

Chapter D7. Cultivation and soil structure

PURPOSE OF THIS CHAPTER

To describe the effects of cultivation on soil structure

CHAPTER CONTENTS

- advantages and disadvantages of cultivation
- cultivation techniques
- machinery design
- semi-permanent beds

ASSOCIATED CHAPTERS

- A3 'Features of soil'
- B2 'Weed control'
- B9 'How do I control erosion?'
- D8 'Landforming and soil management'

EFFECTS OF CULTIVATION ON SOIL STRUCTURE

The soil organic matter can be seen as the darker layer beginning at the soil surface. Organic matter acts as a 'glue' to bind soil particles into aggregates. Therefore, a soil high in organic matter will generally be well structured. This is especially true in loamy textured soils.

A productive pasture phase over a number of years will improve the structure of most soils, because the organic matter content will increase under pasture. This improvement will begin at the surface (since this is where plant residue and manure from stock is deposited) and slowly move down into the topsoil over time.

When a soil is cultivated soil aggregates are broken up and soil is aerated. This exposes soil organic matter, speeds up the breakdown of soil organic matter, and is harmful to soil structure. Therefore, reducing tillage can improve soil structure.

Cultivation (tillage) is a practice that has been introduced to Australia from Europe by our farming pioneers. The principle of cultivation is to turn the soil into a fine tilth to provide the ideal environment for seeds to germinate. Cultivation was also a traditional form of weed control. The climate of most European countries is wet and cool, allowing organic matter to build up in soils even when they are cultivated. This system is better suited to the younger, more fertile soils of Europe. In Australia, regular intensive cultivation has degraded soil structure. Our soils are older, our climate is hotter and drier, and organic matter breaks down quickly. Therefore, cultivation is potentially disastrous for many Australian soils if it is not used correctly.

ADVANTAGES OF CULTIVATION

Cultivation is conducted for a variety of good reasons. It is important that cultivation of the soil does not create as many problems as it solves. Some advantages of cultivation are:

- It is often a form of weed control.
- It can play a part in pest management. For example, tillage is recommended to reduce the number of overwintering heliothis pupae in paddocks where susceptible summer crops such as sweet corn and tomatoes are grown.
- It may be required to incorporate herbicides and soil ameliorants, such as lime.
- It may reduce the incidence of soil-borne diseases. Soil-borne diseases such as rhizoctonia can be a problem in soils where crops are planted using direct drill or zero till.
- It reduces soil strength. High soil strength has been shown to reduce the vigour of crops, especially seedlings. High soil strength is one reason for poor seedling vigour in direct-drilled crops on poorly structured soils.
- It roughens the soil surface; this can help retain moisture.

DISADVANTAGES OF CULTIVATION

Cultivation has the potential to destroy soil structure and make soils more prone to other forms of degradation, such as erosion. Incorrect use of cultivation can have the following effects:

- There may be a reduction in soil organic matter and therefore a decline in soil structure. Good soil structure is important for good root growth and water penetration by rainfall or irrigation.
- Cultivation that mixes surface soil with subsurface soil will lead to a dilution of organic matter (which is most concentrated at the soil surface). This will mean that crusts are more likely to form after cultivation.
- Cultivation can make hardsetting and crusting problems worse, since soil organic matter and stable aggregates are destroyed.
- Cultivation can bring sodic material to the soil surface. This can cause or increase soil crusting.

SOME GUIDELINES FOR CULTIVATION PRACTICES

Implements for aggressive cultivation

- landplanes
- heavy disc implements
- wide-board ploughs
- rotary hoes

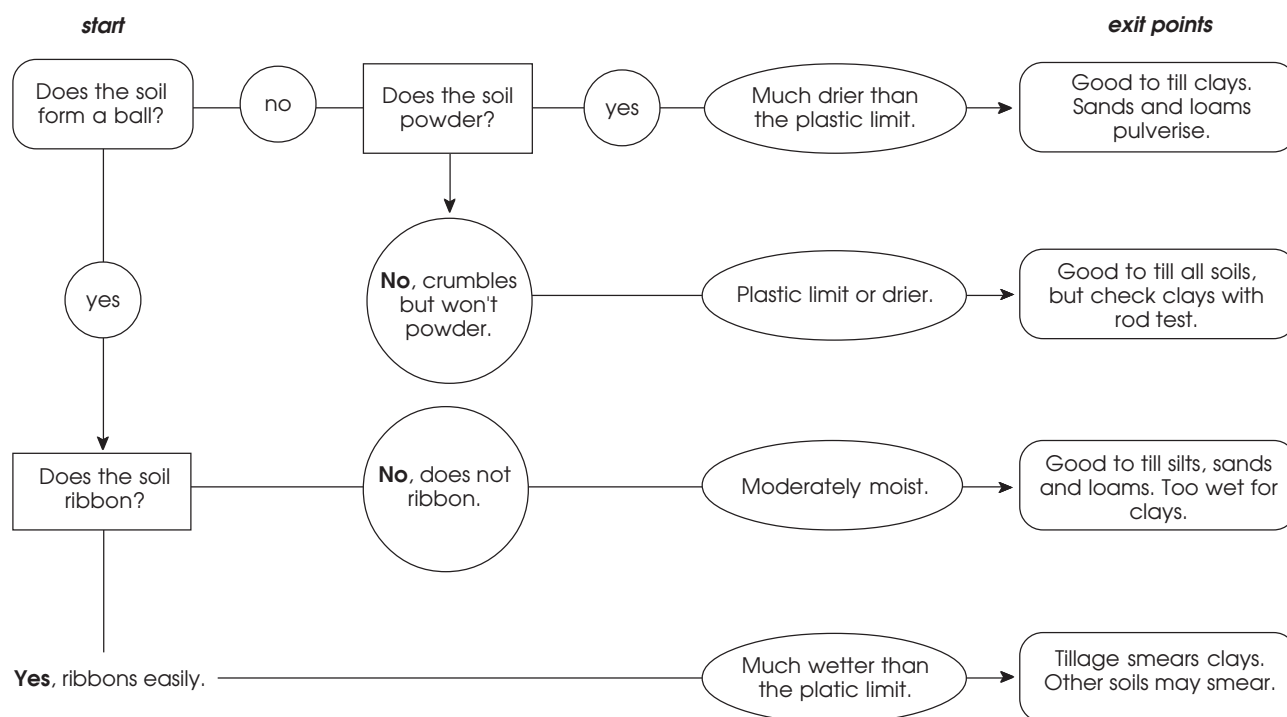
Implements for less aggressive cultivation

- chisel plough
- scarifier
- roller

The negative effects of cultivation can be minimised if certain rules are followed when cultivating. Some of these are:

- Minimise cultivation as much as possible. The less you cultivate a paddock the less likely you are to damage the soil structure. Depending on the vegetable crop or pasture, if soil conditions and machinery are suitable, consider direct drilling. You may need to use more herbicides for weed control.
- Try to use less aggressive forms of cultivation. The more aggressive forms of cultivation, such as levelling equipment, disc ploughs and rotary hoes, are likely to degrade the soil structure very quickly.
- Cultivate at an appropriate soil moisture content (especially when using aggressive implements)—see Figure D7–1.
- When you are using implements that mix soil throughout the cultivation depth, restrict the depth of working to 5 cm or less. The same applies to implements that bury the surface soil. When implements that mix soil are used to greater depths, soil organic matter becomes diluted. Additionally, sodic soil may be brought to the soil surface. Implements with narrow points are less likely to mix or ‘invert’ the soil. **Remember, the priority area in soil management is the soil surface (the top 1 cm).**

Figure D7–1. Soil moisture test for tillage



- When deep cultivating, use non-inversion implements (chisel plough, Agroplow® or scarifier with narrow points). A deep cultivation (15 to 20 cm) can be useful to increase infiltration of water and encourage early root growth. Implements used for this are best followed by a roller.

DIRECT DRILLING

Direct drilling is a technique where crops or pastures are sown into uncultivated soil. In general, the soil is disturbed only in a narrow slot along each sowing line. This technique offers many benefits to growers, since the soil structure will improve over a number of years. Yields, timeliness of sowing and ease of paddock preparation will improve with soil structure improvements.

Direct drilling is therefore a recommended technique for improving soil structure. If you use direct drilling you are likely to get long-term improvements to soil structure and productivity.

Direct drilling in hardsetting soils

In soils with naturally poor structure, such as hardsetting soils, direct drilling does have some problems. The early growth of direct drilled crops is often much slower than that of conventionally cultivated crops. The possible reasons for this observation are:

- the mixing of soil during conventional cultivation reduces the incidence of biological problems such as soil-borne diseases. This mixing does not occur with direct drilling, and so crop growth can be slowed down by biological factors.
- uncultivated soils tend to be much 'harder' than cultivated soils. Crops growing in soils that are hard (that is, that have high soil strength) will grow more slowly than those in 'soft' soils. The high soil strength encountered by plant roots is thought to produce hormones in the plants that reduce shoot and root growth.

Reduced tillage techniques are practised in some highland potato crops and are currently being assessed for sweet corn and processing tomato production.

CULTIVATION TECHNIQUES FOR POORLY STRUCTURED OR HARD SOILS

Hard, poorly structured soils may have poor water infiltration and poor plant vigour. These soils should be 'softened' with cultivation.

A non-inversion cultivation (using narrow points) to a depth of 15 to 20 cm will decrease soil strength while causing little damage to soil structure. This operation should be conducted at the plastic limit or drier, so that the soil 'shatters'. This will make the soil softer and may help with water infiltration without damaging the soil further. This cultivation can be conducted using narrow ripper points fitted to a scarifier or chisel plough.

DEEP RIPPING

Deep cultivation (greater than 20 cm) may benefit soils with poor structure or compaction problems. Like most forms of cultivation, deep ripping can loosen and 'soften' the soil, giving plants access to deeper soil. However, deep ripping must be done carefully, as many problems may occur.

Some good rules for deep cultivation are:

- Cultivate only to the depth required, that is, just below the depth of the compaction layer.
- Use non-inversion cultivation implements (those that do not bury the topsoil).
- Dry the soil profile (with a crop) to cultivation depth before deep ripping.
- Combine deep ripping and gypsum application on sodic or dispersive soils.

Rip only to compaction depth

Draft requirements and fuel consumption will increase considerably with the working depth. To minimise both draft and fuel requirements you should cultivate about 10 cm below the compaction layer.

Poorly structured and restrictive layers are often found in soils of the Murrumbidgee and Murray Valleys. These layers are usually dispersive clays. Soils should be ripped to at least 15 cm in these situations. Ripping of dispersive soils will be more successful if it is combined with gypsum application.

Use non-inversion points

Implements that invert the soil will bury much of the soil organic matter (usually concentrated in the top 2 to 3 cm). This will mean that the soil surface will be more prone to slaking. Crusting and hardsetting may become a problem (or more of a problem). Deep cultivation that inverts the soil may also bring dispersive subsoil to the soil surface. It is therefore desirable to use points and tines that do not invert the soil. Trying to force blunt chisel points through a compacted layer is often ineffective and consumes more fuel. Use the correct ripping points.

Deep-rip dry soil only

Deep tillage of wet soil is unlikely to have any benefits, since the soil needs to be dry to produce cracks when deep cultivating to have a beneficial effect. (Soil should be drier than the plastic limit: see Figure D7–1. Deep tillage of wet soil has been shown to reduce yields. This is thought to be due to smearing and further compaction caused by operation of the deep ripper while the soil is still fairly moist (wetter than the plastic limit).

Before deep ripping the soil should be dried with a crop. This would involve growing a crop as normal until it is 3 to 4 weeks from maturity. From this point on, no irrigation should take place; the crop can then exhaust its store of water in the soil. Winter cereals and canola are useful crops for drying the soil.

Use gypsum when deep ripping sodic or dispersive soils

Deep ripping will have a relatively short-term effect on soils that are dispersive. Dispersive soils can be identified as those with a dispersion index greater than 8 or an exchangeable sodium percentage greater than 5.

Dispersive soils will swell and disperse when wet, so cracks created by the ripper will soon collapse. To maintain the cracks created by the ripper, apply gypsum before ripping.



See Chapter D5 for more information on gypsum use.

MACHINERY DESIGN FOR DEEP RIPPING

Attack angle

The attack angle refers to the angle of the leading edge of the point of the ripping implement. A shallow attack angle of about 30° (22° to 45°) allows for good soil breakout (shattering) without stressing and wearing the ripper tines. Parabolic-shaped tines work well, since the workload is spread across a larger area of the tine.

Narrow points and sweeps both have applications for ripping. Sweeps have the advantage of working effectively to greater depths. However, sweeps are likely to cause some smearing and compaction at the foot of the cultivation layer, especially when the soil is wet. Narrow points do not smear the soil as much as sweeps, but cannot work effectively to the same depth as sweeps.

An ideal compromise is to use a ripper that has deep, narrow points working behind shallower sweep points. This configuration will give maximum shattering of the soil, while minimising compaction at the base of the rip line. The shallow leading tines should work at approximately half the depth of the deeper tines with narrow points.

Work done with such a machine in cotton-growing areas has produced favourable results. Soil ripped by such an implement produces a better tilth and is left less 'cloddy' than soil ripped by conventional rippers; this type of ripping also allows the implement to be worked at a greater depth with reduced fuel consumption.

These machines are not available commercially. However, many rippers can be modified to the configuration outlined above by adding the deep narrow pointed tines to the back of the shallow tine toolbar.

USING SEMI-PERMANENT BEDS

The use of semi-permanent beds is being widely adopted by many vegetable growers; with this method planting beds are retained for up to 10 years (Figure D7-2). Some ripping may be done, but ploughing is avoided if at all possible.

Figure D7-2.



Lettuce seedlings on permanent beds near Windsor. The tops of these semi-permanent beds are cultivated between each crop, but the beds themselves and furrows are kept for at least five crops. (Ashley Senn)

Why semi-permanent beds are a good production technique

- By concentrating on shallow cultivation and avoiding ploughing, costs are greatly reduced. Cultivation time, and therefore machinery maintenance and fuel costs, are typically reduced by one-half to two-thirds, but the crop is the same or better.
- Paddocks that are bedded-up drain better and, since the firm gutters are kept, access during wet conditions is improved. There is also less waterlogging.
- Soil compaction from traffic is confined to a smaller area of the paddock.
- The best soil is kept at the surface where most of the roots are. Manure and fertiliser are not lost by being buried too deeply.
- Organic matter levels are higher, and therefore soil structure is better. Organic matter is oxidised and destroyed when it is exposed to the air by cultivation.
- Because the soil structure is improved there is less surface crusting and more infiltration (soaking-in) of water. More rapid and even wetting of the soil is a major reason for the widespread adoption of permanent beds inland.

Some problems

- Existing plough pans (layers of compacted soil) will need to be loosened before setting up the semi-permanent beds. Soils may be hardsetting.
- Shallow cultivation, especially with rotary hoes in soil that is too wet or too dry, can also damage soil structure. Beds can also slump and lose their shape.
- If organic matter levels are high (this is unlikely), soil-borne diseases such as rhizoctonia may become more common.
- You may need to cope with large amounts of trash, for example, after broccoli.
- This technique cannot be used for potatoes and carrots because different widths of machinery are needed.

