soil cloddiness
- surface clods that resist breaking down after rain or cultivation
- water ponding in tracks and headlands
- wheel tracks with a smeared appearance
- poor crop establishment in wheel tracks
- crop lodging, uneven plant growth and uneven ripening of the crop.

Under the soil surface

Using a shovel, clear back the loose topsoil and dig into the subsoil.

Symptoms to look for include:

- a hard zone below the depth of cultivation (but note that moist soil will be soft, though still compacted)
- soil that remains in hard clods when you try to break it apart
- soil that appears to have no structure
- flat, dull faces on soil structure units
- distorted crop root systems (referred to as ‘right angle disease’).

Whenever a layer of loose cultivated soil is stripped away by erosion, a compacted layer showing evidence of wheel tracks is often exposed.

Susceptible soils

Clay soils are most susceptible to compaction because their fine particles hold more water for longer periods than sand or loam. As a result, clay soils remain in a plastic state, sometimes for the whole year, which means they will compress and shear when a load is applied to them.

Avoiding soil compaction

The following practices can minimise soil compaction:

- reducing the number of tillage operations (preferably by adopting a zero tillage system)
- avoiding traffic and tillage when the soil is moist or wet—planting and weed control are two high-risk times as they usually follow good rainfall.
- using the ‘plastic limit test’ (if a three millimetre diameter rod of a clay soil can be rolled out, then the soil is too wet for cultivation)
- reducing the compacted area by confining as many tillage and traffic operations to the same wheel tracks (a practice known as ‘controlled traffic farming' or ‘tramline farming’)
- using large diameter, narrower tyres, which compact less area than small wide tyres or dual tyres

- using flotation low pressure tyres on all equipment, especially tractors, harvesters and haul out vehicles (if narrow tyres aren't feasible)
- restricting field bins and trucks to the edge of the paddock during harvest times.

Restoring damaged areas

Repair options can be biological or mechanical or a combination of both.

While clay soils are most susceptible to compaction, many have an in-built mechanism to repair structure degradation. They swell and shrink on wetting and drying, which breaks up the compacted soil.

Crop roots create soil pores and promote the formation of cracks in cracking soils. This ‘biological ripping’ is a risk-free form of repairing soil compaction. The best response is gained by rotating crops or growing ‘break crops’ to give different rooting patterns.

Cultivation when the soil is dry will hasten the natural breakdown of clods. This tillage needs to be shallow so that deeper (and usually wetter) soil is not compacted. Before starting, check the soil moisture profile to at least cultivation depth to ensure the soil is dry and that it will fracture rather than smear.

Deep ripping should only be used as a last resort. Ripping moist to wet soil will cause further smearing and compaction. If the soil is dry enough to deep rip, the paddock should be cultivated first to leave some loose soil on the surface. This makes subsequent tillage operations more comfortable for the operator and helps restore the seedbed to a reasonable tilth more rapidly.

Further information

This and other science notes are available from the Queensland Government website www.qld.gov.au – search ‘science notes’. For further information about this science notes series phone **13 QGOV** (13 74 68) – ask for science notes – Land series L84. Other science notes related to this topic include:

- L146—Controlled traffic farming – soil conservation considerations for extensive cropping

For further information on soil compaction visit http://www.qld.gov.au/environment/land/soil/soil-health/compaction/ , or email soils@qld.gov.au.