Managing Tasmania's Cropping Soils

A practical guide for farmers

Bill Chilvers 1996
# Table of Contents

**Introduction** ........................................................................................................................................................................ 4

**Principles**
- Good crops grow in degraded soil - don’t they? .................................................................................................................... 5
- What makes a good cropping soil? .......................................................................................................................................... 6
- Farm planning for cropping farms ........................................................................................................................................ 7
- The importance of organic matter ........................................................................................................................................ 8

**Investigation**
- What soil management types do I have? .................................................................................................................................. 11
- Before we set to work - two key checks
  - roll test for soil moisture ............................................................................................................................................. 12
  - a pit investigation for compaction .................................................................................................................................. 13

**Five Management Types**
- Krasnozems - red clay loams on basalt ................................................................................................................................. 14
- Cressy soils - clay loams on tertiary sediments ....................................................................................................................... 26
- Black Cracking Clays - on basalt or dolerite hills, or recent alluvium .................................................................................... 32
- Duplex Soils - sandy loam over clay on tertiary sediments .................................................................................................. 42
- Deep Sands - windblown deposits ........................................................................................................................................ 52

**More Management Issues**
- Drainage .................................................................................................................................................................................. 58
- Sodic soils ..................................................................................................................................................................................... 63
- Cover crops .................................................................................................................................................................................. 65

**The Implements**
- Direct drilling and local drill conversions .............................................................................................................................. 68
- How the implement breaks the soil .......................................................................................................................................... 73
- Tines ......................................................................................................................................................................................... 74
- Discs ........................................................................................................................................................................................ 76
- The mouldboard plough ......................................................................................................................................................... 77
- Powered implements ................................................................................................................................................................. 80
- Choosing the right implement .................................................................................................................................................. 82
Introduction

Tillage is very subjective. Every tillage implement can be found working on every soil type, and it’s appropriateness reasonably argued. Good soil management lies in the way the implement is operated and the soil conditions at the time. There are no textbook answers or receipts to follow as you stand in the paddock deciding on how to prepare the seedbed. This manual is a mix of broad guidelines and local farmer examples. You are welcome to disagree, because debate and discussion amongst neighbours and farming groups can only improve the way our soils are managed in the long run. It’s up to you to make the decisions and your best tools are a spade to investigate and a willingness to learn.

Cropping is most intense on the krasnozem soils of the north west coast of the state. Intensive tillage using powered implements and mouldboard ploughs is sustainable on these resilient soils if they’re managed with care. Less resilient soils in the Midlands, Coal River and Derwent Valley regions are being cropped with increasing intensity. Sandy soils, shallow duplex soils, sodic soils and black cracking clays all behave very differently from krasnozems. The intensive tillage used on krasnozem soils is not sustainable on these other soils. Structure, drainage, erosion and productivity are suffering as a result.

This manual identifies five basic soil types, and indicates how they might be managed appropriately so the resource is maintained or improved for the future. The five types of soil identified in the manual are broadly defined on the basis of management. These are soil types that can be, and should be managed in a particular way. Don’t worry if your soil doesn’t fit the photograph exactly, since each of the five types embrace a wide variety of soil depths, colours and textures. The detailed description is included to bring together soil pedology (soil description), and soil management, two disciplines which benefit greatly by being side by side. Join a Whole Farm Planning, Topcrop or Farm Best Practice program to find out more about your soil.


This manual is all about fostering appropriate soil management practices for different cropping soils.

Acknowledgments

I would like to thank Bill Cotching for originating the project and his patient supervision. Also to Bill Gibson for his special effort reviewing the manuscript, and the many others who made suggestions for improvement. Thanks to the case study farmers who discussed and shared their soil management expertise with me, particularly those who became case studies. I would like to thank the Farm Best Practice and Topcrop programs for providing numerous opportunities for valuable in paddock discussions. Finally I would like to thank the National Landcare Program and the DPIF for their financial support.
On our rich red krasnozems, after 100 years of erosion and structural decline, we appear to be successfully growing crops in cloddy, compacted subsoils. These degraded soils erode easily, are awful to work, contain little organic matter and few earth worms or living things. But the fact is the crops still grow, and we continue to make a living - so why worry?

In the midlands and Coal River valley on shallow duplex soils, many have gradually deepened the topsoil by ploughing in a little subsoil each time, we have heavy tractors and harvest trucks compacting pores in the underlying clay, we have dust storms sometimes burying a few wires on the fence, and we have powered implements to beat clods into submission. And the crops still seem to grow - so why worry?

Why worry? Because the RISKS increase and the COSTS increase.

The RISKS are that we lose all the buffers that a healthy soil has:

- **buffers against pests and disease.** A healthy soil has a wide range of organisms that tend to keep each other in check.

- **buffers against nutrient deficiencies and toxicities.** Organic matter plays a leading role in minimising leaching of applied fertilisers and supplying the full range of nutrients required for healthy crop growth.

- **buffers against waterlogging or drought.** A healthy soil is full of holes and pores - large ones for drainage and small ones to hold moisture for crop growth. Have a look! If these are removed by compaction or overworking, there is less water available for plant growth between the extremes of waterlogging and water stress.

The COSTS. The clods, the compaction - it all takes more time and money

- **conventional tillage is the only way** - once your soil is degraded, direct drilling failure is more likely, minimum tillage is risky. Conventional tillage can cost $60 to $100/ha compared with $20 for a direct drill operation.

- **expensive harvesting** - clods increase labour requirments on potato harvesters causing potato bruising and associated payment penalties.

- **extra fertiliser** - a degraded soil requires greater inputs

- **extra herbicides** - a degraded soil has greater weed pressure

With farmers’ terms of trade constantly slipping, it’s time to take better care of our soils because one day it will not be economical to produce crops in degraded soil.
Before we look at differences between soils, let us ask what is common to all the cropping soils. Apart from being sufficiently fertile, a cropping soil has to satisfy three physical requirements, not without some conflict:

1. **be suitable for plant growth** - must contain sufficient pores for aeration, drainage and water holding. Must be friable to allow root extension and proliferation. Low bulk density.

2. have a **high bearing capacity** to carry tillage & harvest traffic - must have sufficiently high soil strength to avoid excess sinkage and wheel slip. High bulk density.

3. **resist erosion** - must be sufficiently structured, surface covered or protected by conservation earthworks (banks and ditches)

Soil needs to be of low bulk density for plant growth on one hand, and of high bulk density for carrying traffic on the other! A tricky compromise. As cropping becomes more intensive, soil management becomes a balancing act that every so often, goes horribly wrong.

### Managing the conflict

The following management tools can be applied to any soil type under cropping to minimise this conflict and assist in sustaining your soil as a ‘good’ cropping soil into the future:

1. **Lower tyre pressure.** While axle load determines depth of compaction, tyre pressure determines the degree of compaction. The addition of dual wheels to a tractor will have minor benefit unless the pressure of all four tyres is reduced. More information on page 73.

2. **Tramlines.** Narrow tyres with high pressure form a highly compacted wheeling without affecting crop growth. Used for all spray and fertiliser applications between sowing and harvest.

3. **Bed systems.** The bed remains for the life of the crop. eg onions, carrots and pyrethrum. Subsequent tillage is random.

4. **Permanent beds.** This system is the only one to actually remove the compromise altogether. All traffic is permanently restricted to the wheelings between beds, eg Forth Farm Produce at Forth or lettuces at Houston’s Egg Farm, near Cambridge.

---

*Lettuces in permanent beds, Cambridge.*

*Permanent bed wheelings, ideal for wheel traffic.*
The physical layout of the farm should reflect its most valuable natural resource - the soils. Different soils require different management. This is far easier if paddocks contain only one soil type. For many farms however, soils are such a patchwork that this is impossible, and the whole paddock must be managed to conserve the most erodible or fragile soil type.

Permanent fencelines follow major soil type boundaries
Whatever cropping or irrigation system you might adopt now or in the future, the farm should be subdivided based on major soil type differences to allow appropriate management.

Obtain an aerial photograph of the farm from the Land Information Bureau, GPO Box 44A, HOBART (ph 002 338011), and place a plastic overlay on it. On the overlay:

1. mark permanent creeks, dams, and deep, arterial surface ditches
2. draw boundaries around areas of same soil or similar management type
   - these boundaries will be permanent fencelines. They can be integrated shelterbelts, cutoff ditches and laneways
   - temporary fencing can be used to subdivide these areas according to present irrigation run lengths, thus retaining flexibility for future changes like a different hose length, a hard hose traveller, centre pivot or moveable solid set
   - areas with too much soil variation to fence separately must be managed to preserve the most fragile or erodible soil

### Similar management soils - soils which go together well

- Duplex and sandy banks - under a ‘topworking’ and direct drilling cropping system which retains a surface cover against wind erosion at all times
- Cressy soils and black cracking clay - these are all dominated by clay and suffer from clods and poor drainage. They can be mole drained and worked under a topworking or ploughing system at exactly the right moisture content every time.
- Alluvial soils are very variable but usually dominated by clay. They can be managed as clay soils.

### Soils which do NOT go together

- Duplex with black cracking clays - duplex soil areas commonly contain black cracking clays in drainage lines. Fence these separately and manage differently wherever possible
- Krasnozem with sands or off-coloured sandy loams, as found in Wesley Vale or Scottsdale for example. Fence and manage differently wherever possible

Attending a DPIF Whole Farm Planning course will give you skills in farm mapping as well as information on financial and risk management, estate planning and biodiversity.
The importance of organic matter

Biological activity continuously breaks down coarse crop and pasture residues into very fine material called humus. Humus is what gives the topsoil its dark colour. Both coarse and fine organic matter are essential. Compared with pasture or forest, prolonged cropping results in less coarse material entering the chain, so humus levels tend to diminish:

**Coarse** (easily seen)
- Plant roots & residues

**Fine** (less than 0.002mm)
- Humus

Coarse residues aid infiltration and protect the soil from erosion. They keep your soil biologically healthy.

Biological activity of worms, insects, fungi & bacteria

Humus is vital for maintaining soil structure and fertility. It helps hold soil aggregates together under the stresses of cultivation and heavy rainfall.

Measuring organic matter

The best test is ‘organic carbon’ which measures the full size range of organic matter from the very coarse to the humus. ‘Loss on ignition’ is a simple and cheap test which unfortunately measures several non-organic soil components. The results of a loss on ignition test can be misleading for clay soils which release residual moisture at ignition temperatures. Different laboratories vary in the extent to which may sieve out coarse organic matter during sample preparation. If you have traditionally used the loss on ignition test, it’s ok for comparison provided you stick with the same laboratory.

What is a reasonable level?

Knowing the level of organic matter in your soil over time is a valuable means of assessing the sustainability of your cropping program. Take a sample from paddocks at the beginning and end of a cropping rotation to see how far you’ve run the level down. See how it compares next time the paddock reaches this stage. Did the level recover sufficiently during the pasture phase?

An approximate guide to organic matter levels for Tasmania’s cropping soils.

<table>
<thead>
<tr>
<th>Laboratory test</th>
<th>krasnozem, black cracking clay &amp; Cressy</th>
<th>duplex soils</th>
<th>sands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organic carbon %</strong></td>
<td>high &gt;5</td>
<td>high &gt;4</td>
<td>high &gt;3</td>
</tr>
<tr>
<td></td>
<td>med 3-4</td>
<td>med 2-4</td>
<td>med 1.5-2</td>
</tr>
<tr>
<td></td>
<td>low &lt;3</td>
<td>low &lt;2</td>
<td>low &lt;1</td>
</tr>
<tr>
<td><strong>Loss on ignition %</strong></td>
<td>high &gt;25</td>
<td>high &gt;20</td>
<td>high &gt;10</td>
</tr>
<tr>
<td></td>
<td>med 15-20</td>
<td>med 10-20</td>
<td>med 4-6</td>
</tr>
<tr>
<td></td>
<td>low &lt;10</td>
<td>low &lt;5</td>
<td>low &lt;2</td>
</tr>
</tbody>
</table>

A vicious circle. Depleted organic matter levels leave the soil prone to clods and crusting. Intensive tillage is used to overcome these problems which further depletes organic matter.

An approximate guide to organic matter levels for Tasmania’s cropping soils.
Why does each soil type have such wide variation?
1. cold temperature - slows biological activity. Soil in a colder area of Tasmania tends to have more organic matter as plant residues and humus build up faster than they break down.
2. annual plant growth - where soil moisture is non-limiting for most of the year, plant growth and soil organic matter are higher compared with dry areas. This holds true on a farm level and on a regional level.
3. high clay content - humus becomes intertwined and incorporated in the clay microstructure where it is protected from breakdown. Thus a clay loam will contain more organic matter than a sandy soil.

How much is returned in roots & tops?

![Organic Material Returned By Various Crops (t/ha)](image)

*Roots and tops of various crops (t/ha) returning organic material. Cereal harvested and all stubble returned.


How much effect does a green manure have?
About 25% of the coarse organic matter entering the soil forms humus, while 75% is respired to the atmosphere as carbon dioxide during the first year of its decomposition. The box below shows how many green manure crops would theoretically raise organic carbon by a 1% unit.

<table>
<thead>
<tr>
<th>Organic matter fixed by a vigorous, thick stand of green oats</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry matter yield</td>
</tr>
<tr>
<td>humification factor for green manure</td>
</tr>
<tr>
<td>humus fixed (6t/ha x 0.25)</td>
</tr>
<tr>
<td>approximate weight of 20cm topsoil</td>
</tr>
<tr>
<td>increase in organic carbon from one green manure crop</td>
</tr>
<tr>
<td>number of green manures to increase organic carbon by 1% unit</td>
</tr>
</tbody>
</table>
How much effect does cereal stubble have?
A cereal stubble has a slightly higher factor of about 30%*. About 17 stubbles of 4t/ha each would be required to raise the organic carbon by a 1% unit.


Building Soil Organic Carbon is a Life Long Program

The rate of build up of your soils organic carbon is very slow. Note that the rate of loss under conventional cropping is much faster. If the aim is to increase soil organic matter significantly feedlots, dairy and poultry farms can supply manure, but rates of application need to be in the order of 10-40 tonnes/ha.


This manual has five management types, usually fairly easy to distinguish. However, if you are unsure which type you have, a field texture test is a quick and simple way to find out. Texture refers to the proportions of sand, silt and clay in the soil. Take a tablespoon sized sample from the topsoil and go through the following steps:

**Step 1.** Form the sample into a ball by moistening with water and kneading it. Knead for 1-2 minutes while adding more water or soil until it just fails to stick to the fingers. Sand grains produce a rasping sound and feel gritty. Assess feel and sound according to the chart below.

**Step 2.** Press the soil between the thumb and forefinger to form a ribbon. The ribbon should only be 2-3mm thick.

*The heavier the soil the longer the ribbon.*

<table>
<thead>
<tr>
<th>MANAGEMENT TYPE</th>
<th>TEXTURE OF SOIL</th>
<th>FEEL &amp; SOUND</th>
<th>COHESION &amp; PLASTICITY</th>
<th>RIBBON LENGTH (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Sand</td>
<td>Gritty and rasping sound</td>
<td>cannot be moulded into a ball</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loamy sand</td>
<td>Gritty and rasping sound</td>
<td>will almost mould into a ball but disintegrates when pressed flat</td>
<td>about 5</td>
</tr>
<tr>
<td>duplex*</td>
<td>Sandy loam</td>
<td>Slight grittiness, faint rasping sound</td>
<td>moulds into a cohesive ball which fissures when pressed flat</td>
<td>15-25</td>
</tr>
<tr>
<td></td>
<td>Loam</td>
<td>Feels smooth and spongy</td>
<td>moulds into a cohesive ball which fissures when pressed flat</td>
<td>25-40</td>
</tr>
<tr>
<td>krasnozem</td>
<td>Clay loam</td>
<td>Very smooth, slightly sticky to sticky</td>
<td>plastic, moulds into a cohesive ball which deforms without fissuring</td>
<td>40-50</td>
</tr>
<tr>
<td>Cressy</td>
<td>Clay loam</td>
<td>Very smooth, slightly sticky to sticky</td>
<td>plastic, moulds into a cohesive ball which deforms without fissuring</td>
<td>40-50</td>
</tr>
<tr>
<td>black cracking clay</td>
<td>Clay loam</td>
<td>Very smooth, slightly sticky to sticky</td>
<td>plastic, moulds into a cohesive ball which deforms without fissuring</td>
<td>40-50</td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td>Very smooth, sticky to very sticky</td>
<td>very plastic, moulds into a cohesive ball which deforms without fissuring</td>
<td>50-75+</td>
</tr>
</tbody>
</table>

*Duplex soils have a clay subsoil
Which soils are degraded by working too wet?
ALL SOILS EXCEPT SANDS
especially:
➢ topsoils containing clay - krasnozems, Cressy soils, black cracking clays
➢ sandy loams, these also contain some clay and can become cloddy
➢ subsoils of all soil types including duplex soils where subsoil pores are closed up by compaction

Check 1. Is my soil too wet to work?
Working the soil at too high a moisture content causes compaction. Compacted topsoil results in clods. Compacted subsoil restricts drainage and rooting and is more difficult to alleviate than topsoil compaction.

The roll test for soil workability.

A simple test is to take a hand sample of soil and work in your hands to an even consistency. Then try to form a thin sausage about 3-5mm diameter by rolling the sample between your palms.

➢ This sample is too wet to work. A 3mm sausage is easily formed.

➢ This sample is right to work. It cracks and breaks into short lengths.

➢ If the sample crumbles and a sausage can’t be formed - its ok to work but power requirements will be high.

Test the soil immediately below the plough layer. Often this will be moister and thus more likely to result in deep compaction. Tillage should not be undertaken if this sample fails the test.
Check 2. Is my soil too compact?

Indicators of compaction without seriously looking

➢ **paddock history** - avoiding wet tillage or harvest is not always possible. If this occurred it’s likely the soil is compacted.

➢ **surface water ponding** - is it worse than usual? This indicates a compacted surface layer.

➢ **wheel ruts** - indicate deeper compaction, affecting drainage and aeration below the plough layer.

➢ **patchy crop growth** - paddock preparation wheelings show during growth of the current crop

Assessing compaction requires a look below the surface

The best way to assess compaction is to dig a hole in the paddock **during a period of maximum crop growth**, because a lot can be learnt from actively growing plant roots. Compare it with an uncropped area of the same soil type on your farm. Most cropping paddocks are compacted to a degree somewhere between the gateway and the fenceline. Have a quick dig in these places for an obvious comparison.

**Digging a hole**

Dig a small hole about a 30cm deep, noting ease of digging. Come back from the edge of the hole 10cm and extract a neat, undisturbed slice. Carefully break open the slice vertically, looking for pores and size and shape of soil particles. Compare with the slices from the uncropped area and the compacted area.

Assess the subsoil - dig through the layer immediately below your usual depth of working. Is there a pan here? Are roots bent or thickened in and above this layer? Healthy, actively growing roots are very fibrous, white and of even thickness.

**WHAT IS SOIL STRUCTURE?**

It’s the shape, arrangement and number of solids and voids in the soil.

**IS IT FRIABLE OR HARD?**

Can you see root channels and worm channels?

Do the soil particles have rough, featured faces or smooth faces with sharp angled edges?

Are there clods?

Are roots penetrating clods?

Surface tilth - is it ‘clods and powder’ or a complete range of coarse to fine particles?

**Good structure - particle faces are rough and well featured, with rounded edges, many cracks and holes making it friable in the hand.**

**Poor structure - soil particles are smooth faced, sharp angled, horizontally layered, with few cracks or holes. Roots are not penetrating clods.**
Krasnozems

General Description
Reddish brown, strongly structured, gradational, clay loam to clay soils. A darker A horizon indicates a surface accumulation of organic matter.

Regions & local names
North West coast from Marawah to Sassafras, Pipers River, Deloraine, Scottsdale, Winnaleah, Breadalbane, and a small area around Campbelltown. Mapped along the North West of Tasmania as Burnie clay loam, Yolla clay loam, Lapoinya clay loam

Occurrence
Gently undulating rises to steep hills associated with volcanic lava flows which occurred some 30 to 50 million years ago. Along the North coast, rainfall increases and temperature decreases with distance inland, and the krasnozems generally become darker, more acidic and higher in organic matter. In the cold dry climate of the midlands, krasnozems are characteristically bright red with lower levels of organic matter and high pH. Land capability of areas of Krasnozem soils generally depends on slope, ranging from class 1 to 6.

Key properties of krasnozem soils

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability</td>
<td>Moderate</td>
</tr>
<tr>
<td>Permeability</td>
<td>Rapid</td>
</tr>
<tr>
<td>Root growth</td>
<td>Unrestricted</td>
</tr>
<tr>
<td>Readily available water</td>
<td>High</td>
</tr>
<tr>
<td>Workability</td>
<td>Restricted when wet</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>High (3-5% organic carbon)</td>
</tr>
<tr>
<td>Fertility</td>
<td>Moderate</td>
</tr>
<tr>
<td>pH</td>
<td>Moderately acid</td>
</tr>
<tr>
<td>Salinity</td>
<td>Negligible</td>
</tr>
<tr>
<td>Erosion risk</td>
<td>High</td>
</tr>
<tr>
<td>Water repellence</td>
<td>Low</td>
</tr>
<tr>
<td>Stoniness</td>
<td>Occasional</td>
</tr>
</tbody>
</table>

MAJOR CHALLENGES
- water erosion
- structural decline
- maintaining organic matter

Variability: Topsoil depth varies depending on erosion history. Topsoil depth generally decreases and stoniness increases with distance inland. A particularly loose, fluffy variant is known as ‘snuffy’.

Permeability: Seepage often occurs where impermeable sediments underlying the krasnozem prevent continued downward movement of water. Soil reaches field capacity in 24 to 48 hours after soaking rain. Further drying required before tillage.

Root growth: However, under intense cropping, cultivation pans can develop due to bad tillage practices and/or excessive trafficking.

Readily available water: About 45mm in 300mm depth of topsoil. Compaction reduces available water holding capacity by squashing soil pores that hold water. 75% of water is extracted by non stressed plants from the top half of the root zone.

Workability: Soil must be allowed to dry beyond field capacity before working. A minimum of 3 or 4 fine, drying days after rain are required before the soil is dry enough to avoid damage, longer if its been cool and cloudy. Cultivating or trafficking wet soil causes compaction.

Organic Matter: Intensive cropping without green manure crops or vigorous pasture leys gradually reduces the organic matter reserve.

Fertility: Strongly linked with organic matter contents in the plough layer. Nitrogen is largely held in the organic matter fraction, so levels usually correlate closely with organic matter content. Phosphorus is fixed by the clay fraction so continued applications are necessary. Potassium varies widely.

pH: Near the coast (5.5-6.5) and strongly acid further inland (5.0-6.0). Acidity generally increasing with depth. High lime requirement. Typically 2.5t/ha (1t/acre) of lime increases pH by 0.1 unit between pH 5.5 and 6.5.

Salinity: Negligible.

Erosion risk: Steep slopes, intense unpredictable rainfall events, and fine, unprotected seedbeds combine to make this soil highly vulnerable to erosion. Commonly 2-10t/ha per year (approx 0.2-1.0mm depth) under intensive cropping. Topsoil already completely removed from many hill tops and steep banks.

Water repellence: Sometimes repellent after severe drying, particularly if organic matter levels are low.

Stoniness: Occasional, significantly reducing land capability for cropping.
Burnie Clay Loam profile - from Kindred

Australian classification: Ferrosol
Northcote classification: Gradational

Geology: Tertiary Basalt
Runoff: moderately rapid

Drainage: well drained

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>Dusky red, heavy clay loam; strong medium (20-50mm) structure and strong very fine (2-5mm) structure; few ironstone nodules; abundant very fine roots; field pH 6.0</td>
</tr>
<tr>
<td>20-35</td>
<td>Dark reddish brown, light clay; strong medium (20-50mm) structure and strong very fine (2-5mm) structure; few ironstone nodules; many fine roots; field pH 5.9</td>
</tr>
<tr>
<td>35-60</td>
<td>Dark reddish brown, light clay; strong coarse (50-100mm) blocky structure and strong very fine (2-5mm) structure; few ironstone nodules; many fine roots; field pH 6.1</td>
</tr>
<tr>
<td>60-100</td>
<td>Dark reddish brown, light clay; strong medium (20-50mm) structure and strong very fine (2-5mm) structure; few ironstone nodules; many fine roots; field pH 5.7</td>
</tr>
<tr>
<td>100-150</td>
<td>Red, light clay; few yellowish red mottles; strong medium (20-50mm) structure and strong very fine (2-5mm) structure; no live roots; field pH 4.8</td>
</tr>
<tr>
<td>150-170</td>
<td>Strongly brown, light clay; many dark red mottles; common (10-20%) dispersed basalt gravels; no live roots; field pH 4.5</td>
</tr>
</tbody>
</table>

Combine tillage implements to avoid over-working and compaction.

Maintaining organic matter levels is a major challenge for managing krasnozems under intensive cropping.

Cover crops help reduce erosion.

- our rich red soils

Major challenges
⇒ water erosion
⇒ structural decline
⇒ maintaining organic matter
Keeping our krasnozem soils in good shape

Intensive cropping places great demands on our rich red soils. For a krasnozem to remain healthy under intensive cropping, management must be first rate. In order of priority, the three key areas of management are:

1. preventing erosion
2. maintaining structure
3. maintaining organic matter

Preventing erosion is number one. A poorly structured paddock, low in organic matter’, can be restored under a decade or two of pasture, but a millimetre of soil takes hundreds of years to form. Keeping your krasnozem in good shape naturally reduces it’s erosion potential - a stable, friable, open structure maximises infiltration and reduces harmful runoff. Maintaining organic matter levels is a key to good structure. The three key areas are closely inter-related. Soil conservation earthworks alone can only save so much soil. Erosion is minimised if soil conservation earthworks are combined with good structure and lots of coarse organic matter.

The following pages will help you keep your soil where it belongs.

Soil conservation for krasnozems

CONTOUR DRAINS
Collect run-off from within the crop and divert it into grassed irrigator runs or waterways. These must be put in immediately after planting.

CUT-OFF DRAINS
Divert run-off which is coming onto the paddock. They are built in summer or early autumn. Cut-off drains are cheap and effective.

GRASSED IRRIGATOR RUNS
are used to safely take the water from the contour drains off the paddock. They are permanently sown to grass and prepared 12 months in advance.

GRASSED WATERWAYS
are a wide shallow drain along a natural drainage line permanently sown to grass. They are prepared 12 months in advance.

The following two pages discuss these four aspects in more detail. Contact the DPIWE Soils Offices for soil conservation advise and a farm visit, free of charge.
If you have water coming from outside the paddock;

- cut-off drain
- diversion bank

Cut-off drains are designed to cut across slope, often following farm tracks or fencelines, diverting run-off from its natural line of flow.

Cut-off drains are usually built with an excavator. Batter side slopes according to stability of the soil type; 45 degrees for krasnozems, black cracking clays or Cressy soils, to 20 degrees or less for lighter soils.

Cut-off drains are usually 50cm to 1m deep. Where the fall on the drain exceeds 5% on clay soils, a grassed waterway is necessary.

If you have a natural drainage line running through the paddock

- grassed waterway

A waterway allows runoff to follow its natural course, however steep it may be. Make the bottom wide (up to 1m) and level. Throw a mixture of ryegrass and clover seed on immediately after construction.

If you are cropping an area with even a slight slope

- grassed irrigator lanes
- contour drains

Grassed irrigator lanes hold the irrigator on its track and collect runoff from the contour drains. The lanes are normally 3.0m wide and need only be 100-200mm deep unless on a sideslope. Install when the paddock is still in pasture. Distances between runs must be calculated according to spray boom widths to ensure the runs are not sprayed with herbicide. See the Kindred booklet for details.
Contour drains, installed with a grader blade or spinner drainer, need to be correctly surveyed using a clinometer to avoid erosion or deposition. They must have between 5 and 7% fall on krasnozems and 0.5 to 2% on sandy soils. See the Kindred booklet for details.

Approximate distance between contour drains

<table>
<thead>
<tr>
<th>Slope category</th>
<th>Heavy krasnozem</th>
<th>Sandy loams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep (15%+)</td>
<td>less than 30m</td>
<td>less than 20m</td>
</tr>
<tr>
<td>Medium (10-15%)</td>
<td>30-40m</td>
<td>20-25m</td>
</tr>
<tr>
<td>Low (10% or less)</td>
<td>more than 40m</td>
<td>25-40m</td>
</tr>
</tbody>
</table>

In 1994, the Kindred Landcare group published ‘Keeping Your Soil On Your Farm’, a farmers guide to planning and constructing soil erosion control measures. For anyone with water erosion problems this publication is highly recommended. Copies are available from the DPIWE office, Stoney Rise, Devonport.
Management Guidelines for Krasnozem Soils

1. **Assess paddock for erosion potential before ploughing.** Think in terms of catchments and drainage lines.

2. **Avoid steep slopes and long slopes.** Don’t crop land over 20% slope. Divide long slopes with contour drains or diversion banks.

3. **Divert external runoff.** A single well placed cut-off drain can save your paddock year after year.

4. **Establish grassed waterways.** Leave natural drainage lines unploughed. Interruptions to tillage and spraying operations are minimal.

5. **Consider planting layout.** Permanent grassed irrigator lanes provide a safe drain to dispose of water from contour drains. Grassed headlands help keep trucks off the paddock.

6. **Install contour drains - immediately after sowing.** A long slope is a high risk slope, even if its only gentle.

7. **Cover crops reduce erosion.** Fewer contour drains are required if a cover crop is present.

8. **Avoid wet harvests.** One wet harvest will undo years of careful soil management.

9. **Incorporate crop residues.** Organic carbon is a key indicator of the sustainability of your cropping. Use the plough rather than a deep, slow, powered implement pass to incorporate large amounts of organic matter.

10. **Sow a green manure - immediately after harvest.** Long fallows are not good for long term soil structure and fertility. Short term ryegrass is the best soil rejuvinator.

11. **Deep rip at the friable moisture content.** Ripping moist or wet soil creates clods below the surface.

12. **Underwork rather than overwork our rich red soils.** Don’t prepare a seedbed any finer than is necessary for the seed being sown.
Krasnozem case studies

Colin Parsons, Cropping farmer/contractor, Forth

**Soils**
- mainly krasnozem, with some grey sandy loam patches

**Rotation**
- approx 75% of farm under crop, 25% under pasture
- cropping rotation usually five years long, (potatoes, peas, poppies, onions and triticale), always containing a cereal for groundkeeper and disease control, and to help restore the ground.

**Green Manure**
- Colin traditionally used oats but has changed to short term ryegrass (9-12 months) because:
  a. oats leave the ground very wet for early spring cultivation
  b. ryegrass is a superior green manure for soil rejuvenation
  c. ryegrass provides more feed than oats
- ryegrass does require irrigation to germinate in summer to produce good growth for grazing and then ploughing in August/September
- time between crops is an opportunity for green manuring and grazing. Colin tries to avoid bare fallowing any longer than 6 weeks
- Colin sees many benefits of a cereal in the rotation;
  a) good control of potato ground keepers
  b) good disease break to soft rots and wilts
  c) lets the ground dry right out, producing deep cracking and clod weathering which enhances soil structure naturally
  d) cereal stubble decomposes slowly, enhancing soil structure and reducing erosion risk

**KEY POINTS**
- dryland cereal in the rotation
- paraplough
- pasture/oat potato preparation

**Pasture**

- Apr soil test
- Apr paraplough x2
- cultivate
- oat & fertiliser mix spun on
- power harrow to 75mm (3")
- leave, turf breaks down
- Aug lightly feed off oats
- Oct mouldboard plough
- power harrow
- rip/rotary hoe combination

**Primary Cultivation**
- Colin believes strongly in the use of the mouldboard plough because
  a) its action on soil structure is relatively gentle compared with powered implements
  b) a minimal number of subsequent passes are required to prepare the seedbed

“your skill as a krasnozem farmer really shows when you consistently work the soil at optimum moisture conditions”.

**Potatoes**
c) effective burial of previous crop’s residues or green manure crop
d) produces a relatively weed free seedbed

The paraplough
- Colin finds the paraplough is far more effective at alleviating compaction across the whole cultivated layer compared with a narrow tine ripper (paraplough 4 tines @ 15”, 110hp)
- cropping ground is paraploughed at least once per year
- never paraplough before poppies
- dual wheels are very effective at reducing compaction in seedbeds

Secondary Cultivations
- Colin is careful not to work the soil finer than is necessary for the seed or harvesting operation to follow
- timing is critical - if it’s too moist, stay off the tractor. Even a heavy dew on fallow ground significantly increases structural damage caused by powered implements or the S tine.

Peter Murdoch, Dairy farmer, Moriarty

Soils
- krasnozem with patches of Wesley Vale sands and clays

Rotation
- five years pasture between potato crops

Cultivation
Peter uses just two implements, the agroplough and the rotary hoe. This keeps investment in equipment to a minimum while maintaining flexibility for the different soil types. Lighter soils, being much weaker, are worked at lower rotor speed and higher ground speed with the hoe.

Krasnozems – our rich red soils
Peter uses a contractor with a Lely piggyback combination drill to reestablish pasture.

Charles Langmaid, Vegetable farmer, Kindred

Soils
➢ Krasnozem

Primary Cultivation - a low energy approach
➢ Charles likes to break up the turf and root mat with his spring tine implement;
  a. very little energy is applied each pass
  b. the energy is applied where it is needed - to break the turf and no deeper
➢ The combined rip and rotary hoe cultivation helps avoid compaction by
  a. reducing the number of passes
  b. ordering tillage operations so that the deepest working is as close as possible to the final paddock working

Gavin Clarke, Cropping and beef, Red Hills, Deloraine

Soils
➢ krasnozems, “fluffy” red to heavy red clay loam
➢ rolling hills, many seepage points
➢ stone limitation

Rotation
➢ pasture / potato or poppies / peas / barley / onions / pasture
➢ crop phase between 5 and 10 years
➢ pasture is a cocksfoot and ryegrass mix
**Green Manure**
- traditionally oats, but Tama or tick beans preferred after early harvest
- green manure is not grazed

---

**Pasture**
- spray off depending on twitch
- mouldboard plough to 150mm (6”)
- leave 2 or 3 months
- rip to 300-375mm (12-15”)
- roterra with crumble roller

**Potatoes**
- ploughed deep at least 200mm (8”) for several years incorporating a little subsoil each time with the aims of deepening topsoil and incorporating green manure, but found
  a) topsoil gradually more difficult to work, particularly baking into clods after ploughing, and
  b) too many stones were brought up
- recently changed to shallower ploughing

---

**Deepening topsoil brought problems**
- ploughed deep at least 200mm (8”) for several years incorporating a little subsoil each time with the aims of deepening topsoil and incorporating green manure, but found
  a) topsoil gradually more difficult to work, particularly baking into clods after ploughing, and
  b) too many stones were brought up
- recently changed to shallower ploughing

---

**Oats**
- spray off
- mouldboard plough to 100mm (4”)
- graze unincorporated tops with sheep in dry conditions
- roterra with crumble roller

**Poppies**
- rip/harrow combination used before oat sowing
- drill/harrows/roller combination used for Tama sowing
- roterra - thinking of towing a light Cambridge behind

---

**Ripping**
- when rippers were first introduced 5 years ago, Gavin ripped up to 20 inches deep everytime. Crop growth certainly improved. Now Gavin rips 300-375mm (12-15”) and only before and after potatoes and onions, and still seems to be bringing up as much stone as ever!
- our decision to rip is based on roterra performance - if it rides out of the ground then ripping is required.

---

**Combined Implements**
- Rip/harrow combination used before oat sowing
- drill/harrows/roller combination used for Tama sowing
- roterra - thinking of towing a light Cambridge behind

---

**Tines or powered implements for secondary cultivation**
- The main problem with the S tine after ploughing cultivation is the wheelings, particularly for peas. The s-tine is used only if stone prevents roterra operation

---

**Handling pea and barley stubble**
- pea straw - after raking and baling, the stubble is mouldboard ploughed for green manure oats or Tama, then mouldboard ploughed again, turning the rotted pea straw back on top. This produces excellent surface tilth and erosion risk is reduced
- barley stubble - after hard grazing the paddock is shut up over winter to allow regrowth before a roterra or mouldboard plough spring seedbed preparation

---

**Krasnozems – our rich red soils**

---
Mike Radcliffe, Wesley Vale

Soils
➢ Predominantly krasnozem with areas of sand and duplex typical of Wesley Vale region

Rotation
➢ Continuous cropping with two crops per year on the better ground between the months of September and April.

Organic Matter & Green Manure Crops
➢ Michael believes high soil organic matter is the key to sustaining continuous intensive cropping on the krasnozems. Some paddocks are shown below:

<table>
<thead>
<tr>
<th></th>
<th>Typical Organic Matter Levels (% loss on ignition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good krasnozem</td>
<td>18</td>
</tr>
<tr>
<td>Poor krasnozem</td>
<td>13</td>
</tr>
<tr>
<td>Wesley Vale Sand</td>
<td>3</td>
</tr>
</tbody>
</table>

➢ Every paddock is sown in autumn, usually with Tama ryegrass up until mid April, or oats if later. Michael avoids leaving ground fallow over winter because while nothing is growing, no organic matter is going back into the soil, it’s only being lost.

➢ Whether it’s oats or Tama, the seedbed preparation is absolutely minimal. Often just spin oats over the previous crop residue and shallow disc, Lely or Kuhn, or use the Lely/airseeder combination drill to sow the Tama. The sowing boots on the Lely/airseeder are very lightly sprung, so provided ground speed is reduced, the boots follow the surface of an unlevel or roughly prepared seedbed very well.

KEY POINTS
➢ grassed irrigation lanes in all cropping paddocks
➢ grassed waterways & cut-off drains as required
➢ roterra-airseeder combination implement
Primary Cultivation
Michael generally uses the agroplough and powered implements, but relies on the mouldboard plough and a shallow powered implement pass for spring preparation when the soil is too moist for the agroplough.

Secondary Cultivation
➢ Most residues are returned for long term benefit to the soil. Stocking or baling is avoided.

Whole Farm Planning
➢ The farm is a prime example of good whole farm planning. Windbreaks, gravelled laneways, ditches and soil conservation earthworks are well integrated so each poses minimal interruption to the intensive cropping program.

Soil Conservation
➢ In 1995, Michael enlisted the help of local DPIF soils officers to survey all his paddocks for grassed irrigator lanes, which he then installed himself using a rotary drainer. Unlike many early grassed irrigator lanes constructed with a road grader, these lanes are shallow, (100-200mm) just enough to hold the irrigator and take the water. They’re easy to put in and cause minimal interruption to paddock operations. Irrigation lanes never have to be measured out again. However, achieving perfect alignment and number of beds between the lanes remains a problem, especially with contract sowing on sideslopes.
Cressy soils

**Major challenges**

- drainage
- structure decline (clods, hard pans)
- maintaining organic matter

Lots of worm and root channels, critical for drainage and structure of a heavy soil like the Cressy, are easily closed up by compaction. Does your soil have them?

Cressy profile - from the regional irrigation scheme

Australian classification: Dermosol  
Geology: Tertiary clay  
Drainage: Poor

Northcote classification: Gradational  
Runoff: Moderately rapid

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19</td>
<td>Very dark brown; clay loam; moderate very fine (2-5mm) subangular blocky structure; abundant very fine live roots; abrupt smooth boundary;</td>
</tr>
<tr>
<td>19-26</td>
<td>Dark brown; gravelly clay; moderate fine (5-10mm) angular blocky structure; many very fine live roots; clear wavy boundary;</td>
</tr>
<tr>
<td>26-48</td>
<td>Strong brown; clay; common coarse faint dark yellowish brown primary mottles; moderate medium (20-50mm) angular blocky parting to moderate very fine (2-5mm) angular blocky structure; common very fine live roots; clear smooth boundary;</td>
</tr>
<tr>
<td>48-70</td>
<td>Yellowish brown; clay; many medium prominent red primary mottles; moderate medium (20-50mm) angular blocky parting to moderate very fine (2-5mm) angular blocky structure; few very fine live roots; gradual smooth boundary;</td>
</tr>
<tr>
<td>70-100+</td>
<td>Yellowish brown; clay; few coarse prominent red primary mottles; weak medium (20-50mm) angular blocky parting to weak fine (5-10mm) angular blocky structure; few very fine live roots</td>
</tr>
</tbody>
</table>

Severe compaction

Some profiles have gravelly layers at depth. These areas can be drained with a few deep, open ditches.

Severe compaction

Lots of worm and root channels, critical for drainage and structure of a heavy soil like the Cressy, are easily closed up by compaction. Does your soil have them?
General Description
Dark grey-brown to brown, loam to clay loam topsoil, overlying at about 150mm (6”) depth a reddish brown to grey-brown rather friable clay on brightly coloured, mottled, brown clay.

Region and local names
Westbury, Hagley, Bishopsbourne, Whitemore, Cressy-Longford irrigation scheme
Cressy soils are mapped as Cressy shaley clay loam and Kinburn

Occurrence
On tertiary sediments. Very gently undulating hills and terraces, with the darker, heavier Kinburn soil occurring in hollows and drainage lines. Land capability of areas of these soils is typically 3 to 4.

Key properties of Cressy soils

<table>
<thead>
<tr>
<th>Property</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability</td>
<td>Moderate. Cressy shaley loams grade to heavier, darker soils in the drainage lines (mapped as Kinburn).</td>
</tr>
<tr>
<td>Permeability</td>
<td>Imperfect. Drainage design, cost and effectiveness depends on presence or absence of ironstone gravel in the profile. Install surface drains first. Mole drainage may be a suitable secondary treatment but seek professional advice.</td>
</tr>
<tr>
<td>Root growth</td>
<td>Restricted. Typically these soils waterlog in winter. This restricts the bulk of plant roots to the A horizon.</td>
</tr>
<tr>
<td>Readily available water</td>
<td>Moderate. About 45mm in 300mm depth of topsoil in good structural condition.</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>Moderate. 2-4% organic carbon.</td>
</tr>
<tr>
<td>Workability</td>
<td>Restricted. Cressy soils are less resilient than the krasnozem. They are easily damaged by wet tillage or heavy machinery. Drainage is essential to avoid wet tillage.</td>
</tr>
<tr>
<td>Fertility</td>
<td>Moderate. Potassium and molybdenum deficiencies common.</td>
</tr>
<tr>
<td>pH</td>
<td>Moderately acid 5.5-6.5(1:5 water). Lime requirement far less than krasnozem.</td>
</tr>
<tr>
<td>Salinity</td>
<td>Low in the rootzone but often saline at depth. Surface salinity occurs only in association with seepage or waterlogging.</td>
</tr>
<tr>
<td>Erosion risk</td>
<td>Moderate water erosion risk, particularly on intensively cropped paddocks where organic matter reserves are depleted and compaction restricts infiltration. Exposed subsoil is commonly observed on slopes and hill tops after ploughing.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>Low.</td>
</tr>
<tr>
<td>Rocks &amp; stones</td>
<td>Ironstone maybe present as gravel, shale or occasional large rocks or as a continuous layer. Gravel and small shale is soft and poses no major limitation to tillage and crop production.</td>
</tr>
</tbody>
</table>
Management Guidelines for Cressy Soils

1. **Drainage.** Establish deep surface drains first, according to whole farm plan. Mole drains maybe appropriate to further improve drainage if cropping intensely. Seek professional advice.

2. **Work at the friable moisture content.** Check soil moisture content before every tillage operation.

3. **Avoid wet harvests.** One wet harvest undoes years of good soil management.

4. **Avoid winter forage crops.** Stocking destroys the natural surface tilm.

5. **...and more drainage**
   - divert runoff entering the paddock
   - establish grassed waterways down drainage lines
   - plant up and down slope to encourage surface runoff

6. **Incorporate crop residues.**
   Organic carbon % is a key indicator of the sustainability of your cropping rotation. Use the plough rather than a deep, slow, powered implement pass to incorporate lots of organic matter.

7. **Sow a green manure - immediately after harvest.** Short term ryegrass is best. Long fallows are not good for long term structure and fertility.

8. **Underwork** rather than overwork the Cressy soils.
Ross Gibson, ‘Mill Farm’, Hagley

Soils
➢ Cressy shaley clay loam

Rotation
➢ approx one third of farm under crop
➢ usually poppies / peas / cereal / peas / cereal, or potatoes / cereal / peas / cereal / cereal

Green Manure
➢ oats after all crops except late dug potatoes
➢ oats broadcast directly on grazed stubble, one or two discings
100mm (4“) deep.
➢ oats winter grazed

Pasture
➢ traditionally perennial ryegrass/ white clover mix (Ellet, Tasdale) for 4 years
➢ traditional pastures not lasting due to pasture grub damage
➢ about to try short term ryegrass (Concord, Progrow)
➢ deep rips only before potatoes to achieve sufficient depth of tilth 300mm (12“) for planting
➢ winged ripping tines produce a complete soil shattering with a single pass
➢ no powered implements are used
➢ mouldboard plough is usually used in seedbed preparations except the oat green manure
➢ discs are used instead of mouldboard plough to conserve moisture in dry years
➢ cereal stubbles are returned by disc or mouldboard plough after grazing and baling

1994/95 CROPPING PROGRAM (HA)
peas 23
broad beans 10
potatoes 7
wheat 8
oats 8
barley 75
poppies 15

➢ remnant stubble could be found mixed throughout topsoil, associated with signs of intense worm and biological activity
➢ Ross has purchased a European brand of discs with a spacing of 250mm (10“) rather than the standard 300mm (12“), with the benefits of finer chopping of stubbles and less ridging during shallow working

Cressy soils – drainage is the key
Gordon & Stuart McGee, Bishopsbourne

Soils
- Cressy shaley clay loam.
- 2.5 to 3% organic carbon on most cropping paddocks, which is a reasonable level considering these soils have been cultivated for 100 years or more.

Rotation
- potatoes / cereal (wheat or Triticale) / poppies or peas
- pasture traditionally 2-3 years, now thinking of changing rotation to a system of short term ryegrass (1year) every 2nd or 3rd crop.
- perennial crops of phennel, grass seed and chicory are also grown.
- would prefer more perennial crops because the soil rejuvenates under these without tillage, and there are no annual costs of tillage.

Barley
- graze stubble with sheep
- broadcast oats
- disc once
- graze over winter
- mouldboard plough July
- leave 4 to 6 weeks
- S tine
- S tine

Wheat
- The Gibson’s have an International 511 drill with Superseeder points, but find the trash clearance and tine breakout severely limiting any direct drilling options. An undercarriage purchase or conversion is being considered.

Hogweed and a compacted surface after peas made direct drilling difficult. The Gibson’s are keen to modify their drill.

Potatoes
- harvest
- shallow disc and S tine, or S tine twice only
- sow autumn

Pasture
- mouldboard plough 200mm (8”)
- rotary hoe
- plant

Cereal
- Barley
  - graze stubble with sheep
  - broadcast oats
  - disc once
  - graze over winter
  - mouldboard plough July
  - leave 4 to 6 weeks
  - S tine
  - S tine

- Wheat
  - The Gibson’s have an International 511 drill with Superseeder points, but find the trash clearance and tine breakout severely limiting any direct drilling options. An undercarriage purchase or conversion is being considered.

- Hogweed and a compacted surface after peas made direct drilling difficult. The Gibson’s are keen to modify their drill.

- Gordon & Stuart McGee, Bishopsbourne

Soils
- Cressy shaley clay loam.
- 2.5 to 3% organic carbon on most cropping paddocks, which is a reasonable level considering these soils have been cultivated for 100 years or more.

Rotation
- potatoes / cereal (wheat or Triticale) / poppies or peas
- pasture traditionally 2-3 years, now thinking of changing rotation to a system of short term ryegrass (1year) every 2nd or 3rd crop.
- perennial crops of phennel, grass seed and chicory are also grown.
- would prefer more perennial crops because the soil rejuvenates under these without tillage, and there are no annual costs of tillage.
Green Manure
➢ traditionally oats, but grazing animals tend to destroy structure in the top couple of inches. This compaction is far worse under oats than short term ryegrass.

Primary Cultivation
➢ mouldboard ploughing is used extensively on the McGees’ farm, with minimal secondary passes. The McGees are very keen to acquire/make a furrow press to further reduce additional tillage passes.
➢ a roller or cultipacker is towed behind every implement to crush clods and avoid baking by consolidation and moisture retention. The rotary hoe is only used before potatoes.

Deepening the topsoil
➢ the McGees have traditionally ploughed a little deeper every time, mixing a little subsoil into the topsoil with the aim of deepening topsoil.
➢ this practice has allowed potatoes to be grown but Gordon admits the soil has become heavier, more prone to clods and trickier to manage. Mixing has diluted the topsoil’s organic matter, reducing soil fertility.

Drainage
➢ constructing deep surface drains where required was the first step in the drainage program
➢ approximately half the farm has underground drainage installed
➢ perforated plastic pipe with gravel backfill is the main treatment. Success relies on the secondary treatment of mole drains, installed using a hired bulldozer for $210/ha at 1.5m spacing. These empty into the pipe drains through the gravel backfill connection.
  1. Grid drainage - for paddocks of even or minimal slope, 30m spaced parallel drains costing about $1500/ha
  2. Strategic drainage - for undulating paddocks with distinct drainage lines, pipes follow the hollows, and moles are installed crossing these. Around $750/ha
➢ with drainage, ploughing can be achieved early at optimum and even moisture content across the entire paddock, towing the roller behind to avoid baking and clod formation.
➢ the McGees can now safely work their drained soils 2-3 days after rain and be assured that smearing and compaction is not occurring. Clods are the biggest problem with cropping these soils. This is largely avoided with drainage.
➢ potatoes are the farm’s biggest income (20ha on a 6-7 year rotation), and drainage has removed virtually all the risk of waterlogging or wet harvest. If rain occurs immediately following irrigation, you don’t have to worry at all. The aim is to finish potato harvest by the beginning of June.

Cressy soils – drainage is the key
Major challenges
⇒ working at the right soil moisture
⇒ drainage
⇒ clods and smearing

Coal River, lower hillslopes

Australian classification: Vertosol
Northcote classification: Uniform
Geology: Tertiary basalt
Runoff: Moderately rapid
Drainage: Imperfect

Depth cm

0-38
Black: heavy clay; massive parting to moderate medium (20-50 mm) polyhedral structure; common very fine live roots; abrupt smooth boundary;

38-50
Very dusky red; gravelly heavy clay; massive parting to moderate fine (5-10 mm) polyhedral structure; many angular stratified basalt gravels (20-60 mm); common very fine live roots; sharp smooth boundary;

50-67
Dusky red; gritty light clay; massive structure; sharp smooth boundary;

Deep surface drains are a key to successful management of alluvial black cracking clays.

Self mulch tilth of a black cracking clay soil

Autumn plough and one pass S-tine in spring - a minimum tillage preparation for black cracking clays.
MAJOR CHALLENGES
➢ working at the right soil moisture
➢ drainage
➢ avoiding clods & smearing

General description
A black, structured, swelling clay overlies (at 30-60cm depth) a mottled, greyish brown or strong brown sandy clay. The surface soil, of light clay or clay loam, is thin (<10cm) and strongly self-mulching, developing a strong very fine granular structure on drying.

Occurrence
Either on hillslopes of basalt or dolerite parent material where rockiness often limits cropping capability, or as a recent alluvial deposit along drainage lines, floodplains of creeks and rivers. This soil can occur in association with other lighter soil types, making separate management difficult.

Regions and local names
Found throughout the state. Local names in mapped areas of the Coal River Valley are Roslyn, Churchill, Cranston, Laburnam, Dolerite and Basalt 1. In the Midlands, the alluvial black cracking clays are known as Canola. The land capability of areas of these soils is 4 or lower depending mainly on the frequency of flooding.

Typical Canola profile - from the midlands
Australian classification: Vertosol  Geology: Alluvium  Runoff: Moderately rapid
Northcote classification: Uniform  Drainage: Imperfect

0-15cm  Black; **light clay or clay loam**; generally no mottles; moderate very fine granular structure plus moderate fine subangular or angular blocky structure; generally no stones; pH 6.0; salinity 0.1 dS/m; clear or abrupt smooth boundary

15-35  Black to very dark grey; **light to heavy clay**; may have few grey and strong brown mottles; moderate medium-coarse angular blocky structure with some fine granular peds; generally no stones, some profiles may have few dolerite stones; pH 6.5; salinity 0.2 dS/m; clear to gradual smooth boundary

35-60  Black to very dark grey; **medium clay**; few brown or dark yellowish brown mottles; moderate angular blocky structure or lenticular structure; few manganiferous and/or calcareous nodules; generally no stones; some profiles may have few dolerite stones; pH 7.2; salinity 0.5 dS/m; clear boundary

>60  Strong brown or greyish brown; **sandy clay or medium clay**; common yellowish brown mottles; massive or medium lenticular structure; few calcareous or manganiferous soft segregations; generally no stones; some profiles may have few dolerite stones; pH 7.4 salinity 1.0 dS/m.

What is self-mulching?
A special tilth forming characteristic of these soils. The ability to form a natural seedbed during wetting/drying and freeze/thaw cycles.

- sent to test our skills
Key properties of black cracking clay soils

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability</td>
<td><strong>Moderate.</strong> As alluvial soils, variation in structure is high, some are horrendously cloddy, some beautifully friable, perhaps reflecting management history. On basalt or dolerite hillsides, variation is considered in terms of stoniness and limited topsoil depth.</td>
</tr>
<tr>
<td>Self mulching</td>
<td><strong>High.</strong> The ability of the soil surface to crumble over time into fine (&lt;1mm) aggregates, forming a natural tilth by shrink/swell cycles. Encouraged by wetting, drying, frost, and by avoiding compaction from machinery and stock.</td>
</tr>
<tr>
<td>Premeability</td>
<td><strong>Restricted.</strong> Permeability slow after wetting and crack closure. Prone to flooding where associated with rivers, streams or drainage lines. Under cropping, wet areas become structurally degraded unless drainage works achieve uniform soil moisture across the whole paddock.</td>
</tr>
<tr>
<td>Root growth</td>
<td><strong>Restricted.</strong> High soil strength constricts roots to natural planes of weakness ie. cracks and voids. In the topsoil, rooting is dependent on the self-mulching natural tilth formation.</td>
</tr>
<tr>
<td>Readily available water</td>
<td><strong>High.</strong> About 45mm in 300mm topsoil depth. In a clay soil, a large proportion of soil voids are extremely small, and the water they contain is held too tightly for roots to extract. The soil may feel reasonably moist in the hand but the plants may be under stress. Holding capacity is reduced by mismanagement - compaction and decline in organic matter levels.</td>
</tr>
<tr>
<td>Organic matter</td>
<td><strong>High.</strong> 3-4% organic carbon under cropping, up to 7% under vigorous pasture.</td>
</tr>
<tr>
<td>Workability</td>
<td><strong>Poor.</strong> These are known as ‘Sunday soils’, because they’re too wet to work one day, and too dry the next. More than any other soil, the key to successful management and long term productivity lies with timeliness of paddock operations. Encourage the soils inherent self-mulching properties to form the seedbed by ploughing early and good drainage.</td>
</tr>
<tr>
<td>Fertility</td>
<td><strong>High.</strong> Inherently high clay and organic matter levels are reservoirs of plant nutrients. May become deficient in phosphorus and potassium.</td>
</tr>
<tr>
<td>pH</td>
<td><strong>Slightly acid,</strong> becoming neutral to slightly alkaline with depth.</td>
</tr>
<tr>
<td>Salinity</td>
<td><strong>Variable.</strong> Sometimes slightly saline topsoils, salinity increasing with depth.</td>
</tr>
<tr>
<td>Sodicity</td>
<td><strong>Variable.</strong> Muddy, discoloured puddles and runoff, and slumping or running together of the surface after mouldboard ploughing are good indicators.</td>
</tr>
<tr>
<td>Erosion risk</td>
<td><strong>Moderate.</strong> High soil strength and cohesion make these soils comparatively resistant to erosion. However, erosion does occur on steep or long slopes or in alluvial sites with fast flowing flood waters.</td>
</tr>
<tr>
<td>Water repellence</td>
<td><strong>Low</strong></td>
</tr>
<tr>
<td>Rocks &amp; stones</td>
<td><strong>Variable.</strong> Rounded dolerite stones or vesicular basalt stones.</td>
</tr>
</tbody>
</table>

Sunday soils at their worst. Maximise the soils natural self mulching ability to form the seedbed. Install drains and plough early.
These are the most frustrating of all cropping soils. Compared with other soils, the clods are spectacular and unforgiving, and it has the narrowest moisture range for working. However, when in good physical condition, their self mulching characteristics can form a seedbed with a zero-till or minimum tillage.

**Tillage**

What are appropriate tillage practices for black cracking clays? Most of Australia’s wheat, sorghum and cotton is grown on these soils where long fallows play an important role, primarily for moisture conservation, but the natural self-mulch is certainly promoted. The depth of friable self-mulch is commonly 10cm(4”) or more. This depth of self-mulch is rarely seen in Tasmania. A comparison of management is shown:

Why are our black cracking clays so cloddy and difficult compared with elsewhere in Australia?

1. Ours are stocked heavily which causes severe surface compaction especially in wet conditions
2. Ours receive more intensive tillage. Conventional tillage (chisel plough), used elsewhere in Australia is equivalent to our minimum tillage. Mouldboard ploughs and powered implements are not used anywhere else in Australia on black soils.
3. Ours are poorly drained, and often share the paddock with other soil types. Tillage occurs before the black soil areas are really dry enough.
4. Our fallows are rarely longer than 8 months. Elsewhere fallows of 12-18 months may occur while sufficient moisture for crop growth accumulates in the profile. Long fallows promote a natural self-mulched seedbed, but reduce long term soil organic matter levels.

On the mainland, the self mulching characteristic of this soil seems to be stronger, whether as a result of management, climate or inherent in the soil itself would require more investigation.

**Self-mulch versus tillage**

In Tasmania, there are two basic approaches to preparing the seedbed on this soil. Either autumn plough and leave fallow over winter, or spring plough, forming the seedbed by tillage. Both options are valid and should be used in a sustainable cropping program, since, be it a wet year or a dry year, a complete disaster is avoided, and the workload on labour and machinery is spread over time.

**Autumn preparation - Let the weather do the work**

- plough early (chisel, one way or mouldboard plough)
- leave over winter to self mulch
- in spring, one or two very light, shallow workings once dry enough (using dutch harrow, smudge, S tine with front smudge board or shallow powered implement)

Short term risk - a wet winter or flooding will cause slaking and the whole ploughed layer runs together to form a massive continuous layer. The surface dries and bakes in the spring, preventing any drying or movement of the water beneath. By the time its dry enough underneath to bear a tractor, the surface has baked. Any tillage results in clods.
Long term risk - organic matter levels build during active plant growth and decline during fallows. Six months of crop growth a year is simply not enough to maintain humus levels in the long term, making the soil gradually more prone to damage by tillage, traffic and stock.

Spring - Form seedbed by tillage
- spring plough, towing a roller/press
- follow immediately to conserve moisture (dutch harrow, smudge, S-tine with front smudge board or shallow power harrow)

Short term risk - the surface immediately dries and bakes while the soil below is still too moist for tillage.
Secondary tillage operations result in clods which resist passive (tined) attempts to form a seedbed. This leaves the options of high powered ‘bashing’ rotary implements, sowing deep, or sowing and irrigating.

Long term risk - more tillage leads to poorer structure, then requiring more tillage........

Remember, whatever tillage option is used, smearing and compaction are by far the biggest factors in determining whether your black cracking clay will improve or decline over time.

Long fallow or green manure?
A long winter fallow will give you a nice self mulched seedbed come spring time, but this is at the expense of long term sustainability. Humus levels in the soil build during active plant growth and decline during fallows. Six months of crop growth a year is simply not enough to maintain humus levels in the long term. Green manures, ryegrass, topworking and stubble retention are the best tools for ensuring the soil is biologically active nearly all year round.
For black cracking clays in bad structural condition, a long fallow might be the only option.

Maximise wetting and drying cycles
These cycles promote the self-mulching structure. Plan your rotation to include a dryland cereal crop inbetween irrigated crops to ensure a really severe drying and deep cracking occurs. If several irrigated crops are grown, the soil never has a chance to really dry and deep crack.

Black cracking clays and depth of ploughing
These soils are often uniform black cracking clay for 60cm or more. Therefore, can’t we just bury the clods? Unfortunately not. The deeper you go the fewer fracture lines (straw, roots and worm holes), exist which means deep ploughing will bring up more cloddy clay. **Plough shallow**, just to the depth of the friable root zone, usually 100mm (4”). This is the minimum depth for modern mouldboard ploughs.
Shallow ploughing encourages self mulching seedbed formation. (See page 79.)
Management Guidelines for Black Cracking Clays

1. **Work at the friable moisture content.** Use the rolling in hand test before tillage. Wet tillage destroys the soil’s ability to form a natural self mulching seedbed.

2. **Promote surface drainage.**
   - for undulating paddocks, open up drainage lines linking hollows and depressions with broad shallow grassed ditches. Leave unploughed during cropping.
   - for flat paddocks, plant up and down whatever slope exists to encourage shedding of surface water down rows or wheelings.
   - for very flat paddocks, construct beds or parallel shallow ditches on a 20-40m spacing, or mole drain. Seek professional advice.

3. **Use the natural tilth.** Use long fallows rather than tillage in cloddy paddocks. If a good tilth exists, avoid stocking and direct drill a cereal crop.

4. **Avoid wet harvests.**
   Decades of careful soil management are undone with one wet harvest.

5. **Avoid stocking in wet conditions.** Grazing winter forage crops or oats is highly effective at destroying the natural tilth by pugging.

6. **Retain stubbles and residues.**
   Avoid using powered implements to incorporate large amounts. More humus is lost than gained - better to burn and ‘topwork’ than ‘hammer’ these soils. Use the mouldboard plough, tines or discs.

7. **Avoid erosion on long steep slopes**
   Break long slopes with a diversion bank or small contour drains

8. **Don’t crop areas at risk of erosive flooding**

---

*Surface drains follow mouldboard plough finishes.*
*After surveying, finishes were broadened with a road grader.*
*Ploughing will gradually crown the land between.*
Black cracking clay case studies

Noel Beven - black soils on dolerite hills

Soils
➢ self mulching black soil on foot slopes of dolerite hills
➢ slopes up to 20 degrees
➢ depth 200-300mm over brown clay (probably mildly sodic/saline)
➢ good structure, plenty of coarse organic matter present

Crops
➢ Noel grows various brassica seed crops, tick beans, onion seed, carrot seed as well as poppies, oats for grazing/green manure and fresh vegetables.

Rotation
➢ having cropped continuously for eight years following a 20 year pasture - Noel believes soil conditions are better than when they began
➢ all stubbles and residues are mulched
➢ uses short rotation ryegrass pasture
➢ alternates legume/non legume in rotation (peas & beans)

Tillage
➢ generally chisel plough x2, leave over winter, then S-tine or rotterra only if necessary
➢ s-tine good except for compacted wheelings
➢ mouldboard plough only for residue/stubble incorporation
➢ deep ripping - not used, not convinced of benefit
➢ tows harrows behind final cultivation - one less pass

Comments
➢ compaction is major problem - likes to drag boot across seedbed and find no ridges
➢ very aware of clay soils limited workability, risky soils for cropping
➢ strong believer in returning lots of organic matter
➢ water erosion is a problem in winter brassicas with beds up and down slope
➢ believes in cultivating to leave fallow rough (ridged) to avoid erosion, capping, & promote natural weathering, however, a rough fallow does promote moisture loss in dry years
➢ capping is a major problem for poppies in the valley (most black dolerite soils are too coarsely structured for poppies). If 36 hours can elapse between sowing and rainfall then capping seems to be avoided.

Justin Nichols, Campania road, Coal River Valley

Soils
➢ black soils on dolerite and duplex soils

Crops
➢ 200 acres of irrigated cropping, (80% of farm), with peas, canola, poppies, barley, oats, broad beans, seed onions/cabbage

Rotations
➢ duplex soil cropped for 5 years but believes this the limit of the soils capability
➢ black soil, 5 to 6 years is ok, provided its worked correctly (at the right moisture content)
➢ typical rotation - cereal / poppies / peas / canola / cereal
Tillage
➢ barley stubble feed off, chisel plough and leave rough over winter to self mulch
➢ mouldboard ploughs all bean trash
➢ agroploughs (250mm, 10”), simply to make secondary cultivations much easier and improve infiltration with very little surface disturbance or mixing

Comments
➢ Believes the Coal River irrigation scheme is designed on 3 years cropping in 4 years. These soils are capable of this intensity of cropping only under the best management. Water costs about $120/ML, so higher value crops are required (orchard/vine/seed) to take the pressure off the soils by allowing a longer rotation.
➢ Maintaining organic matter levels is a real concern for Justin, particularly when pastures are so poor due to grubs and droughts. A concerted effort of green manuring (sorghum or Sudan grass under irrigation) and return of all crop residues will probably maintain organic matter levels higher than under a rotation with a poor pasture phase.

Ron & Chris Gunn, ‘Glenquoin’, Teatree

Soils
➢ black cracking clay on dolerite hills
➢ on leased block near Richmond - duplex with black cracking clay drainage lines

Rotation
➢ cereals on ‘Glenquoin’
➢ on leased area fed by regional irrigation scheme, crops 5 to 7 years with peas, broad beans, cereals, poppies and canola, using a short term ryegrass for best cropping paddocks, and perennial pasture in less frequently cropped paddocks

Tillage
Ron and Chris try to minimise their tillage where ever possible, and make best use of the self mulching ability of their black cracking clays.

Cereal
➢ graze
➢ chisel plough 1 or 2 times
➢ leave
➢ burn excess straw
➢ sow

Peas
➢ chisel plough 1 or 2 times
➢ leave
➢ harrow
➢ spray off
➢ sow peas

The brothers have a six row Shearer trash-culti drill which suits their minimum tillage system well. Paddocks are either chisel ploughed or disced in autumn, left to self mulch over winter before sowing. Soil moisture has to be just right to avoid smearing on the black cracking clay soils. “You have to be prepared to wait around and go when it’s right.” The drill is not converted for direct drilling so stubbles are grazed and later burnt if too much stubble remains for the drill to pass without blockage. The brothers say a mulcher would be an excellent tool for chopping stubbles and residues, allowing retention of more organic material to sustain lengthening cropping rotations.

MAIN POINTS
➢ one pass between cereal crops
➢ minimum tillage for peas and onions
David Smith, ‘Park Nook’ (leased), Cressy

Soils
➢ Park Nook’s best cropping soils are alluvial brown clay loam soils on a present floodplain. The soils crack and self mulch.
➢ The watertable approaches the surface during winter. Most paddocks are undulating and dissected by old stream channels, with gravel and stone seams at varying depths.

Drainage
Poor drainage means tillage is a continual compromise between too dry on the banks and too wet in the hollows. Soil management can be mediocre at best. The main limitation to drainage is the Lake River, which approximates the depth of the hollows in the surrounding cropping paddocks. Deepening of this channel would destroy the corridor of native/introduced vegetation and cause a decline in stream quality. Low lying paddocks and depressions on this farm should not be cropped.

Rotation
Potatoes, peas, poppies, Pak choi, chicory, brassica seed crops, onions, squash, beans and sweet corn are all grown with no strictly defined rotation.

Green Manure
About 80ha of the 120ha cropped each year traditionally had an oat green manure over winter. Annual ryegrass has now largely replaced oats as the green manure.

Cultivation
The same basic preparation is used for all crops using the plough, dutch harrow and roterra:

Which is the lesser of two evils?
David is unsure - whether to plough early (Jun/Jul) and cause compaction/smearing, or plough late (Oct) and bash the soil to a seedbed because of baking. The long term answer lies in drainage.

Drainage would remove wet areas of the paddock, allowing a well timed early plough with the whole paddock at an even, friable moisture content that’s right for ploughing and working.
Brian Lawrence, farm manager, ‘Formosa’, Cressy

Soils
➢ mainly alluvial black cracking clays (Canola) in magnificent structural condition
➢ some Brumby and Brickendon with saline discharge areas used for dryland cereals

Drainage
➢ Brian places great emphasis on very shallow surface drains that use the topography. These follow any depressions on the gently undulating alluvial plain. They’re installed with a grader blade and followed up after sowing with a spade to clean any lose soil from the bottom.

Rotation
➢ irrigated peas for seed and processing, green beans, poppies and Chinese cabbage. Dryland barley and ryegrass seed grown with limited irrigation. Cropping rotations are lengthening, one paddock appears to be in fine condition after 9 years cropping.
➢ the ryegrass seedcrop plays an important disease break and soil rejuvenation role in the rotation, particularly as the rotation lengthens towards continuous cropping. It’s grown for 2 years and has been sown up to the end of April on Formosa.
➢ Brian manages the rotation so that a maximum of two irrigated crops are grown before a dryland cereal. The cereal really dries the soil, promoting deep cracking and mulching, an important mechanism of structural rejuvenation for this soil type. Under continuous irrigated crops, the ground never has a chance to really dry deeply.

Green manure
➢ traditionally oats spread directly onto ungrazed stubble or the previous crop, followed by a shallow discing. This has worked well, the only problems being slow germination and early growth, and some grazing of the oats in wet conditions is bound to occur.
➢ this year the drill is being converted to allow direct drilling of annual ryegrass into the ungrazed stubbles of all crops. The ryegrass will be irrigated for germination most years. After some grazing, the ryegrass will be mouldboard ploughed under about May/June to allow winter self mulching before final seedbed preparation.

Pushing the cropping rotation
Formosa soil tests show a healthy 6-9% organic carbon (or 15-19% loss on ignition), and Brian aims to maintain these levels under lengthening cropping rotations (8 years plus). He sees the following three management points as very important;

a. No stocking in wet conditions, no wet tillage and avoid wet harvests if possible.
b. Have an oats or ryegrass green manure every winter.
c. Avoid long fallows - though they produce a good self mulch in the short term, in the long term organic matter levels are declining. 3, 4 or 5 months of active crop growth per year is simply not enough to maintain organic matter levels on an annual basis.

Cultivation
The mouldboard plough and roterra are used for all paddock preparations.

Peas
➢ spread oats on surface, Jan
➢ shallow disc
➢ limited grazing in dry conditions
➢ mouldboard plough, July/Aug
➢ smudge if dry
➢ leave
➢ roterra*
➢ sow poppies

Poppies
A significant area of Tasmania’s cropping soils are duplex. Duplex refers to the strong texture contrast between the topsoil and subsoil. A uniform profile has no texture contrast and a gradational has moderate texture contrast.

**Typical Brumby profile - from the midlands**

- **Australian classification:** Sodosol
- **Northcote classification:** Duplex
- **Geology:** Tertiary clay
- **Runoff:** Moderately rapid
- **Drainage:** Poor

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>Very dark greyish brown; <strong>loam or sandy loam</strong>; few yellowish brown mottles; weak subangular blocky structure; pH 5.5; salinity 0.1 dS/m; clear smooth boundary;</td>
</tr>
<tr>
<td>10-30</td>
<td>Greyish brown to light brownish grey; <strong>fine sandy loam or loamy fine sand</strong>; few to common yellowish brown mottles; weak structure; some profiles with ironstone nodules; pH 6.0; salinity 0.1dS/m; abrupt wavy boundary;</td>
</tr>
<tr>
<td>30-50</td>
<td>Light olive brown to brown; <strong>medium clay</strong>; common yellowish brown and common dark brown mottles; massive structure when moist, prismatic when dry; sometimes with manganese concretions; pH 7.0; salinity 0.1dS/m; gradual smooth boundary</td>
</tr>
<tr>
<td>50+</td>
<td>Olive brown; <strong>heavy clay to medium clay</strong>; common yellowish brown to red mottles; structure massive (moist), blocky (dry), sometimes with manganese concretions; pH 7.5; 0.2dS/m</td>
</tr>
</tbody>
</table>

**Riversdale profile - from the Coal River Valley**

- **Australian classification:** Sodosol
- **Northcote classification:** Duplex
- **Geology:** Quaternary alluvium
- **Runoff:** Rapid
- **Drainage:** Imperfect

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td>Black; <strong>sandy loam</strong>; weak fine (5-10mm) subangular blocky structure; few very fine live roots; sharp smooth boundary;</td>
</tr>
<tr>
<td>14-37</td>
<td>Very dark brown; <strong>clay</strong>; very few fine faint dark reddish brown primary mottles; weak medium (20-50mm) angular blocky structure; few very fine live roots; abrupt smooth boundary;</td>
</tr>
<tr>
<td>37-55</td>
<td>Dark brown; <strong>clay</strong>; massive parting to weak medium (20-50mm) polyhedral structure; few very fine live roots; clear (20-50mm) smooth boundary;</td>
</tr>
<tr>
<td>55-76</td>
<td>Dark yellowish brown; <strong>clay</strong>; massive parting to weak medium (20-50mm) polyhedral structure; few faint clay skins very dark greyish brown coating ped faces; few very fine live roots; clear smooth boundary;</td>
</tr>
<tr>
<td>76-100</td>
<td>Yellowish brown; <strong>clay</strong>; massive structure; no live roots;</td>
</tr>
</tbody>
</table>
How to crop these soils sustainability
Capability and management depends on topsoil depth and texture. If there is less than 150mm (6”) of sand or loam topsoil then the soil is unsuitable for intensive cropping which demands deep seedbeds and mouldboard ploughing.

DEPTH OF TOPSOIL

Shallow
less than 100mm (4”)

Medium
100-150mm (4”-6”)

Deep
more than 150mm (6”)

RANGE OF CROPS

• cereals and fodder
• NOT POTATOES

• cereals and fodder
• irrigated vegetables
• peas, poppies, beans, onions
• NOT POTATOES

• cereals and fodder
• irrigated vegetables
• peas, poppies, beans, onions
• irrigated root crops
• potatoes, carrots, brassica vegetables and seed crops in beds

SOIL MANAGEMENT

• direct drill cereals
• topwork with tines or disc
• NEVER MOULDBOARD PLOUGH

• direct drill cereals
• topwork with tines or disc
• occasional shallow mouldboard ploughing
• retain residues and stubbles

• direct drill cereals
• topwork with tines or disc
• mouldboard ploughing
• green manuring
• retain residues and stubbles

DO NOT mouldboard plough areas at risk of wind erosion
topsoil depth does NOT include the bleached A2 subsoil layer

Major challenges
⇒ paddock variability
⇒ wind erosion
⇒ waterlogging
⇒ maintaining organic matter
Regions and local names
Most of Tasmania’s arable soils are duplex. Extensive areas occur in the Midlands (Brumby, Woodstock, Brickendon, Newham) and Coal River Valley (Apricot, Richmond, Bridge, Riversdale, Coal, Strelly, Carrington, Nugent, Southfork, Enfield, Daisy) as well as the East Coast, the Meander and Derwent Valleys.

Occurrence
Extensive on tertiary sediments, often with surface deposits of windblown sands as dunes or thin sheets. Commonly occur in conjunction with heavy, black cracking clays which follow natural drainage lines or the present floodplain. Land capability of duplex soil areas is 4 or less depending on limitations such as depth, wetness and slope.

Key properties of duplex soils

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddock variability</td>
<td><strong>High.</strong> Topsoil depth and texture varies greatly across the paddock depending on accumulation of windblown sands. Depth and texture determine management practices. The whole paddock must be managed to avoid wind erosion of the sandy areas.</td>
</tr>
<tr>
<td>Horizon boundaries</td>
<td><strong>Commonly wavy.</strong> To determine topsoil depth, don’t rely on just one or two holes.</td>
</tr>
<tr>
<td>Permeability</td>
<td><strong>Low.</strong> Impermeable clay B horizon causes waterlogging. Options for improvement are limited. Concentrate on surface drains, maintaining organic matter levels and avoiding compaction of pores in the subsoil clay.</td>
</tr>
<tr>
<td>Organic carbon</td>
<td><strong>Low to medium</strong> contents in the A1 (about 2% for a sandy loam), dropping sharply very low levels (0.2%) in the A2 and negligible levels in the clay subsoils. Decline is rapid under conventional cropping.</td>
</tr>
<tr>
<td>Root growth</td>
<td><strong>Restricted.</strong> Very few roots extend into the A2 or clay B horizons because of poor fertility and drainage.</td>
</tr>
<tr>
<td>Readily available water</td>
<td><strong>Low.</strong> About 25mm in 200mm depth of sandy loam topsoil. Shallow topsoil and restricted rooting into the A2 and B layers mean crops quickly move from waterlogged conditions to drought conditions. Irrigation is required in frequent small volume applications.</td>
</tr>
<tr>
<td>Workability</td>
<td><strong>Moderate.</strong> Commonly restricted by waterlogging in autumn, winter and spring. Low where the sandy A horizon is thin. Heavy traffic or tillage operations in wet conditions compacts the clay B horizon. These soils are easily overworked to a powdery tilth.</td>
</tr>
<tr>
<td>Fertility</td>
<td><strong>Low.</strong> Topsoils have low total nitrogen contents, medium to low total phosphorus and low available potassium.</td>
</tr>
<tr>
<td>pH</td>
<td><strong>Moderately to strongly acid</strong> topsoils, (pH 5-6). pH increases with depth becoming alkaline in the lower profile (&lt;1m).</td>
</tr>
<tr>
<td>Salinity</td>
<td><strong>Low to high.</strong> Less than 0.2 dS/m, generally increasing with depth, many subsoils being slightly saline at greater than 50cm depth. Highly saline scald areas are commonly associated with drainage lines or toeslopes.</td>
</tr>
<tr>
<td>Sodicity</td>
<td><strong>Slight to moderate</strong> in upper B horizon, increasing with depth, especially the Brumby Association. Dispersion and slow permeability are problems associated with sodicity.</td>
</tr>
<tr>
<td>Erosion risk</td>
<td><strong>High.</strong> Thin, light textured topsoils are susceptible to wind and water erosion if overworked and exposed.</td>
</tr>
<tr>
<td>Crusting</td>
<td><strong>Variable.</strong> Common problem for small seeds like poppies.</td>
</tr>
<tr>
<td>Rocks and stones</td>
<td><strong>Usually none</strong> but sometimes have alluvial waterworn remnants, or ironstone deposits as gravels, rocks or large slabs.</td>
</tr>
</tbody>
</table>
How much cropping can duplex soils take
The pasture phase is critical. In higher rainfall areas where pasture growth is more vigorous and less susceptible to root feeding grubs, longer cropping rotations can be supported. A run out pasture puts nothing into the soil and fertility and organic matter levels decline. For more intensive cropping, short term ryegrass (8 months to 2 years), provides the option of shortening the rotation to say 2 or 3 years crop between pastures, particularly if the pasture is irrigated.

- Under conventional cultivation involving stubble grazing/baling and mouldboard ploughing, a rotation with about 2 years of crop in 10 is considered sustainable.
- Under direct drilling or topworking with stubble retention or shallow incorporation, and surface drainage, perhaps 5 to 6 years of irrigated and cereal crops can be grown in 10 years.
- Under dryland cereal/legume rotation with minimal grazing of stubbles and direct drilling, continuous cropping may be sustainable.

Is ripping appropriate?

- of the topsoil - a shallow ripping may be appropriate after compaction as part of a topworking tillage program.
- of the A2 horizon - is pointless. The sodic nature of this spewey layer means it will collapse to its original state during the first wetting after ripping
- of the clay subsoil - is also pointless. The overlying sodic A2 will flow into and block any cracks and voids created by the ripping operation.

Are powered implements appropriate?
These soils are very fragile. Structure is minimal and is maintained only by the presence of roots and organic matter. Powered implements are not necessary, but can be used with care for shallow workings at the right moisture content. Use a low rotor speed and high forward speed. Some models allow opening of rear shutters to minimise pulverisation. A good seedbed is best prepared using tines and/or discs.

Can I deepen by topsoil?
Yes, but at the expense of fertility, structure and erodibility. The underlying pale A2 layer is acid, structureless and often sodic. Mixing in a little over time will gradually degrade your topsoil.

| What NOT to do! |
|-----------------|-----------------|-----------------|
| 1. mouldboard plough paddocks at risk of wind erosion | 3. overwork |
| 2. do not plough or mix in the A2 layer | 4. deep rip below the topsoil |

An overworked duplex soil with lumps of subsoil clay mixed in the topsoil causing crusting and poor infiltration.
Management Guidelines for Duplex Soils

Management depends on topsoil depth and wind erosion risk.

<table>
<thead>
<tr>
<th>Topsoil Depth</th>
<th>Crops</th>
<th>Soil Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHALLOW</td>
<td>cereals and fodder only</td>
<td>direct drill</td>
</tr>
<tr>
<td>Topsoil less than 100mm (4”)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td>cereals and fodder</td>
<td>direct drill</td>
</tr>
<tr>
<td>Topsoil 100-150mm (4”-6”)</td>
<td>peas, poppies, beans, onions</td>
<td>topwork with tines and discs</td>
</tr>
<tr>
<td></td>
<td>NOT potatoes</td>
<td>occasional mouldboard plough#</td>
</tr>
<tr>
<td>DEEP</td>
<td>cereals and fodder</td>
<td>direct drill</td>
</tr>
<tr>
<td>Topsoil greater than 150mm (6”)</td>
<td>peas, poppies, beans, onions</td>
<td>topwork with tines and discs</td>
</tr>
<tr>
<td></td>
<td>potatoes, crops in beds</td>
<td>mouldboard plough#</td>
</tr>
</tbody>
</table>

# provided there is NO RISK OF WIND EROSION

1. **Prevent wind erosion.** Do NOT mouldboard plough sandy duplex soils at risk of wind erosion.
2. **Topwork** with tines or discs. Topworking retains turf and crop stubbles on the surface between crops.
3. **Avoid overworking.** Duplex soils are fragile. Use of powered implements requires skill and judgement. Deep mixing and stirring rapidly destroys structure and fertility.
4. **Do NOT plough shallow duplex soils.** Most duplex soils are too shallow for mouldboard ploughing (100mm or 4 inches of topsoil is minimum). Gradual mixing of the bleached A2 layer, or worse still, the brown subsoil clay, with your topsoil will degrade longterm structure and fertility.
5. **Promote surface drainage** - for undulating paddocks, open up drainage lines linking hollows and depressions with broad shall grassed ditches. Leave these unploughed during cropping. In flatter paddocks, plant up and down slope.
6. **Retain and/or incorporate all stubbles and residues.** Your efforts will be rewarded. If you wish to incorporate large amounts of organic matter, use the mouldboard plough rather than a powered implement provided topsoil is deep enough.
7. **Adopt direct drilling techniques.** Developing techniques for potatoes and poppies is a top priority since these crops cause the most erosion. Ask field officers for advice.
8. **Avoid compaction and pugging.** Assess subsoil moisture before ploughing, working or harvesting. Grazing oats, rape or turnips in wet conditions is a sure way of destroying your cropping soil.
**Duplex Soil Case Studies**

Andrew Bond, ‘Eastfield’, Cressy

**Soils**
- Brumby/Panshanger sand complex of deep sandy banks and shallow duplex hollows
- Woodstock on higher terraces, (shallow duplex with ironstone gravel)
- Eastfield, stony dolerite soil, too stony for cropping
- Cressy shaley clay loam and Kinburn.

**Rotation**
- Andrew grows higher value crops between long pasture phases of about 10 years duration. Cropping phase varies from 2 years on the shallow Woodstock soil to 5-6 years on the better Cressy and Brumby/Panshanger soils
- crops include potatoes, beans, poppies, onions and some barley and peas.

**Organic matter management**
Being in a higher rainfall area of the midlands, Andrew can sustain productive and vigorous pastures for up to 10 years. Such long pasture phase builds soil organic matter and structure sufficiently to last through the cropping phase without green manure crops or incorporating large amounts of stubbles/residues. Stubbles/residues are rarely burnt, usually baled and grazed to a point where subsequent tillage is not inhibited but erosion is avoided.

**Cultivation**
Andrew uses the mouldboard plough to bring a paddock out of pasture, and uses a heavy s-tine cultivator and roterra between crops.

**Pasture**
- Mouldboard plough
- S tine or roterra
- sow barley

**Barley**
- direct drill oats after harvest
- sprayed off oats
- leave for 2 weeks
- heavy S tine x2
- shallow roterra
- sow onions

**Peas**
- 1995 onion preparation on Panshanger sand/Brumby at high risk of wind erosion;

**Onions**
- Topworking is best for duplex soils

---

**MAIN POINTS**
- surface drainage for duplex soils
- long pasture phase
- heavy duty S tine implement

---

Andrew inspecting topworked onion seedbed
Surface Drainage
Waterlogging in the hollows is a major limitation to cropping Brumby/Panshanger complex soils. After surveying the paddock if necessary, natural drainage lines are linked with broad shallow permanently grassed drains, constructed with a road grader, laser guided if fall is minimal. It is important to grade spoil well away so crop rows have a continuous fall off the banks all the way to these drains. To avoid excessively deep surface drains, some hollows are drained with underground pipe and sump structures.

Andrew Youl, Symmons Plains, Epping Forest

Soils
➢ Main cropped soil is Brumby which varies across the paddock, the banks being deep sand to the hollows where clay comes to within a few inches of the surface.
➢ Other less fertile uncropped duplex soils include Brickendon with Newham foot slopes, the Newham containing saline scald areas, and Woodstock shallow ironstone gravel country usually left in native bush or developed into a pasture.

Crops
An impressive range of crops have been grown at various times on Symmons Plains;

<table>
<thead>
<tr>
<th>Canary seed</th>
<th>Peas</th>
<th>Potatoes</th>
<th>Dill</th>
<th>Spearmint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet</td>
<td>Beans</td>
<td>Lupins</td>
<td>Sorghum</td>
<td>Peppermint</td>
</tr>
<tr>
<td>Squash</td>
<td>Onions</td>
<td>Cabbages</td>
<td>Sweet corn</td>
<td>Pak choi</td>
</tr>
<tr>
<td>Maize</td>
<td>Triticale</td>
<td>Sunflowers</td>
<td>Lentils</td>
<td>Chinese cabbages</td>
</tr>
<tr>
<td>Lucerne</td>
<td>Barley</td>
<td>Parsley</td>
<td>Clover seed</td>
<td>Artemesia</td>
</tr>
</tbody>
</table>

Rotation
Generally alternate with a cereal in between each crop, the rotation continued until the decline in soil quality begins to lower yield.

Tillage
➢ Paddock preparation for all crops is now achieved with a single pass Kuhn operation (spikes rotating on a horizontal shaft, followed by a solid toothed roller)
➢ major advantages are excellent timing of tillage to soil moisture conditions due to high work rate and single pass. Other advantages are listed on page 49.
Planned addition will be ripping tines to the front of the machine, not so much to alleviate deep compaction, but to loosen topsoil before it passes through the spikes, particularly after grazing. This will reduce load on the machine.

Various tillage systems have been tried on Symmons Plains but not continued. These include mouldboard ploughing and tined secondary passes, (discontinued because of slow work rates and excessive number of passes), and chisel ploughing.

---

**MAJOR ADVANTAGES OF THE ONE PASS POWERED IMPLEMENT SYSTEM**

- Even incorporation of crop residues
- Chops crop residues
- No secondary tillage wheelings
- Disintegrates clods
- Mixes residues and clods throughout topsoil
- Adjustable rear flap varies degree of pulverisation

---

**CAUTION**

Powered implements and duplex soils

Duplex soils are structurally weak. Overworking the soil is very likely using a powered implement. Overworking develops a soil with problems such as poor aeration and drainage, clods and powder seedbed, crusting and wind erosion. The many advantages of the powered implement are soon lost unless its operated with a high level of skill, care and judgement.

---

*Topworking is best for duplex soils*
PJ & NJ Chilvers, ‘Winburn’, Nile

The Chilvers family farm about 800ha at Nile in the North Midlands, with various stock and crop enterprises. Cereals (oats, wheat & barley), grey peas and irrigated processing peas and poppies are grown every year. Green beans have also been grown.

**Soils**
- mainly duplex (Brumby Association) overlain with windblown sands, sometimes as a thin sheet and sometimes as small dunes.
- some recent alluvial soils varying from black cracking clay to stoney loams associated with the Nile river.
- black cracking clay (Canola Association) varying from very poor to very well structured

**Rotation**
- a third to half the arable area is cropped in any one year.
- perennial pastures (ryegrass, Cocksfoot, Phalaris and clovers) are sown and usually remain productive for 4-6 years before succumbing to pasture grub infestation.
- a cropping rotation on better duplex paddocks usually consists of peas or poppies / cereal / cereal / peas / cereal

**Green Manure**
Oats are sometimes direct drilled into mulched poppy, pea or cereal stubble. Volunteer seed from previous crop and the oats all germinate and provide growth for winter grazing. Stock are taken off during wet weather to keep compaction to a minimum. Oats are mouldboard ploughed prior to peas.

**Primary Cultivation**
- crops are preferably direct drilled or sown into ‘topworked’ seedbed (shallow discs and tines). Mouldboard plough preparation is used only for processing peas.
- it is observed the soil remains in better condition under ‘topworking’/direct drilling, particularly if the season allows the stock to be kept off the cropping paddocks. The topsoil structure remains friable, open and full of continuous pores that go down into the subsoil, enabling a longer cropping rotation.
- No powered implements are used, though at times the Chilver’s have been tempted to try one on their poorly structured black soil (clods). A stiff tined cultivator is used on occasions for weed control in long fallows.

---

**Main Points**
- topworking & direct drilling
- no powered implements
- stubble grazing avoided prior to direct drilling

**Excellent soil structure after incorporating pea stubble.**

**Stubble mulching plays an integral part of the Chilvers’s topworking and direct drilling program.**
Secondary Cultivation
➢ the S tine with front levelling boards and double crumble rollers behind is a key implement used for all seedbed preparations. (Front cover photo.)
➢ a Nobili flail mulcher is used on stubbles, two passes for heavy stubbles, breaking straw into 20cm or less lengths. This improves trash flow and speeds biological breakdown for direct drilling or mouldboard ploughing

Direct drill barley in barley stubble yielded the same as an adjacent paddock conventionally worked and sown the same time.

an example of soil management between wheat and peas ’94/’95, taking advantage of that years summer rainfall by direct drilling oats for grazing.

- flail mulch x 2
- direct drill oats
- mouldboard plough Sept
- S tine
- sow peas

Wheat

Peas

direct drilling cereal, no winter grazing

- flail mulch x 1 or 2
- shallow disc x 1 or 2
- allow winter regrowth
- scarify
- direct drill

Barley

Barley

topworking poppy preparation, avoiding soil crusting and wind erosion

- spray off Aug
- shallow disc twice
- scarify to obtain even seedbed depth
- drop seed on surface (late Aug)

Pasture

Poppies

Topworking is best for duplex soils
Deep Sands

General description
Deep (>70cm, 28") uniform sandy profiles characterised by topsoils ranging from reddish brown to greyish brown. Topsoils show a slight accumulation of organic matter and weak structure.

Regions and local names
Deep sands are not extensive, they occur as coastal deposits along the state’s North coast, and as windblown deposits known as Panshanger in the Midlands, and Invequarity, Penrise and Pines in the Coal River valley.

Occurrence
Being windblown deposits, these soils are notoriously variable in depth and occurrence across any one paddock. They may occur as deep dunes or as a sheet of varying thickness deposited over the top of older soils. In other areas, where sands have been blown over dolerite hills, outcrops and floaters of dolerite bedrock may be common in the profile. Land capability is typically 4.

Key properties of deep sand soils

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeability</td>
<td>Rapid. However, waterlogging occurs in hollows where underlying clay approaches the surface.</td>
</tr>
<tr>
<td>Root growth</td>
<td>Unrestricted. No inherent physical barriers to maximum potential rooting depth. Compaction by tillage, traffic or stock can pack sand grains together and restrict root growth. Hard pan below tillage depth can form.</td>
</tr>
<tr>
<td>Readily available water</td>
<td>Low. About 30mm in 300mm of topsoil depth. Irrigation is required as frequent small volume applications.</td>
</tr>
<tr>
<td>Workability</td>
<td>High. No moisture restriction on tillage operations. Easily overworked.</td>
</tr>
<tr>
<td>Organic matter</td>
<td>Low. 0.5-1.5% organic carbon in the topsoil.</td>
</tr>
<tr>
<td>Fertility</td>
<td>Poor. Plant nutrients supplied almost entirely from organic matter. Applied nutrients easily leached, particularly if organic matter levels are depleted. Low in total nitrogen and available potassium. Available phosphorous low to medium in topsoil.</td>
</tr>
<tr>
<td>pH</td>
<td>Slightly acid, becoming neutral to slightly alkaline with depth. Low buffering capacity.</td>
</tr>
<tr>
<td>Salinity</td>
<td>None. Saline seeps may occur at the edge of dunes where they overlie a clay substrate.</td>
</tr>
<tr>
<td>Erosion risk</td>
<td>High. Sandy texture, weak structure and loose consistence make these soils highly prone to wind and water erosion.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>Variable. Not necessarily related to depleted organic matter levels. Humic substances coating sand grains can be non-wetting.</td>
</tr>
<tr>
<td>Surface crusting</td>
<td>Variable. More likely if coarse organic matter is depleted by initial mouldboard ploughing out of pasture or by several years of cropping. A problem for germination of small seeded crops like poppies.</td>
</tr>
<tr>
<td>Rocks &amp; stones</td>
<td>Outcrops may occur in sands deposited on dolerite hills.</td>
</tr>
</tbody>
</table>
**Typical Panshanger sand - from the midlands**

<table>
<thead>
<tr>
<th>Australian classification: Tenosol</th>
<th>Geology: Windblown sand</th>
<th>Drainage: Rapid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northcote classification: Uniform</td>
<td>Runoff: Moderate</td>
<td></td>
</tr>
</tbody>
</table>

**Depth cm**

| 0-10 | Very dark greyish brown **sand to loamy sand**: single grained or fine (5 - 10 mm) subangular blocky structure; loose or very weak consistence; common fine roots; field pH 5.8; clear smooth boundary |
| 10-53| Strong brown to dark yellowish brown; **sand to loamy sand**: some profiles may have a few grey or brown mottles; single grained or massive structure; few fine roots; field pH 6.7; gradual smooth boundary |
| 53-75| Strong brown to yellowish brown; **loamy sand**: single grained or massive structure; few clay coatings and a few manganiferous soft segregations in some profiles; very few fine roots; field pH 7.0; gradual smooth boundary |
| 75 + | Variable yellowish brown colours, may be mottled; **sand to loamy sand** but some clay horizons; single grained or massive structure; |

**Major challenges**

- wind erosion
- waterlogging hollows
- maintaining organic matter

Direct drilling potatoes into ripped, dessicated pasture

A direct drilled poppy emerging through cereal stubble

Wind erosion at Wesley Vale
Management Guidelines for Sandy Soils

1. Retain a cover on the surface at all times. About 1.5 to 2t/ha of stubble provides sufficient protection against wind erosion. Sow a cover crop.


3. Adopt direct drilling techniques, minimum tillage or topwork with tines or discs.

4. Powered implements are not appropriate for sandy soils. Wind erosion risk is increased and loss of humus is maximised.

5. Leave high risk sandy banks out of crop

6. Irrigate frequently with small volume applications
Growing potatoes in sands is sustainable only if wind erosion is avoided. The only way to avoid erosion is to keep sufficient coarse organic matter on the surface of the mould.

For potato preparation in sands:

- two shallow discings will leave the most organic matter in the mould for erosion control. For highly erodible paddocks this is best.
- a deep pass with a powered implement is a second preference. The powered implement results in the mould containing pieces of organic matter evenly mixed throughout.
- the plough should not be considered for sandy soils because it buries organic material below the depth of moulding. Mouldboard ploughing maximises erosion risk.

Striking a balance

While producing a mould with sufficient organic material for erosion control is a must, too much organic material as lumps of turf tends to cause uneven moisture within the mould, excessive moisture loss and more manual workload during harvest. But erosion control comes first.
Ian MacKinnon, Glen Esk & Snaresbrook, Conara

Crops
➢ Dryland cereals, grain legumes and lupins

Soils
➢ mainly duplex (Brumby) overlain with windblown sands (Pansanger) of varying depths from sheets to dunes
➢ the deeper sands tend to be odd shaped areas within paddocks so the whole paddock has to be treated with extreme care

Rotation
➢ aims for 9-10 year rotation similar to that followed in the Australian wheat belt, however, finding a reliable and profitable legume for the rotation remains a problem. Lupins and various grain legumes have been tried.

<table>
<thead>
<tr>
<th>1st year cereal</th>
<th>6th lucerne/clover*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd cereal</td>
<td>7th lucerne/clover*</td>
</tr>
<tr>
<td>3rd cereal</td>
<td>8th lucerne/clover*</td>
</tr>
<tr>
<td>4th legume</td>
<td>9th lucerne/clover*</td>
</tr>
<tr>
<td>5th cereal</td>
<td>*used for grazing</td>
</tr>
</tbody>
</table>

Traditional tillage

Oats
➢ heavily graze with sheep
➢ burn
➢ off set disc 2-3 passes
➢ harrow
➢ drill
➢ roll

Wheat

Minimum tillage
Ian still likes to off-set disc out of pasture in Autumn and sow oats in April. He has converted an International 6-2 drill for direct drilling, used successfully with cereals, legumes and lucerne.

Making money is the main reason for direct drilling. Sustainability and the Landcare ethic are very much secondary benefits.
Rob Morey, ‘Flexmore Park’, Penna

Soils
crops 200-300 acres of deep windblown sand

Rotation
crops only 2 years (barley, potatoes), followed by a 12 month fodder crop, before returning to a long lucerne based pasture.

Cultivation
Rob never mouldboard ploughs because of the erosion hazard.

Lucerne
➢ spray off during active growth
   (Glyphosate & Dicamba)
➢ sow barley

Barley

➢ harvest
➢ allow regrowth weed & grain
➢ deep rip
➢ plant potatoes August
➢ pre emengent burn off herbicide, Sep

Potatoes
➢ broadcast cereal seed immediately prior to potato harvest
➢ harvest potatoes

Fodder crop*
➢ oats/rape or barley/rape mix for 12 month grazing

Fodder crop*
➢ harvest
➢ heavily graze stubble, autumn
➢ direct drill cereal cover crop
➢ direct drill lucerne 2 weeks later

Lucerne

DIRECT DRILLING POTATOES ON SANDS
➢ rip, plant and pre-emergant burn off
➢ cereal broadcast prior to harvest
➢ lucerne based pasture

*oats/rape or barley/rape mix for 12 month grazing

Sandy soils — easy to work, easy to lose
Diagnosing your drainage problem is the key to achieving success with any drainage solution. You need to know the source of the water and where it is moving in the soil. This will ensure correct selection of drain depth and position.

Planning

The layout of both surface and subsurface drainage must be considered early in the planning process. The location of surface drains will influence the location of fences, shelterbelts, laneways and the shape of paddocks.

The most satisfactory way of doing this is with an aerial photograph of the farm enlarged to an appropriate scale. This service is available from the Land Information Bureau, GPO Box 44A, Hobart (Ph 03 62 338011). The photograph allows you to record the extent of problem areas, where drains are to be installed, and estimate distances and costs involved.

When to investigate, when to install

During winter, a couple of days after a good soaking rain, is the best time to take a closer look your wet area. You can identify the extent of wet areas and identify soil layers on which a perched water table occurs.

Take a spade or auger and dig a series of small pits or holes up to 1 m deep in and around wet areas. Use pegs to mark out drainage lines and potential drain locations. Summer and autumn are the best times to install drains. This is when soils are dry and have their greatest bearing capacity for supporting heavy construction machinery. Machines won’t become bogged and trench sides smeared.

What to look for when digging your pits:

Dig or auger holes down into the subsoil

* Soil colours. Paler, bluer colours indicate poor drainage. Mottles are spots, blotches or streaks of subdominant colours different from the main soil colour.

* Where does the water flow into the pit from?
  - from the bottom; indicates a ground water problem
  - from a particular layer; indicates perched water
  - from the surface; indicates surface sealing or perching.

* Layers of contrasting texture or hardness, eg. sand over clay, lenses of sand, or hard pans. These will result in perching and will require placement of drains at a specific depth. If water perches near the soil surface on a particular layer, there is only limited potential for significantly improving drainage.

* Hard concretions of various sizes and shapes or soft black segregations often indicate poor drainage. These are composed of iron and/or manganese. In extreme cases these can form thick impenetrable ironstone or “coffee rock” on which water now perches.

Do your holes fill with water from the bottom - even slowly?

➢ yes, deep open surface drains or subsurface drainage is a solution
➢ no, options are limited to land forming or shallow surface drains
Good soil management begins with good drainage

Keen to tackle that wet area?
Ask your local DPIF office for a copy of The Drainage Manual, a helpful booklet and audio cassette tape on drainage planning and installation.

How much fall should a surface drain have?
A minimum of 0.3% (30cm in 100 m)
Erosion is likely where fall is greater than 1% (1 m in 100 m) for duplex or sandy soils, or 5% (5 m in 100 m) for krasnozem, Cressy and black cracking clay soils.

Successfully removing a seep like this one with sub-surface drainage often requires several attempts. Improve your chances by placing a few investigative open drains into the seepage area a year before and observing water movement over the winter.

Thinking of subsurface drainage?
Always explore and implement surface drainage options first, especially in duplex soils.

Milky puddles and slumping structure indicate unstable soil, not suitable for mole drains.

“I’ve found shallow land planing (+/-5 cm), has reduced the effects of winter waterlogging on my duplex soils.”

Jim Taylor - Nile.

Use the topography.
Join depressions and hollows with shallow surface drains for waterlogging in black cracking clays, Cressy and duplex soils.

Signs of poor drainage-
• Pale colours
• Red-stained root channels
• Mottles
Excess Rainfall & Irrigation

Divert excess water while it’s on the surface whenever possible rather than allow water to run and fill low lying areas.

SURFACE WATER PROBLEM

Ponding or erosion
Infiltration restricted by poor soil structure, silty texture or non-wetting organic matter
Divert surface water from entering the area
Control and direct runoff without erosion

SOLUTIONS

Ponding on flat areas
- cut-off drain (20-40cm)
- land levelling
- beds or moulds (20cm)
- hump and hollow
- mouldboard bedding

Erosion on steep areas
- cut-off drains
- grassed waterways (10cm)
- grassed irrigator lanes
- contour drains (10-15cm)
- diversion banks 20-50cm)
- cover crops/stubble retention
- topworking

Waterlogging
Perched watertable on clay subsoil of duplex soils
The extent to which this land can be improved by drainage is limited, no matter how much you spend

SOLUTIONS

- divert runoff from entering the area
- surface drains linking hollows
- strategic subsurface with sumps
- gravel moles

seek professional advice

Link hollows and depressions with surface drains.
**Infiltration**

**SUBSURFACE WATER**

**Watertable**
Regional watertable associated with floodplain
Controlling the height of the table can produce first rate cropping soils

**SOLUTIONS**
open arterial drains (100-200cm), depth and spacing depend on soil permeability and presence of underlying gravel layers
seek professional advice

**Seepage**
Water infiltrates, hits deep impermeable layer and moves along it to resurface some distance downslope

**SOLUTIONS**
Deep seepage intercept drain (70-120cm) in the form of;
- open ditch
- French (stoned) drain
- subsurface pipe and gravel backfill
seek professional advice

Place intercept drain upslope where watertable is at least 450mm (18”) below the surface. Ensure drain is dug into underlying impermeable layer.

A pumped drainage scheme near Bishopsbourne
Surface or subsurface drains?
Surface drains are a minimal investment (say $2/m), last a long time provided stock are excluded and can always be deepened or moved. Subsurface drainage schemes are only warranted for intensive cropping or dairying farms. Strategic subsurface drains that use the topography may be worthwhile for less intensive farms. Large amounts of money are literally sunk in subsurface drainage ($5-10/m) - if it’s right, that’s fine, but if it doesn’t work......

Tips on surface drains
➢ install in dry conditions and use a dumpy level if necessary
➢ a minimum fall of 0.3% or 30cm in 100m for a surface drain requires regular maintenance, especially vegetation and stock exclusion. A two wire electric fence is all that’s required for trained stock.

Tips for subsurface drains
➢ install in dry conditions. A trenchless machine should create lots of soil heave as it passes, rather than smearing and compaction of trench sides.
➢ mole drain in spring when the subsoil is moist and topsoil dry. A small bulldozer is best.
➢ check relative depths of gravel backfill and mole channel to ensure the two connect.

Drainage by soil type
The table below is a guide to drainage problems and solutions for various soil types. Specific sites will vary in their requirements.

<table>
<thead>
<tr>
<th></th>
<th>Krasnozem</th>
<th>Black cracking clay-hills</th>
<th>Black cracking clay-alluvial</th>
<th>Cressy</th>
<th>Duplex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>erosion &amp; seepage</td>
<td>erosion</td>
<td>waterlogging</td>
<td>waterlogging</td>
<td>waterlogging</td>
</tr>
<tr>
<td>cut off drain</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>grassed waterway</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>grassed irrigator run and contour drains</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>seepage intercept</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>deep arterial</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>strategic* subsurface</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>strategic shallow surface</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>grid subsurface</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>mole channels</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Strategic drains target particular areas of the paddock as opposed to a grid drainage scheme involving evenly spaced parallel drains across the whole paddock.
What is a sodic soil?
Take a crumb of suspect soil and drop it into a glass of pure rainwater. Watch how it breaks down over the next 12 hours. Most clays slake, this is normal. But some clays disperse, these we call sodic clays.

**Slaking.** Fragments flake off the soil crumb due to pressures that build up as water forces air to escape during the wetting process. Most clay soils will slake when wetted, particularly after a long dry period. This is not a sodic clay.

**Dispersion.** If you drop a lump of sodic clay into a glass of fresh water, the water gradually goes cloudy. A muddy halo forms if the sample isn’t shaken at all. This is a sodic clay.

Do you have a sodic soil and where is the sodicity occurring in the profile? These are the first steps of investigation.

Where do they occur?
About a third of Australia’s soils are sodic. Brumby, Newham, Brickendon and Woodstock are soils of the Midlands likely to be sodic to some degree. Some black cracking clays are also sodic. Most sodic soils in Tasmania are classified as moderately sodic or less.

What part of the profile?
Sodic soils are highly variable in terms of where in the profile the sodicity occurs and the degree of sodicity.

What is the problem with sodic soils?
Overcoming waterlogging. Existing cracks and fissures in the subsoil offering drainage of excess water from the topsoil, are blocked off by the unstable sodic layer which flows and chokes these channels during waterlogged conditions.
Management of sodic soils under cropping

There are two basic approaches, both involving drainage;

1. **Good soil management** - drainage (strategic underground or surface), increase organic matter inputs, avoid compaction and adopt minimum tillage/direct drill cropping program.
   - no risk of failure
   - low cost, long term improvement
   - appropriate for dryland cereals or occasional irrigation (peas/poppies)

2. **Reduce sodicity** - involves applying gypsum (contains calcium) combined with drainage (to leach sodium chloride out of the clay)
   - high risk, try a small area first
   - will not work if poor soil management practices continue
   - high cost, bulk gypsum costs at least $70/tonne ex Railton (apply at 2-5t/ha)
   - short term, unless gypsum application is continued, tillage intensity is reduced and organic matter inputs are increased
   - appropriate for more intensive cash cropping/high return situation

For undulating paddocks, a combination of the above may prove most effective and economic. The whole paddock receives good soil management practices, with severely waterlogged depressions and drainage lines being linked with underground drains and treated with gypsum.

Flatter paddocks with extensive areas of shallow sodic soils, are best managed using option 1. ie good soil management practices, where slight improvements in soil condition can be expected year by year. Intensive drainage and gypsum treatments are unlikely to improve the paddock greatly, let alone pay the costs.

**Deep Tillage and sodic soils**

Deep ripping disrupts existing pores in subsoil layers and aggravates the unstable nature of sodic layers. The soil collapses to its original condition as soon as the profile becomes waterlogged again.

**Mole drainage and sodic soils**

If the duplex soil has a distinct pale A2 layer, this may flow into the mole and cause failure, even if it’s not sodic. Risk of initiating tunnel erosion if there is some slope.

**Further reading**


The Distribution of Sodic Soils in Tasmania, Doyle, R.B. & Habraken, F.M.  

Introduction to Soil Sodicity, Cooperative Research Centre for Soil and Land Management.  
In the future, cover crops are set to play an increasing role in the growing of clean, green produce. The Tasmanian DPIF conducted very encouraging trials in 1994/5 using a ryecorn cover for brassicas planted as speedlings. The ryecorn cover was allowed to reach about 600mm high before spraying off with glyphosate two weeks before planting. Not a single herbicide spray was required during the life of the crop and soil losses were negligible. The main barrier to wider adoption of sowing into cover crops is that modification of the drill is required for added trash clearance.

Apart from some oat cover crops for lettuces in the Coal River valley, onions are the only commercial annual crop commonly grown with a cover.

What are the benefits?

➢ flexibility, being a short term ‘crop’ as opposed to shelterbelts or other more permanent barriers
➢ low cost
➢ complete protection across a paddock. The benefit of shelterbelts or corn shelter rows diminishes with distance
➢ adds to soil structure and biological activity, a living mulch
➢ smothering of weeds, reducing or removing the need for herbicides

Cover crops for onions

Two ways of growing a cover crop for onions
1. **sow cover before onions** and burn off just prior to onion emergence using non-selective herbicides.
2. **sow cover and onions together**, and burn off about three weeks after onion emergence using selective herbicides. This method is most commonly used at present.

The herbicides

These are divided into Selective and Non-selective (against onions). Your agronomist may use low rates with the aim of slowing but not killing off the cover. The life and benefits of the cover are prolonged, while competition with the onions is minimised.

It all depends on the weather!

The timing of herbicide application requires an experienced agronomist considering the 3-4 week delay between burn-off application and cover crop dessication. Also, oat growth is affected by warm and cold weather more than onion growth. Warm weather - oats grow faster than onions. Cold weather - oat growth slows dramatically while onions keep growing.
Sow cover before onions - two examples
University Farm, Cambridge, sandy loam over clay, 1-3% slope
Reason for sowing cover is to reduce wind blasting of emerging onions and some erosion control. In addition, several contour drains were installed to reduce erosion risk using an old single furrow plough. Oats were used at the usual rate of 30kg/ha.

University farm program 1994/5  Oat cover

<table>
<thead>
<tr>
<th>Time</th>
<th>Day 1</th>
<th>Day 10</th>
<th>Day 21</th>
<th>Day 47</th>
<th>Day 60?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>sowing</td>
<td>emergence</td>
<td>4-5 leaf stage*</td>
<td>tillering</td>
<td>tillering</td>
</tr>
<tr>
<td>Onions</td>
<td></td>
<td></td>
<td>sowing</td>
<td>almost emerged</td>
<td>4 leaf</td>
</tr>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
<td>non selective</td>
<td>selective</td>
</tr>
</tbody>
</table>

*Non selective applied just prior to onion emergence a kill of all weeds and hoping some oats would survive and shoot again to provide continued protection.
Timing of herbicide application depends on temperature, moisture and sunshine hours. Seek professional advice.

University farm program 1995/6 Triticale cover

<table>
<thead>
<tr>
<th>Time</th>
<th>Day 1</th>
<th>Day 10</th>
<th>Day 21</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triticale</td>
<td>sowing</td>
<td>emergence</td>
<td>2-3 leaf stage*</td>
<td>5 leaf stage</td>
</tr>
<tr>
<td>Onions</td>
<td></td>
<td>sowing</td>
<td>almost emerged</td>
<td>3 leaf</td>
</tr>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td>non-selective</td>
<td>selective</td>
</tr>
</tbody>
</table>

Timing of herbicide application depends on temperature, moisture and sunshine hours. Seek professional advice.
*Roundup @1.5l/ha just prior to onion emergence or up to 3 weeks (for root release) prior to sowing if using a precision drill which requires a trash free seedbed

Sow cover & onions together - an example
Roberts Vegetables Pty Ltd and Nigel Wade, Table Cape 1995/96
A krasnozem soil containing ironstone gravel. The gravel is picked up by the wind and knocks the waxy outer coating off the onion plants. With a damaged coating the onions are no longer protected against selective herbicides.

<table>
<thead>
<tr>
<th>Time</th>
<th>March</th>
<th>10 May</th>
<th>11 May</th>
<th>26 June</th>
<th>Week 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poppies</td>
<td>harvest graze stubble</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>oats spun onto stubble Roterra/crumble roller once</td>
<td>4-5 leaf stage starting to tiller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onions</td>
<td>onions sown</td>
<td>almost emerged</td>
<td>flag leaf stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td></td>
<td>pre emergent*</td>
<td>selective**</td>
<td></td>
</tr>
</tbody>
</table>

*knock back oat growth only
**kill off oats
Competitive effects of cereal cover
➢ A vigorously growing cereal will compete for moisture during onion germination and early growth.
➢ In drier regions like the Midlands or Coal River, spraying off the cereal before onion sowing may be the best option.
➢ Once the cereal is sprayed, growth and uptake of moisture and nutrients ceases, even though the herbicide may take 3 to 4 weeks to kill the cereal cover. The only competition after spraying is shading.

Triticale - an alternative to oats
➢ Triticale is more upstanding than oats, allowing more herbicide to reach other weeds
➢ Oats are more substantial plants due to tillering at such low plant density. This makes the cover more difficult to kill off.

Retaining cereal stubble - an alternative to a cover crop.

A cereal stubble is well worth considering:
➢ provides cover pre- and post-onion sowing
➢ no competition with the onion crop
➢ no critical timing of herbicide applications

but what are the problems?
➢ a stubble’s challenges lie in tillage (type of implements, timing, depth and speed of work). There are small seed drills that handle a reasonable amount of stubble. One example is the Accord airseeder, used by Ron & Chris Gunn of Richmond to sow into barley stubble after some grazing and discing.
➢ excessive stubble can affect germination of small seeds like onions

A retained stubble has no competitive effects or herbicide requirements.
Direct drilling & locally converted drills

Benefits of direct drilling
Crop stubbles were traditionally seen as a problem and a good farmer was one who managed to remove by grazing, burning and ploughing every last remnant of the previous crop’s residue. Today, farmers are beginning to see stubbles as a resource. Adopting new technology and modifying old machinery allows effective use of the resource to bring a wide range of benefits.

Which soils are appropriate?
All soil types. For deep sands and duplex soils, the chief benefits are control of wind erosion and preservation of structure. For clay soils, which require expensive cultivation to prepare, the benefit lies in lower costs. For all soil types, fertility largely depends on the soil’s organic matter level, and experience has shown the levels usually improve under direct drilling.

Direct drilling clayey soils (krasnozem, Cressy & black cracking)
Under direct drilling a clay soil may either improve or deteriorate, depending on management. Under poor management, compaction increases year by year. Under good management, the crumb structure or natural tilth of the surface layers improves, largely because of the gradual increase in organic matter in the top few centimetres of soil. Biological activity in the topsoil improves porosity and structural stability, and a beneficial organic cycle is developed.

Factors influencing soil condition trend under minimum cultivation for clayey soil.

<table>
<thead>
<tr>
<th>Deterioration</th>
<th>Present state</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>unstable soil type</td>
<td></td>
<td>self mulching soil type</td>
</tr>
<tr>
<td>poor drainage</td>
<td></td>
<td>good drainage</td>
</tr>
<tr>
<td>late drilling</td>
<td></td>
<td>winter cropping</td>
</tr>
<tr>
<td>unnecessary traffic</td>
<td></td>
<td>timely drilling</td>
</tr>
<tr>
<td>poor weed control</td>
<td></td>
<td>minimum traffic</td>
</tr>
<tr>
<td>excessive surface trash</td>
<td></td>
<td>tramlines (controlled) traffic</td>
</tr>
<tr>
<td>prolonged wet weather</td>
<td></td>
<td>dry weather and frosts</td>
</tr>
</tbody>
</table>

COMPACT IMPERMEABLE TOPSOIL

POROUS TOPSOIL

Basic design features of direct seeding drills

1. **WIDE TINE SPACING** (400mm minimum), 3-6 rows of tines, wide spacing between rows of tines (400mm minimum)
2. **HIGH TINE BREAKOUT** (100-200kg), tines mounted on stiff frame
3. **NARROW POINTS** (20-40mm) for minimal soil surface disturbance

New drill or modify my old one?
A new trash seeder at $30 000 is an investment that’s hard to justify, particularly as most cropping farmers in Tasmania require a versatile machine that can cope with conventional sowing one day and direct drilling the next. Existing seeders can be modified for as little as $1000.

Modifying a seeder may require some engineering skills and equipment which not all farmers have. There is also the need for knowledge on how to go about modification. Has somebody done something simple, cheap and effective to a seeder like yours? The following case studies are some good initial ideas and contacts. Also, contact the DPIWE Topcrop program for a copy of *There’s no money in dust*, a Victorian drill conversion guide.

---

**Drill conversions**

**Moreton Jenson, ‘Carinya’, Bishopsbourne**
- 14 run Shearer disc drill box mounted on homemade frame with Pacific tines & boots, and Superseeder points
- sows over 3 rows with clearances of 750mm(30”) between rows and 550mm(22”) between tines
- cost of materials including old drill was about $4500
- Moreton has mounted the box 600mm above the frame which in hindsight is excessive for 3 rows. It could be dropped 100-150mm, and the capacity of the fertiliser box increased to about three times the size of the seed box.

Moreton likes the way the tine design and narrow machine width allow even depth placement over undulating ground.

The drill is mainly used to sow autumn oats into runout pasture which has been sprayed off sometime in May. After grazing and harvesting, the stubble is burnt in Feb/March, s-tined and pasture seed spun on. Early germination is assured under irrigation.
Direct drilling allows longer cropping rotations, with less time on the tractor

Essential features of direct drills
1. wide tine spacing
2. high tine breakout force
3. narrow points

Direct drilling is appropriate for all soil types

Stock and direct drilling don’t mix
⇒ 25-50 mm of friable surface tilth is a key prerequisite for good seed/soil contact
⇒ KEEP STOCK OFF stubbles you intend to direct drill into.

We converted our drill in 1993
By 1995 we were cropping 30% more area. Annual tractor hours have actually fallen over this time.

Michael Chilvers - Nile.

Peter Skirving (right) of Cressy, explains some aspects of his home-made undercarriage to a group of Topcrop farmers.
International 6-2, Ian MacKinnon, ‘Glen Esk’ & ‘Snaresbrook’

➢ Lifted seedbox 150mm (6”).
➢ Tine frame - old one removed and Ryan frame fitted with 24 Ryan tines with spear points. 230lb breakout, $160 each.
➢ Press wheels (Sharmans, SA) walking configuration. Press wheel pressure: 1.8kg per cm of press wheel width in cultivated ground and 2-3kg per cm width in direct drilling ground. Press wheels cost $170 each.

Cost about $16,000 including the original drill but not including 50-60 hours workshop labour.

Chamberlain 6 row trash seeder, Duncan Mills, ‘Leverington’, Cressy

➢ originally 3 rows cultivation and 3 rows seeding, modified to sow over all 6 rows,
➢ removed cultivating tines and lifted seed box 900mm(3 feet) so that fertiliser and seeding tubes fall 45° or steeper,
➢ on each tine, a long u-bolt holds the following arrangement in place behind Primary Sales points slotting to 100mm (4”) deep:
  - the fertiliser tube, fertiliser deep banded at the bottom of the slot
  - smudge bar (25mm wide) collapses the sides of the slot and determines the depth of seed placement
  - seed placement tube, seed falling on smudged trench
  - 6 links of chain to drag soil over seed
➢ tine breakout force increased with second springs and heavier 3/4” rod,
➢ a hot air system prevents condensation & blockage of fertiliser tubes based on a Holden car heater.

Heavy stubbles & future modifications
➢ heavy stubbles and header rows are still too much for the modified drill and disc colters to cut ahead of the tines and work deeper with narrower tines could be added
➢ a ‘straw storm’ straw spreading system for the header would avoid bulky header rows
➢ tried Ryan narrow points but too much surface disturbance, which reduces effectiveness of residual weed control

Costs
➢ approx $50 per tine assembly excluding chain and rear bracket assembly
➢ one month in the farm workshop
➢ Primary Sales points $16 each
International 6-2, Peter Skirving, ‘Fairbanks’, Cressy

➢ International 6-2 20-run combine
➢ built 3 row float frame of 3” box and 1/4” x 3” flat
➢ designed and constructed own tine clamps and shear system
➢ Janke tine and points
➢ tine spacings of 19”(475mm) between rows and 21”(525mm) along rows

For conventional sowing, the Skirvings simply remove the direct drill float and replace the original float, the machine thus retaining its versatility.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel for float frame, bolts, clamps etc</td>
<td>$800</td>
</tr>
<tr>
<td>Janke tines @ $25 each</td>
<td>500</td>
</tr>
<tr>
<td>Janke points @ $10 each</td>
<td>200</td>
</tr>
<tr>
<td>tungsten tipped by local engineer @ $5 each</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1600</strong></td>
</tr>
</tbody>
</table>

Shearer trash culti, PJ & NJ Chilvers
‘Winburn’, Nile,

➢ Shearer Trash Culti drill, G series, 24- run, 4-row
➢ Raised seed-fertiliser box 300mm (12”) 
➢ Removed cultivating tines
➢ Seeding tines spread evenly across all 4 rows to achieve spacings of 450mm (18”) between rows and 525mm (21”) between tines along each row, maintaining the standard planting intervals of 175mm (7”)
➢ The machine remains versatile, alternating between 100mm points for conventional sowing and knock-on lucerne points for direct drilling.

Tine breakout at about 160lbf is ok for sowing into reasonably friable soil. Sowing directly into sprayed out pasture is not achievable on stock compacted loams or black cracking clays.

For pasture establishment, poor depth control remains a problem associated with minor humps and hollows in the paddock. The machine is unable to cope with these changes.

Press wheels recently purchased will improve seed/soil contact, particularly for spring direct drilled cereals.

Janke press wheels with 25mm hollow tyres have recently been purchased for approximately $200 each.
How the implement breaks the soil

When the implement engages with the soil, the soil is either loosened or compacted. Unfortunately it’s not simply a case of deciding which we want, and selecting the appropriate implement. There are many soil and implement factors influencing the final outcome, the most important being soil moisture.

If you were to extract a neat, undisturbed block of soil with your spade, and gradually stand on it, the block of soil would resist your weight up to a certain point, then suddenly break. When a force is applied to the soil it can break in one of three ways:

1. **Brittle failure**
   Soil crumbles along a well defined natural planes of weakness. *The soil is loosened.*

2. **Compressive failure**
   Soil shears along an infinite number of planes. Occurs in wet conditions or deep conditions where uplift is confined. *The soil is compacted.*

3. **Tensile failure**
   Soil is placed under tension. Soil breaks along well defined natural planes of weakness. *The soil is loosened.*

➢ **Brittle or tensile failures are required for all types of loosening and clod breaking operations.** Apart from their cutting action, discs create a mixture of brittle and tensile failures, as do forward inclined tines, and powered implements used carefully.

➢ **Compressive failure is bad.** If the soil is moist, any implement will cause this kind of failure. Occurs as a result of heavy loads applied to the soil or by tines working below critical depth (see tines section).

➢ **Tensile failure is the most efficient** way of loosening a soil in terms of power requirement, and allows loosening at slightly higher soil moisture contents. The mouldboard plough or winged tines produce tensile failure.

Tyre pressures and compaction
The degree of compaction is very sensitive to tyre pressure. Reducing tyre pressure is an avenue relatively easy to follow compared with other ways of reducing compaction such as avoiding stocking cropping paddocks, keeping trucks off the paddock at harvest, or tilling and harvesting only in dry conditions.

Remember,
➢ depth of compaction is determined by axle load
➢ degree of compaction is determined by tyre pressure
### Tines

Tines are immensely variable in their effect on the soil, depending on angle, width, depth and springiness of the tine, and the condition of the soil. Nearly all seedbed preparations involve a tined implement, whether as a primary loosening tool or as secondary levelling and clod breaking tool.

**Shallow tined cultivations - the S tine**

For all soil types, the S tine is one of our most valuable and highly recommended tillage implements, particularly when combined with a front levelling board and rear crumble roller. It is gentle on soil structure, produces a good seedbed tilth and has a low draft requirement. It is recommended by poppy and onion company field staff as generally the best implement to use for the final pass.

**Tines for primary cultivation**

The aim of chisel ploughing, ripping or subsoiling is to heave and shatter the soil, not to compact and smear below the surface. It’s worth getting off the tractor and having a quick dig behind the implement to make sure you’re not operating below critical depth.

---

<table>
<thead>
<tr>
<th></th>
<th>truck tyres</th>
<th>tractor tyres</th>
<th>farm 4wd tyres</th>
<th>radial tyres</th>
<th>flotation tyres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>670KPa</td>
<td>275</td>
<td>275</td>
<td>100-140</td>
<td>28-55</td>
</tr>
<tr>
<td>PSI</td>
<td>100psi</td>
<td>40</td>
<td>40</td>
<td>15-20</td>
<td>4-8</td>
</tr>
</tbody>
</table>

If you have dual wheels on the tractor, the above rule shows the importance of reducing tyre pressure in all tyres, otherwise the degree of compaction remains the same as without duals.

Most new tractors are now supplied with radial tyres which operate at lower pressures than cross ply tyres.
**Staying above critical depth**

Some factors that reduce critical depth and reduce the effectiveness of subsoiling are illustrated below:

Also, avoid placing depth wheels near tines as these restrict upward movement of the soil and make compressive failure more likely.

**Adjust your tine spacing**

Notice in the previous diagram how above critical depth, soil fails at about 45 degrees. Tine spacing must be sufficiently close to avoid leaving undisturbed ridges of soil below the surface. Unless this is investigated with a spade, the operator continues to do a poor job of the whole paddock.

Recommended tine spacing for various implement configurations and depth of work

- conventional narrow tines: 1 to 1.5 times depth*
- winged tines: 1.5 to 2 times depth
- winged tines & shallow leading tines: 2 to 2.5 times depth

*not including loose surface soil, eg ploughed before ripping

**Is deep ripping worthwhile? (300mm plus)**

A recent United Kingdom study of ripping between 300 and 375mm depth (12-15”), found a positive response of crop yield in only 3 out of 76 paddocks. Unless a hard layer is very obvious from an examination of the profile, there is unlikely to be any benefit. According to the Kondinin Group*, in Australia deep ripping is mainly applied to sandy, light textured soils where a traffic pan has developed. The lower the clay content of a soil, the deeper the hard layer. Deep sands develop a layer at about 30cm depth, and loamy sands about 20cm depth. Duplex soils will have traffic pans if the clay is deep enough, but generally do not respond to ripping unless the clay is deeper than 25cm.

**Shallow ripping (200-250mm or 8-10”)**

This is the most common ripping operation. It aims to shatter the topsoil to just below the plough depth.

- adjust tine spacing to avoid ridging - a 1:1 ratio of depth to spacing for narrow tines
- a good way of achieving sufficient depth of tilth for the potato planter to operate, but make it one of the last passes in the preparation sequence to avoid recompaction
- commonly used prior to a shallow powered implement pass, recompaction being the only problem here
- ripping after harvest is ok provided soil moisture is not too high causing ‘knife through butter’ syndrome, but it’s best to sow oats, lupins or short term ryegrass to open up the soil for the next crop
- ripping on the contour can be a valuable means of avoiding erosion while the rest of the paddock is being harvested

---

**Avoid Recompaction**

- Soil after the ripping operation is highly susceptible to recompaction
- Make your deepest working last in the preparation sequence.
How long do the beneficial effects of ripping last?
Unless actively growing roots grow into the new cracks created in the ripping operation, the effects are quite temporary - just a few weeks or months. Rip during peak growth of a ryegrass green manure to make the most of the ripping operation. The longer your can avoid recompaction the better.

Do not rip duplex soils
Duplex soils which containing a pale spewy layer between the topsoil and the clay are very unstable. Ripping disrupts any natural pores in this layer and waterlogging is likely to be worse after deep ripping. Subsoiling into the clay can cause a permanent degradation of the soil’s cropping capability. Chisel ploughing of the topsoil is a good primary cultivation technique for these soils.

* The Seeding Edge, (2nd ed, 1993), Kondinin Group, Belmont, WA ph (09) 478 3343

It is generally thought that discs are not good for the soil. Why is this? Probably because discs were once the farmers only tool beside the chisel plough, and thus took the blame for much of the soil degradation that has occurred in the past. Discs are not necessarily any worse than other implements at our disposal today, but like any implement, can cause great damage to the soil if used incorrectly or at the wrong soil moisture content.

Discs and soil structure
The cutting action of discs take no account of the natural fracture lines of the soil. Cutting forms new aggregates with shinny smooth faces. The smearing becomes severe as soil moisture increases, so that in wet conditions, discs are very damaging to your soil. Discs can also overwork sand and duplex soils if two or more passes are involved.

Discs for minimum tillage
Discs are best used together with tined implements in a topworking tillage system, appropriate for all soil types, particularly sands and duplex soils. Discs are an excellent tool for chopping and shallow incorporation of coarse organic matter, reducing trash load for subsequent sowing.

Shallow incorporation of surface stubbles or residues promotes biological activity and breakdown, reduces trash load for subsequent tined operations, and leaves sufficient cover for wind and water erosion control. Its a good half way between leaving it all on the surface and deep burial. Left on the surface, organic matter has minimal contact with soil organisms and is too dry most of the time for biological activity. Deep burial disrupts soil structure and opens up the soil, exposing humus to breakdown, so that in effect more organic matter is lost than gained.
The mouldboard plough

Faced with the challenge of preparing a seedbed, farmers in Tasmania commonly opt to use the mouldboard plough in their tillage sequence. Correctly used, the mouldboard plough is an excellent implement for incorporating crop residues or green manure crops, and requires a minimal number of passes of secondary tillage to produce the seedbed. However, for some Tasmanian soils, the mouldboard plough is not appropriate. Soils prone to wind erosion are protected by coarse organic matter in the surface layer which is buried in a mouldboard plough operation. Some soils are too shallow for mouldboard ploughing and these are permanently degraded as low fertility, structurally poor subsoil is mixed with the shallow topsoil.

Inversion is the action of the mouldboard plough. Have a look at the paddock to be worked and decide if inversion is required, taking into consideration:

➢ the requirements of the seed to be planted, (small seeds require finer seedbeds)
➢ the moisture and structure of the soil, (very wet or dry, cloddy or fine)
➢ surface cover (amount and type - pasture, green manure, stubble)

Plough performance

Finishing the paddock in record time is often the main yardstick of plough performance. In fact, the plough can produce a wide range of soil conditions, from an almost unbroken furrow to an open, broken finish with considerable loosening, by adjusting depth and speed of operation. Different mouldboard shapes are available to achieve similar soil conditions at different depths and speeds.

Secondary problems arising after ploughing are largely associated with incomplete burial, cloddiness, levelness or openness of the surface and these can be minimised by making adjustments of depth and speed, or by changing mouldboard shape.

Where’s the skill in ploughing?

➢ setting up the implement and tractor. Read the plough manual - you’ll be surprised what you might learn.
➢ producing the desired finish.

What finish does a good ploughman aim for?

➢ Level surface. Each pass should turn onto the last pass without noticeable difference and every board should turn its furrow identically.
➢ Tight finish. Lower speed means the board doesn’t throw the furrow leaving a loose, unconsolidated finish. Soil structure is less disrupted, secondary pass wheelings are less severe, and a better seedbed is achieved with a tight, firm finish.
For a well finished ploughed paddock, a single shallow (50mm / 2") powered implement or s-tine pass before sowing is all that’s required. If a roller/packer is towed by the plough, the paddock and well structured paddock be sown directly. A rough, loose finish requires extra work to level and firm.

How deep should I plough?
Never plough deeper than the topsoil. Incorporating subsoil is more expensive than you think. Subsoil is very low in organic matter and therefore supplies few nutrients, degrades topsoil structure and is of little use for crop growth. Soil tests show that each centimetre of krasnozem subsoil requires $700 worth of fertilisers and 8500kg of organic matter per hectare before it approaches the value of topsoil. Twenty green manure crops would be required to supply this amount of organic matter.

Popular makes of mouldboard ploughs are generally designed for deep, fertile European soils. This shape of board does a poorer job of burial and evenness of finish when attempting to plough shallower than 150mm (6").

Sandy soils
Do not mouldboard plough sandy soils. Any soil low in organic matter is prone to erosion. Coarse organic material is a sandy soil’s natural defence against erosion. Placing it at the bottom of the plough layer is asking for trouble. This hazard is greatest for the sand and sandy loam soils of the state where in dry windy conditions, wind erosion is noticed first on the mouldboard ploughed paddocks.
➢ Do not mouldboard plough sandy soils.
➢ When possible, these soils should be topworked with tined implements in a minimum tillage or direct drill system.

Duplex soils (sandy loam over clay)
Mouldboard ploughing is appropriate for deeper duplex soils only. The topsoil is the uppermost layer, usually darker and higher in organic matter than the pale spewy layer below. Never plough deeper than the topsoil. If the topsoil is less than 100mm (4 inches) deep then the soil is not suitable for mouldboard ploughing. 100-150mm (4-6") is marginal.

Many shallow duplex soils are prone to both wind erosion (on the banks) and waterlogging (in the hollows). Mouldboard ploughing early and leaving the fallow ‘open’, may help keep topsoil dry to allow early spring seedbed preparation, but this is at the expense of long term sustainability. Organic matter and structure decline under long fallows, increasing the risk of erosion and degree of waterlogging. These soils are best managed under a program as follows:
1. surface drainage linking hollows with broad shallow ditches
2. subsurface drainage where appropriate (seek professional advice)
3. minimum tillage and stubble retention/incorporation using tines/discs and trash handling drill

Cropping beyond the lands capability.
Do not plough shallow duplex soils.
Krasnozem soils, Cressy soils and loams
Mouldboard ploughing is highly appropriate for these soils. Intensive cropping requires incorporation of large amounts of organic matter, well prepared seedbeds and good weed control. The mouldboard plough achieves these requirements while being relatively gentle on the soil’s structure.

Black cracking clays
Mouldboard ploughing is less appropriate for these soils.
➢ These soils are self mulching, creating a natural seedbed during shrink/swell cycles. This will only occur if stock are kept off the paddock.
➢ By carefully using the self mulching capability, only minimal tillage is required. Shallow topwork with tines or discs at the optimum moisture content.

If you do plough black cracking clays, a level finish is particularly important because the seed can be sown in the natural, self mulched surface tilth produced overwinter. A rough ploughing operation requires levelling prior to sowing. Levelling knocks the self mulched surface tilth into the hollows and exposes unweathered clay on the humps. This is a difficult seedbed to sow into. Black cracking clay paddocks are often ploughed rough with the aim of drying out the surface. If drainage is sorted out then a rough finish is not required.

Minimum tillage & the mouldboard plough
Loss of structure and fine organic matter (humus) goes hand in hand with the amount of soil disturbance. Powered implements tend to maximise disturbance with their stirring and mixing action, tines cause minimal disturbance, while the mouldboard plough lies somewhere in between.

The furrow press has been recommended for Tasmanian soils by visiting international specialists in soil management. The plough/press will produce a seed bed in a single pass on duplex or well structured clayey soils. Agfest 1995.
During the cropping phase soil structure tends to decline. Good soil management is all about slowing the rate of decline to a minimum. Powered implements used without care and skill degrade soil structure very rapidly by overworking or operating in soil too moist for tillage.

Powered implements are immensely variable in their action on the soil. At best, they create a level, firm seedbed, chop and incorporate coarse organic matter and break clods all in a single pass. What more could one ask for? However, at worst, in a single pass powered implements can create more damage than any other implement, while appearing to do a fine job.

Powered implements and soil structure
Overworking and working in moist soil conditions are the two chief problems associated with powered implements. Soils with a history of powered implement use tend to;
➢ require more energy to form the seedbed each year
➢ suffer ‘clods and powder’ seedbed syndrome
➢ suffer poor drainage as natural pores and cracks are destroyed
➢ crust more readily
➢ have a high wind and water erosion risk. An overworked surface layer can act like a sponge, preventing excess water moving down through the profile.

Why use powered implements?
➢ As a risk management tool. For intensive cropping where planting and harvesting occurs like a dog chasing its tail, there simply isn’t time for several tillage passes all at the right moisture content or for long fallows where natural weathering does the work. Gentler implements can be used most of the time, while the powered implement is there when the ‘instant seedbed’ is urgently required.
➢ To shallow chip and semi-incorporate surface cover or dessicated pasture. Deep, slow powered implement passes are worst. These maximise loss of organic matter and destruction of natural structure. Do not use these implements for deep working. Use tines such as the agroplough for minimal surface disturbance or the chisel plough for disturbance right to the surface.

Where is the skill?
➢ In avoiding overworking. Judging just how much energy to apply to the soil and adjusting rotary speed and forward speed accordingly requires considerable expertise.
➢ In judging soil moisture. See earlier chapter which illustrates the simple roll test for assessing soil moisture.
Sands and duplex soils
Overworking to a ‘clods and powder’ seedbed is a major problem for these soils. Use of powered implements tends to make this scenario more likely, bringing on associated problems of rapid loss of organic matter, wind erosion, waterlogging and surface crusting. All these are exacerbated by intensive tillage.

A powered implement can be used with care, either as a final, shallow low energy pass or as a one pass total seedbed preparation, with the aim of avoiding numerous passes with discs and tines, some of which will be poorly timed in terms of soil moisture. A powered implement can also be used for chipping turf for preparation of a potato seedbed.

Clays and loams
Powered implements can be used with care in these soils, particularly as a shallow, low energy pass before sowing, as a ‘power harrow’. In an intensive cropping system where incorporation of large amounts of green manure and stubble is necessary, use the mouldboard plough rather than a deep, high energy powered implement pass.

Black cracking clays
Use of powered implements gradually reduces this soil’s ability to form a natural self mulching seedbed. In bad condition, black cracking clay clods tend to disintegrate the implement rather than vice versa.

Guidelines for using powered implements
1. Avoid overworking - adjust rotary speed and forward speed to produce no finer seedbed than the next crop requires.
2. Check soil moisture before starting work - if you can roll a sausage it’s too wet.
3. Use as a shallow (2-4", 50-100mm) working implement to chop and incorporate organic matter and to produce the seedbed finish.
4. Do NOT use as a deep working implement (over 100mm, 4"). Use tines for deep loosening and your powered implement for the surface finish.
# Choosing the Right Implement

<table>
<thead>
<tr>
<th>Operation</th>
<th>Objective</th>
<th>Implement</th>
<th>Comments</th>
<th>Potential Problems</th>
<th>Draft* kN/m of width</th>
<th>Potential soil damage #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loosening</td>
<td>Subsurface cracking &amp; heaving</td>
<td>Deep ripper</td>
<td>Rigid tines designed to work at or below plough depth (10-18”/ 250-450mm). Alleviates compaction caused by trafficking and stock in wet conditions. Breaks plough pan if one exists (see soil inspection). Two passes required using standard narrow tines, one pass using winged tines.</td>
<td>High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>up to 17 per tine at 450mm (18”) depth</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agroplough</td>
<td>Rigid tines designed to work at or below plough depth. Tine leg is slanted sideways at 45 degrees rather than vertically. Draft is significantly reduced by having the tine follow the natural line of soil fracture.</td>
<td>High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>14 per tine at 450mm (18”) depth</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paraplough</td>
<td>Rigid tines designed to work at or below plough depth. Tine leg is slanted sideways at 45 degrees rather than vertically. Draft is significantly reduced by having the tine follow the natural line of soil fracture.</td>
<td>High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>7</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Complete disturbance</td>
<td>Chisel plough</td>
<td>Stiffly-sprung tined plough, wide points (100mm). Leaves coarse organic matter on the surface. Good topworking implement. Two passes usually required.</td>
<td>High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>7.5 for primary discing</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td>Mixing &amp; Cutting</td>
<td>Cut/mix clods &amp; surface organic matter</td>
<td>Off set discs</td>
<td>Semiburial of organic matter leaving some on the surface for erosion control. Good topworking implement. Very detrimental to soil structure if used in moist or wet conditions.</td>
<td>High soil moisture, smearing - check before working.</td>
<td>2.9</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disc plough</td>
<td>Semiburial of organic matter leaving some on the surface for erosion control. Good topworking implement. Very detrimental to soil structure if used in moist or wet conditions.</td>
<td>High soil moisture, smearing - check before working.</td>
<td>2.9</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One way plough</td>
<td>Drill</td>
<td>High soil moisture, smearing under seed</td>
<td>12</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drill</td>
<td>High soil moisture, smearing - check before working.</td>
<td>12</td>
<td>✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Invert soil Incorporate residues</td>
<td>Mouldboard plough</td>
<td>Complete or partial burial of organic matter, rough or smooth finish, firm or loose finish, depending on adjustment of colters, skimmers, depth and speed.</td>
<td>High soil moisture, smearing - check before working.</td>
<td>1.5</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Increase soil density</td>
<td>Rollers tyres</td>
<td>Conserves moisture in the seedbed and increases soil/seed contact for even germination. Tow behind the drill. Best at low speeds.</td>
<td>High soil moisture - check before working</td>
<td>2</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Increase soil density &amp; break clods</td>
<td>Furrow press</td>
<td>Heavy cast iron rings with a sharp cutting angle. Commonly towed behind mouldboard plough in Europe. Reduces number of secondary tillage passes. Reduces erosion risk.</td>
<td>High soil moisture - check before working</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Draft is the force per meter width.*

# Potential Problems
- **High soil moisture**: High soil moisture can lead to compaction below the surface, affecting root growth and reducing water infiltration.
- **Smearing**: Smearing results in a smooth surface, which can reduce water infiltration and nutrient availability.
- **Wind erosion**: Wind erosion can occur when the soil surface is not protected, leading to loss of topsoil and reduced crop yields.

# Draft* kN/m of width
- The draft is the force per meter width of the implement. It indicates the amount of effort required to move the implement through the soil.

# Potential soil damage #
- **✗**: Indicates low potential for soil damage.
- **✖**: Indicates medium potential for soil damage.
- **✖ ✖**: Indicates high potential for soil damage.
- **✖ ✖ ✖**: Indicates very high potential for soil damage.
<table>
<thead>
<tr>
<th>Operation</th>
<th>Objective</th>
<th>Implement</th>
<th>Comments</th>
<th>Potential Problems</th>
<th>Draft* kN/m of width</th>
<th>Potential soil damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disintegration</td>
<td>Finer surface tilth</td>
<td>Harrows</td>
<td>For disintegration of surface clods. More effective at higher speeds</td>
<td>High soil moisture - check before working</td>
<td>1.5</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Break clods, level surface</td>
<td>Dutch harrow</td>
<td>Smudge with short vertical spikes extending into the plough layer. No trash handling ability. Good secondary implement to follow mouldboard plough. Preserves moisture. Levels surface.</td>
<td>High soil moisture - check before working.</td>
<td>3.0</td>
<td>✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Break clods</td>
<td>Roterra</td>
<td>Tractor powered. Vertical spikes or blades rotating about a vertical axis. Stirring and clod breaking action. Fineness of tilth depends on forward speed. Leaves more coarse organic material on the surface than the rotary hoe. Severely damaging to soil structure if used incorrectly (tilth too fine or soil too moist).</td>
<td>Overworking. High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>30 for primary pass, 10 for secondary</td>
<td>✗ ✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Break clods &amp; incorporate surface residues</td>
<td>Rotary hoe</td>
<td>Tractor powered. Horizontally angled blades rotating about a horizontal axis. Mixing and clod breaking action. Fineness of tilth depends on forward speed. Leaves less coarse organic material on the surface than the power harrow. Severely damaging to soil structure if used incorrectly (tilth too fine or soil too moist). Can cause a hoe pan to develop.</td>
<td>Overworking. High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>30 for primary pass, 10 for secondary</td>
<td>✗ ✗ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Break clods &amp; incorporate surface residues</td>
<td>Rotary spikes</td>
<td>Tractor powered. Spikes rotating about a horizontal axis. Mixing and clod breaking action. Fineness of tilth depends on forward speed. Chops and incorporates clods and coarse organic material. Severely damaging to soil structure if used incorrectly (tilth too fine or soil too moist).</td>
<td>Overworking. High soil moisture, smearing &amp; compaction below the surface - check before working.</td>
<td>30 for primary pass, 10 for secondary</td>
<td>✗ ✗ ✗ ✗</td>
</tr>
<tr>
<td>Rearrangement</td>
<td>Sort clods to the surface</td>
<td>S tine cultivator</td>
<td>Springy, forward inclined tines sort and break clods with low input energy. 4 or 5 rows of tines give a levelling effect while crumble roller firms the seedbed. Good topworking implement. Excellent as final pass before drilling.</td>
<td>High soil moisture - check before working.</td>
<td>3</td>
<td>✗ ✗</td>
</tr>
<tr>
<td></td>
<td>Break clods</td>
<td>Flail mulcher or slasher</td>
<td>Smashes standing cereal straw, green manure or crop residue into smaller pieces on the soil surface for incorporation. For direct drilling into cereal stubbles, mulching improves flow of stubble past drilling tines.</td>
<td></td>
<td>3-5</td>
<td></td>
</tr>
</tbody>
</table>

# Refers to the implements soil degrading capability if used incorrectly or inappropriately.