

## Good soil structure ensures crops and pastures are able to explore the soil for moisture and nutrients and maximise their yield potential.

Well structured soils have adequate spaces (pores) between the aggregates, allowing water and air to enter the soil. The soil should also drain easily, while holding enough moisture to maintain plant growth. Poorly structured soils have few aggregates and few pores between the soil particles.



*Good top soil structure resulting from practising conservation farming (Photos: Ian Toole)*



*Poor top soil structure caused by multiple tillage (Photos: Ian Toole)*

## Soil structure

### Factors that improve soil structure:

- Organic matter helps bind and stabilise the soil.
- Tap-roots create large channels which, when the roots decay, provide ready access for water, air and new plant roots to the sub-soil.
- Fibrous roots are useful for binding the soil. When these roots die, their remains become part of the organic matter.
- Calcium, in the form of gypsum, can help to improve a soil's structure if the soil is dispersive. Dispersive soil tends to collapse into individual soil particles: sand, silt and clay.
- Conservation farming techniques such as stubble retention, reduced tillage, and maintaining groundcover help soil structure.

### Factors that destroy soil structure:

- Multiple cultivations, especially if soil is too wet or dry
- Long bare fallows
- Grazing when soil is wet or has minimal groundcover.

The red soils in the Western Catchment have inherently poor structure, especially the sub-soil. These soils are referred to as 'massive'.

## Crusting and hard-setting

Crusting and hard-setting are two soil processes that may or may not occur at the same time.

Soils that **hard-set** undergo structural breakdown after wetting and then set to a hard structureless mass when dry.

Soils that **crust** also undergo structural breakdown after wetting and/or with raindrop impact and seal and form a crust. In this case the underlying soil may not undergo structural breakdown and its aggregate integrity may be retained.

The causes of hard-setting and crusting are usually a combination of management impacts such as excessive cultivation, hoof impact, low organic matter and soil texture.

Soil texture is a good predictor as to whether a soil will hard-set. If a soil is a silty clay loam or a clay loam, the result will be worse as the small amount of existing clay will block pores. The resulting soil will have close-packed aggregates with very small pores. When the

soil dries, it becomes very hard because of this tightly packed structure.

Higher soil strengths found in the red soils around Nyngan and Condobolin are related to the high percentage of silt and fine sand particles. If the soil has high amounts of fine sand and silt particles and has been subject to more than two crops in a row (increasing number of cultivations) then the soil has a high potential to set hard (Khu and Chan 1993).

Effective management of hard-setting and crusting soils includes increasing groundcover and organic matter and reducing cultivation.

In other soils, such as self-mulching, cracking clays, crusting is not such a problem. These soils slake into small aggregates when wet which can join together in a thin, weak crust. However on drying, the crust shrinks and small cracks form.

## Preventing crusting and hard-setting

Organic matter provides bonds that stabilise a soil. There is less crusting if these bonds are in place. A pasture phase is often the most effective way to incorporate organic matter into the soil.

Increased organic matter and reduced tillage also encourage soil animals such as earthworms that burrow and therefore create pores. They also recycle nutrients by breaking down organic matter from the surface and incorporating it into the soil profile.

Management practices that promote organic matter build-up and avoid structural degradation should be implemented to reduce the risk of crusting and hard-setting.

### Recommended practices are:

- avoiding cultivating or driving in paddocks when the soil is too wet
- avoiding cultivation when the paddock is too dry
- adopting chemical fallowing and other reduced tillage practices
- establishing a vigorous pasture
- avoiding stocking fallows.

## Sodic soils

Sodicity is a measure of the exchangeable sodium in a soil. A soil is defined as sodic when sodium makes up more than six per cent of the total exchangeable cations, and the salinity is low.

A soil chemical test reports sodicity as exchangeable sodium percentage (ESP).

An ESP of more than six suggests a sodic soil.

High concentrations of sodium cause the swelling and dispersion of soil clay particles which leads to a deterioration of the soil structure.

Dispersion causes soil micro-aggregates to collapse into individual soil particles: sand, silt and clay.



*Dispersive soil in water (Photo: Ian Toole)*

The grey soils in the Western Catchment are naturally sodic, especially those on the Darling riverine plains.

## Management of sodic soils

The first step in managing a sodic soil is to increase the concentration of salts (preferably calcium salts) in the soil solution. For farmers in the Western Catchment this can be achieved by surface application of gypsum.

Generally the rates of gypsum recommended are 2.5 t/ha for sodic soils (ESP 6–4) and 5 t/ha for highly sodic (ESP >15) and sodic alkaline soils (as gypsum is less effective when soils have a high pH).

The most effective way to determine the response to the application of gypsum is to conduct strip tests on your property and combine these with the results from laboratory tests to work out optimal gypsum application rates.

A longer-term aim should be to replace exchangeable sodium with calcium and use organic matter as a soil binder. Increasing organic matter will help reduce the effects of sodicity. Even if it is not economical to apply gypsum there are management practices that can be used to increase the productivity of a sodic soil.

## Compaction

Compaction is the process of rearrangement of soil particles leading to a decrease in total pore space, pore size, and increase in bulk density.

Pores are critical for the movement of water, nutrients and air and they provide a way for roots to enter the soil. Compaction of the pores means that roots have trouble growing, there is less oxygen in the soil and when it rains water is not absorbed fast enough and therefore runs off.

Heavy farming machinery and animal traffic on wet soils can cause compaction to depths of up to 70 cm.

## Hardpans

Hardpans are formed by repeated cultivations carried out to the same depth.

Digging a hole or pit and examining the soil profile is a reliable way of finding hardpans.



*Soil pit showing a hardpan (Photo: Neroli Brennan)*



*Root distortion due to a hard pan (Photo: Ian Toole)*

Root behaviour can also be a useful guide because tap-roots often turn at right angles when they hit a hardpan. Canola and the grain legumes are particularly sensitive to hardpans.

## Soil organic matter

Organic matter is any living or dead animal or plant material. It includes living plant roots and animals, plant and animal remains at various stages of decomposition and their excretions.

The grey and red soils of the Western Catchment are naturally very low in soil organic matter.

### The following factors increase the rate of loss of organic matter:

- cultivation
- repeated wetting and drying of soil
- burning stubble
- overgrazing of stubble.

### To increase organic matter:

- Retain stubble and plant residues
- Adopt no-tillage practices
- Avoid long bare fallows
- Rotate pastures.

## Erosion

Erosion causes a loss of topsoil, which contains most of the soil organic matter and nutrients. Land degradation resulting from erosion is difficult and costly to overcome.

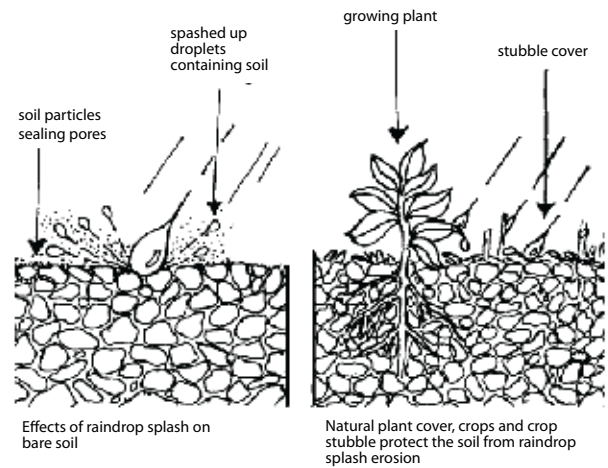
### Methods for preventing erosion

**Reduce runoff.** Because runoff carries soil in suspension, reducing runoff reduces erosion.

**Slow the erosive agent.** Water and wind erosion are reduced by slowing down the rate at which they travel across the soil.

**Keep the soil in place.** Undisturbed soil with good surface cover is the most resistant to erosion.

Surface cover reduces the risk of both water and wind erosion. Stubble management is the most important element of an erosion control program in Western Catchment cropping paddocks.



Surface cover protects the soil from raindrop impact  
(Source: SOILpak for dryland farmers on the red soil of Central Western NSW)

### References and further reading

*The effects of cropping on the Western CMA red soils*

*The effects of cropping on the Western CMA grey soils*

*SOILpak for dryland farmers on the red soil of Central Western NSW*

*Northern Wheat-Belt SOILpak*

*Dryland Cropping Guidelines for the Western Farming Systems Zone*

### For more information:

[www.western.cma.nsw.gov.au](http://www.western.cma.nsw.gov.au)

or

[www.dpi.nsw.gov.au](http://www.dpi.nsw.gov.au)

### Acknowledgements

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