Chapter D6. Improving soil structure by crop rotation

PURPOSE OF THIS CHAPTER

To explain how to rotate crops and pastures to improve soil structural stability

CHAPTER CONTENTS

- contributors to soil structural stability
- effects of pasture and grazing

ASSOCIATED CHAPTERS

- A3 ‘Features of soil’
- D1 ‘Soil examination and structural rating’
- D7 ‘Cultivation and soil structure’

SOIL STRUCTURAL STABILITY

A soil’s structural stability is its resistance to slaking and dispersion. A structurally stable soil will retain its structure when wet. Additionally, research has shown that improvements in the aeration and water penetration of loamy soils are related to the proportion of water stable aggregates that are bigger than 2 mm in diameter. In clay soils the critical size may be much smaller—0.25 mm.

Soils with poor structure need structural improvement to produce high yielding crops and pastures. Poor structure in the soil may be visible as:

- crusted or hardset topsoil (massive structure)
- pugged topsoil (damage from stock)
- slaking score greater than 2
- dispersion index greater than 8
- compacted zones, such as those under wheel tracks or plough pans.

Some soil structural problems are naturally occurring—for example, sodicity. However, most problems are caused by, or made worse by, human activity. Inappropriate use of cultivation is largely responsible for soil structural decline. However, you need to improve the structure of the soil first before you use any conservation tillage methods, such as direct drilling). A pasture or crop phase that allows a build-up of organic matter in the soil is usually the best method of improving soil structure and soil structural stability.

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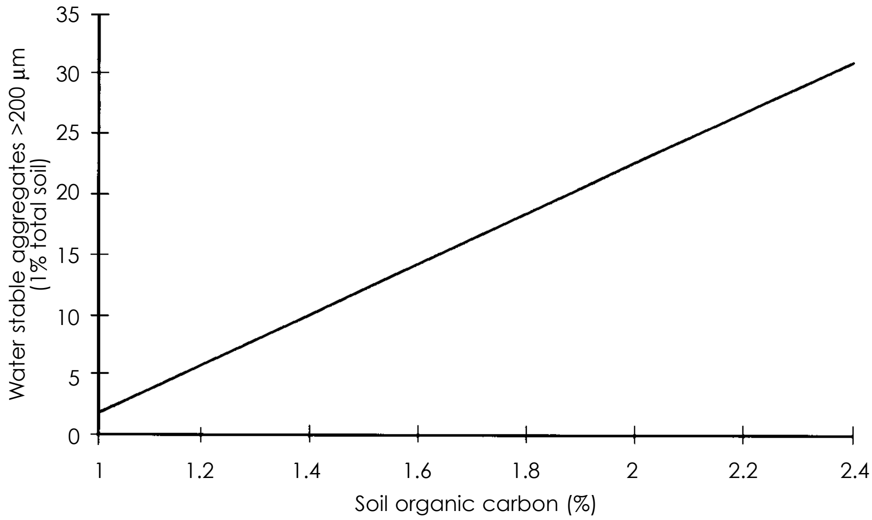
See Chapter D7 for more information on cultivation techniques.

Many studies have shown that the organic matter content of the soil has a strong influence on its stability, for example, on its resistance to slaking and dispersion (Figure D6–1). A soil that does not slake or disperse has the potential to be well structured if compaction is avoided, allowing for excellent plant growth under irrigated conditions.

Figure D6–1. Soil organic matter and structure



A build-up in soil organic matter is therefore likely to benefit soil structure and plant growth. Tisdall and Oates (1982) found that soil organic matter decline was most rapid in the following situations:

- after cultivation
- after a period of bare fallow
- when crop residues were removed.

One way to improve soil structure is by rotation of vegetable crops with pasture/cereal phases.

Note: If you do not use conservation tillage practices you will soon lose the crop benefits that come from soil improvement through rotation.

PASTURE AND SOIL STABILITY

Increases in structural stability (resistance to slaking and dispersion) are related to the amount of root material plus mycorrhizal fungi produced by a pasture.

Soil structure (as measured by the proportion of aggregates resistant to slaking) is best under virgin, uncultivated soil, followed by permanent pasture. The most unstable soils are those that alternate bare fallow with cultivation to produce crops. A pasture phase is useful for improving the structure of a poorly structured soil, since it allows the soil organic matter to build up. Pastures continually add organic matter to the soil via roots and decaying shoots. Pastures are not cultivated, and hence allow the soil organic matter and soil structure to improve.

Pastures must be productive to give maximum benefits to the soil. Therefore, an adequately fertilised and irrigated pasture will benefit the soil most through higher additions of organic matter.

Pastures protect the soil surface better than crops, since the surface cover is usually maintained throughout the year. This will benefit the soil in the following ways:

- The soil surface is protected from raindrop impact. Raindrop impact can destroy the soil surface structure, causing crusting to occur.

- Plant residues on the soil surface break down to form compounds that help increase the structure of the soil.
- Plant residues encourage the surface feeding of soil animals such as earthworms. Earthworm burrows benefit the soil by creating pores through the soil, encouraging the movement of water and air and the growth of plant roots.

The pasture type will also influence the soil. Grass pastures—especially those with extensive finely branched roots, such as ryegrass—have the most benefit. Additionally, grass pastures act as hosts for a beneficial type of fungus that lives in the soil in association with plant roots. This fungus (known as mycorrhiza), produces many long, thin filaments that act as a 'glue' to bind soil particles into aggregates. Ryegrass has been shown to improve soil structure dramatically because of its large, fibrous root system that acts as a good host for mycorrhizal fungi.

While ryegrass can help improve soil structure, so too can many other forms of pasture. Clover and lucerne pastures are likely to benefit subsequent crop growth by increasing soil nitrogen levels.

Vegetable growers, particularly those with limited land resources, must weigh up the benefits of using pasture in rotation to improve structure against the loss of production from not continuously cropping.

Vegetable growers in some areas should also consider crops in rotation for biological control, or biofumigation of some soil-borne pathogens and nematodes.

EFFECTS OF GRAZING ON SOIL

Bulk density is defined as the mass of oven-dried soil per unit volume. Soils with high bulk density have a smaller volume of pore space than soils with a low bulk density. Very high bulk density (greater than 1.6) is therefore undesirable for plant growth, since infiltration, aeration (supply of air to roots), and soil strength are likely to be below optimum.

Compacted layers in soils have high bulk density, and therefore limit plant growth.

Grazing of pastures can have some negative effects on topsoil structure. Compaction of the topsoil is most likely when the soil is wet, when high stocking rates are used, and when stock are grazed for extended periods of time.

On one clay soil at Leeton, stocking at approximately 20 sheep/ha led to a dramatic decline in production compared with an ungrazed pasture. At 20 sheep/ha grazing for 5 weeks (starting 1 day after the irrigation water had drained off), pasture production was 58% lower than on the ungrazed pasture. This difference was attributed to an increase in bulk density of the topsoil (Figure D6–2), and the direct effect of sheep damaging pasture plants when grazing and walking on them. Between 34% and 58% of the decrease in pasture production was due to changes (increases) in the bulk density of the soil. Bulk density is likely to remain high until the soil is cultivated or undergoes extensive cracking when dry (clay soils only).

Many vegetable growers use livestock to clean up crop residues. Sometimes the cost in damage to soil management can outweigh the benefits.

Figure D6–2. Soil bulk density and stocking rate