NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SOILpak - dryland farmers on the red soil of Central Western NSW
Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/central-west

Updated versions of this document can also be found at the above web address.

PART A. INTRODUCTION

Chapter A1. About this manual

Chapter A2. The ideal soil for dryland farming

Chapter A3. District soil management problems

A1. About this manual

SOILpak for dryland farmers on the red soil of Central Western NSW is a 'best practices' soil management manual.

This manual is relevant to the management of red soil under dryland crop and pasture production in Central Western NSW. The outermost corners of the region are the Gilgandra, West Wyalong, Hillston and Nyngan districts. The region is bordered by the Newell Highway in the east (see Figure A1-1).

Red-brown earths and red earths that tend to be naturally hardsetting are the predominant soil types used for dryland cropping in Central Western NSW. They therefore receive the most attention in this manual. Some cracking clay soil types are also found, particularly around Trangie and Warren. For dryland cropping on these cracking clays, refer to *Northern wheat-belt SOILpak*. *SOILpak for cotton growers may also be useful*.

SOILpak manuals concentrate on the skills needed to:

- assess the condition of a soil, with emphasis on soil structure; and
- understand the management options for maintaining or improving soil condition.

This manual does not aim to make the final decision for dryland farmers. Instead, it provides options which can assist farmers and their advisers to develop successful soil management strategies.

Good soil management has economic benefits and improves your chances of obtaining good crop yields. Yield mainly depends upon the season; and so in a favourable season even a poorly-structured soil can produce a good crop. However, in a poor season a good yield is more likely to be obtained on a well-structured soil. Soil structure is just one factor influencing overall soil condition.

Poor soil management can lead to large yield losses and high input costs.

Sensible soil management also improves the condition of the surrounding environment. For example, erosion control prevents the silting up of water courses and the transport of nutrients attached to soil particles.

The information in this manual has been collated from a wide variety of sources, many of which are not easily accessible. Being in loose-leaf format, *SOILpak* can be easily updated.

INTENDED AUDIENCE

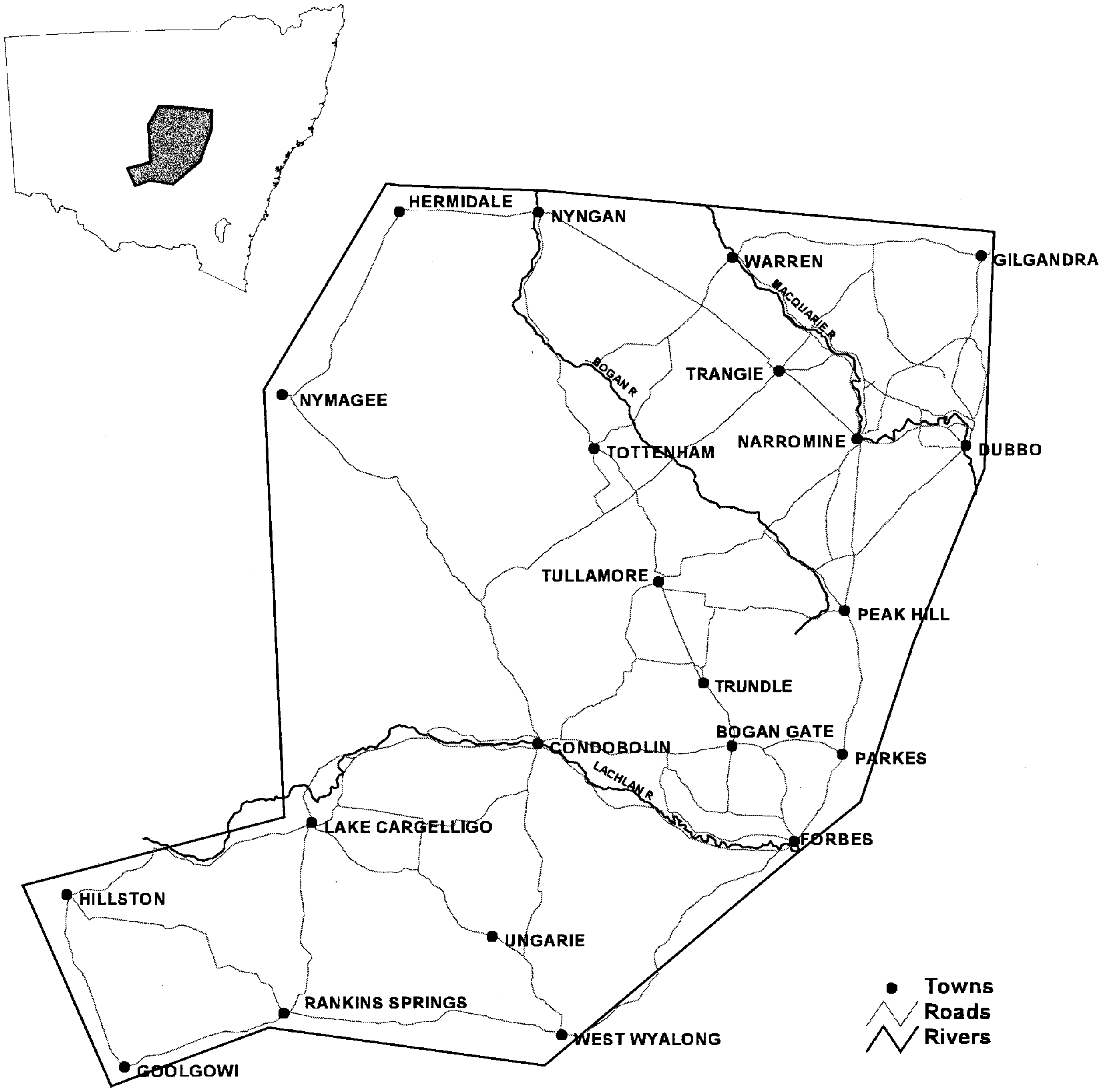
SOILpak is intended for:

- growers who want to learn more about how to manage their soil, and;
- extension officers and consultants who wish to become more skilled in advising their clients on soil management.

YOU CHOOSE

SOILpak for dryland farmers on the red soil of Central Western NSW gives you relevant information and a list of management options, not a set of answers. Management options to consider for a range of circumstances are given.

Figure A1-1. Central Western NSW (shaded and detailed)



It will be up to you to decide, given your resources and economic situation, which option best suits your needs. Your decision must take account of disease, insect and weed management and equipment availability. You will have to decide how much time you have and what the risk of unfavourable weather is likely to be.

The weather is an over-riding factor in all farming operations. *Please remember, when following any plans or guidelines, that the weather may not allow them to be realised.*

There is no doubt about the value of soil assessment—it is recommended strongly. However, *the final decision about which soil management option to select is the responsibility of growers and their advisers*.

OVERVIEW OF CONTENTS

The manual is subdivided into parts and chapters:

- The remainder of *Part A* describes an *ideal soil* so that you can form a picture of what to aim for. Key soil properties of the soil used for dryland farming in Central Western NSW, and some district soil management problems, are discussed.
- *Part B* offers help for a range of situations where you may need a *concise list of management options* to consider without long explanations.
- *Part C* concentrates on the *diagnosis of soil condition*, with emphasis on soil structure information from the paddock and laboratory. Other chapters may refer you back to Part C.
- *Part D* deals with the *practical aspects of soil management* (the ‘how’) following soil diagnosis, but includes some background information (the ‘why’) to help you make decisions with more confidence.
- *Part E* contains *background reading*. It has a more theoretical tone and focuses on soil processes.
- The *appendixes* include a *glossary* of soil management terminology, the *description sheets* and a ‘*further reading*’ list.

Each chapter starts with a summary page outlining the contents of that chapter.

SOILpak caters for two types of users:

- users wanting an overview and/or quick help; and
- ‘best management practice’ users wanting measures of soil condition, and details of options for overcoming soil management problems.

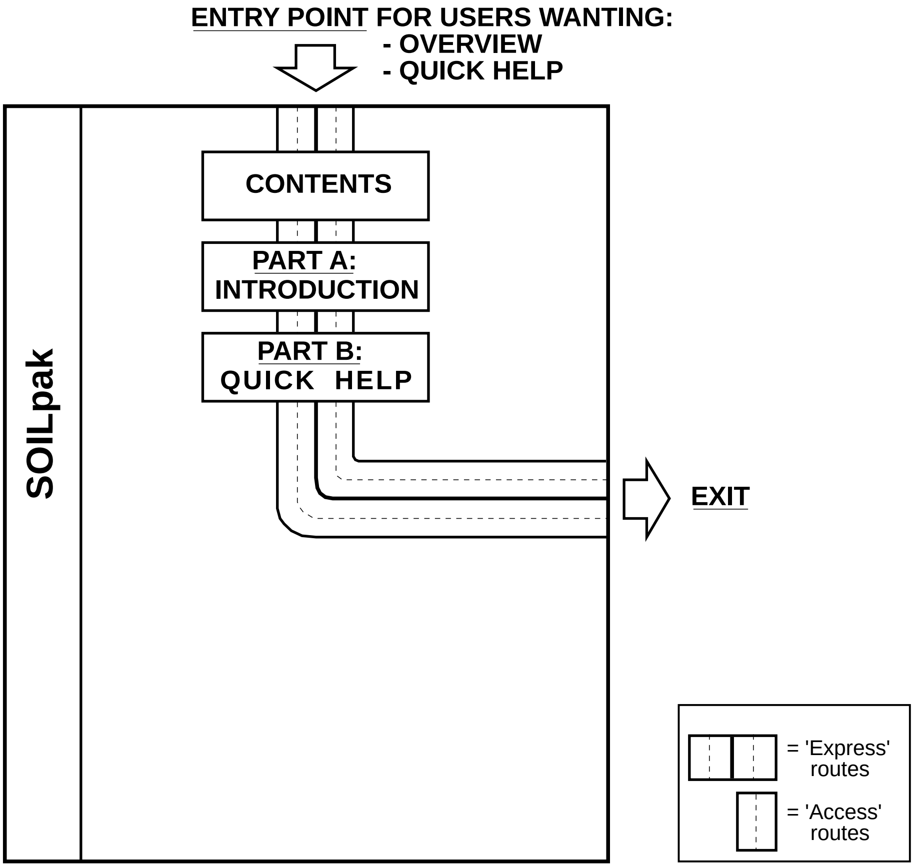
Examples of pathways through the manual, and likely starting and finishing points, are shown in Figure A1-2. To deal with a specific problem it is not necessary to read the entire manual—refer to the index for guidance. The following examples show how the *SOILpak* manual can be used.

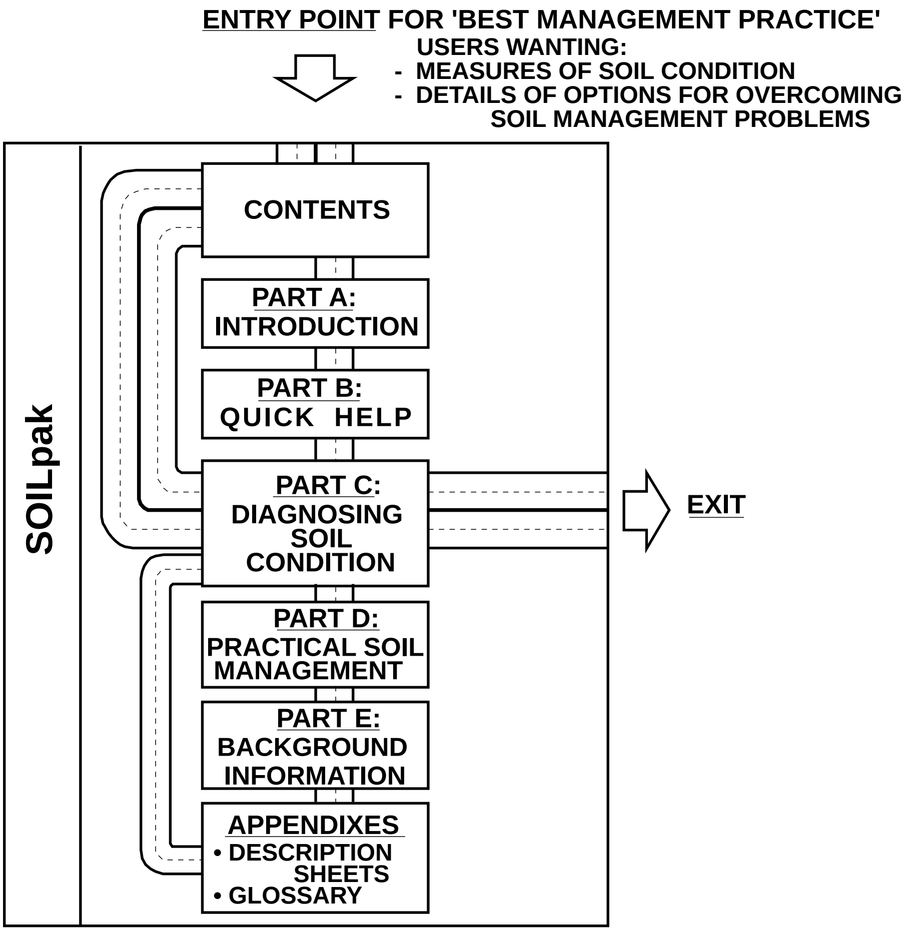
THE FUTURE

The producers of this *SOILpak* have worked hard to keep its contents simple, relevant and accessible. The emphasis is on a system that is useful in the field and easily updated.

As research workers develop and refine improved methods of

Figure A1-2. Pathways through the manual





diagnosing and improving soil condition, the new methods will be incorporated into *SOILpak*.

We reserve the right to update or change this information at any time without notice. Your local agronomist can provide the latest list of updated pages. Updates may become available from the NSW Agriculture Web site.

IDENTIFYING RESEARCH NEEDS

Compilation of this *SOILpak* has highlighted many gaps in our knowledge, some of which are mentioned throughout the manual. Further research is required to ensure continuing progress in soil management techniques. Research leaders have been given details of these problems.

On-farm trials are very important for testing new ideas and fine-tuning existing recommendations. They are discussed in Appendix 3.

HOW TO USE THE SOILPAK MANUAL- SOME EXAMPLES

To illustrate how the *SOILpak* manual can be used by dryland farmers and their consultants, consider the following examples:

Example 1

An entire paddock had poor growth and disappointing yields during the previous winter. The following pathway was used to diagnose and overcome the problems.

Trouble-shooting guide

- Figure B1-1
- Figure B1-3.

Field signs

Hard, dense topsoil and subsurface soil; and dispersion.

Soil pit digging: where, how and when?

Chapter C1.

Diagnosis of soil condition; comparison with critical limits

- description sheet (Appendix 6)
- chapters C2, C3 and C4.

Conclusion

Hardsetting, exacerbated by low organic matter; sodic topsoil.

Management options

- gypsum application (Chapter D4)
- stubble retention (C6)
- pasture phase (D4)
- biological drilling (D4)
- deep tillage (D4)
- structure assessment after deep tillage (C5)
- ongoing monitoring of soil condition (C4).

Example 2

Yield mapping of a wheat paddock indicated a 250% difference in grain yield between the best and worst sections, even though a controlled traffic farming system had been introduced two years earlier. The following pathway was used to see if problems in the poor area were soil related.

Trouble-shooting guide
Quick help (see Chapter B12).

Soil pit digging: where, how and when?
Chapter C1.

Diagnosis of soil condition; comparison with critical limits:

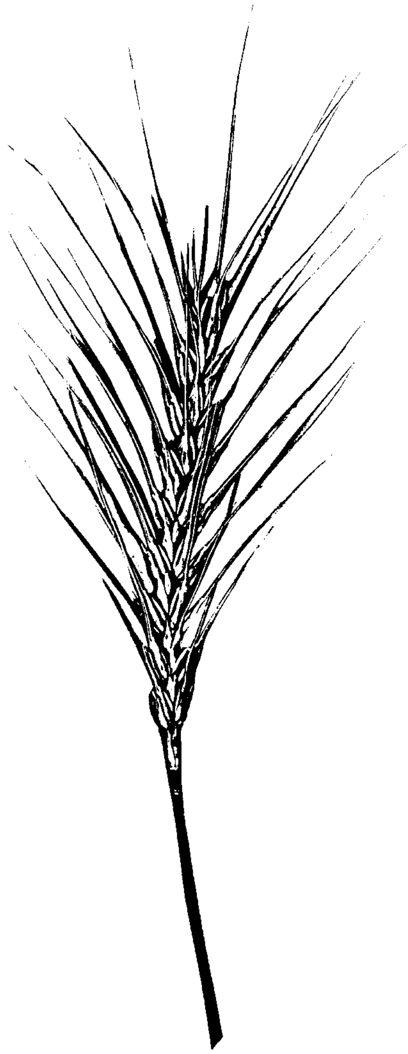
- description sheet (Appendix 6)
- inspections in both the good and poor yielding sections of the paddock
- Chapters C2, C3 and C4.

Conclusion
Sodic subsurface soil and subsoil in areas with poor yield.

Management options:

- gypsum application; variable rate (Chapter D4)
- ongoing monitoring of soil condition (C4).

A2. The ideal soil for dryland farming



PURPOSE OF THIS CHAPTER

To provide a benchmark against which soil used for dryland mixed farming can be compared. Technical specifications are given at the end of this chapter.

CHAPTER OVERVIEW

The following points are covered:

- infiltration and internal drainage
- plant available water capacity (PAWC)
- slope, surface drainage, waterlogging and flooding
- suitability of soil structure for seedling establishment
- suitability of soil structure for root growth
- nutrition
- balance between cations
- salinity
- pH
- erosion control
- soil variability and microrelief.

Other chapters to refer to:

- Chapter A3: ‘District soil management problems’.
- Chapter E1: ‘Soil used for dryland farming in Central Western NSW’.
- Chapter E4: ‘Effects of sodicity and salinity on soil structure’.
- Chapter E6: ‘Organic matter and soil biota’.
- Chapter E7: ‘Plant growth in response to soil structure and temperature’.

FEATURES OF AN IDEAL SOIL FOR DRYLAND FARMING- AN OVERVIEW

For successful crop and pasture growth the soil needs to provide plants with adequate:

- water
- air
- nutrients
- physical support.

The ideal soil condition and management practices for high-yielding, low-cost dryland farming are shown in Figure A2-1. The features mentioned in this diagram are explained in the following text.

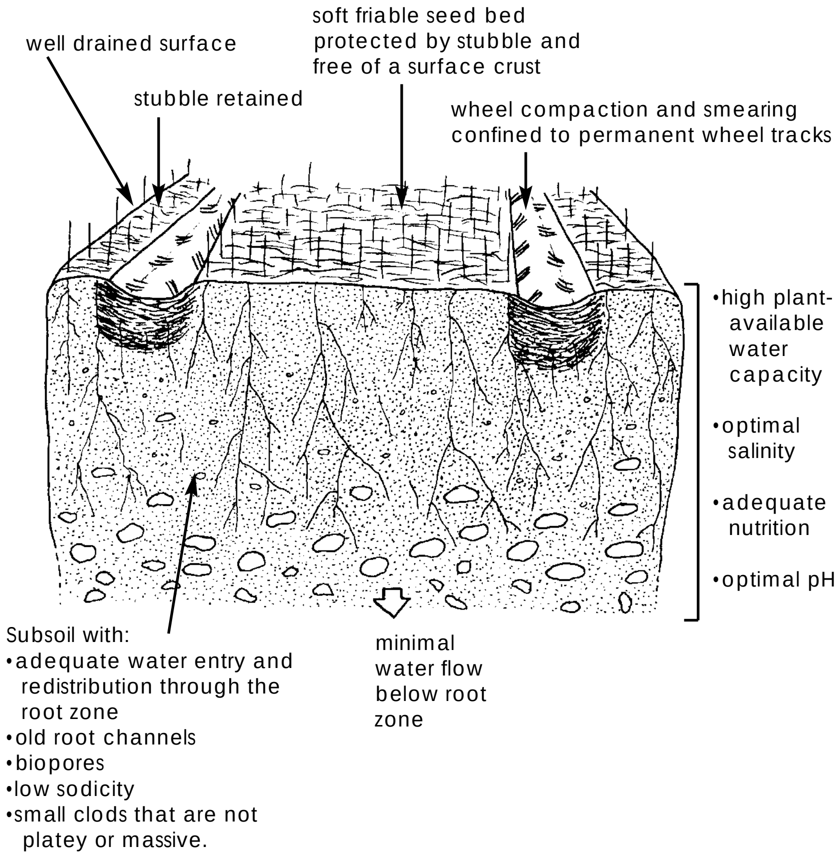
It is rare to find a soil that is ideal in all of the aspects shown in Figure A2-1. We should aim to manage and improve our soil so that it can perform to its full potential (which will vary with soil type and district). If any one soil factor is not ideal, plant growth will be limited.

Infiltration and internal drainage

To allow adequate water entry into the soil, and to encourage root exploration by quickly re-establishing aeration after rainfall, soil needs to have adequate porosity for infiltration and internal drainage. Pore-size distribution is also important.

When rain falls on the soil surface, water moves downwards through the soil profile. The rate at which water moves into the soil

Figure A2-1. Features of an 'ideal' soil, showing some ideal management practices



profile through the ground surface is known as the infiltration rate.

When the intensity of rain exceeds the infiltration rate of a soil, water will pond and if the rainfall persists it will run off. Runoff leads to soil erosion, particularly if the soil surface is bare. Runoff will occur sooner from a soil with a low infiltration rate, than from a soil with a high infiltration rate. Surface cover increases the amount of water that enters the soil.

Structural damage (e.g. compaction and smearing) reduces permeability (the movement of water through the soil), so that transfer of water to lower layers of soil is reduced. Damage can be caused by traffic (vehicular and livestock) or tillage when the soil is too wet.

Some soil characteristics cause the permeability of soil to be low. Soil types which have high levels of exchangeable sodium and/or display crusting and/or hardsetting have a low infiltration rate and poor profile permeability and drainage.

Red earths and red-brown earths have a relatively good surface infiltration rate if they do not set hard or form an impermeable crust. Pasture or retained stubble reduce the tendency of the soil to crust.

The redistribution of water within the soil following infiltration depends upon the internal drainage of the soil profile. In a soil with good internal drainage, water drains from the larger pores, cracks and channels; and allows entry of air. Plants require at least 10% air in the soil.

Some soil has a clay subsoil that is far less permeable than the sand or loam that lies above it. These are ‘duplex’ or ‘texture contrast’ soil types. This can restrict internal drainage because water moves much more slowly through the subsoil than through the topsoil. Water lying on top of the less permeable subsoil (a perched watertable) may lead to poor aeration at the boundary between the topsoil and subsoil. Infiltration and internal drainage are illustrated in Figure A2-2.

Internal drainage of red-brown earths can be a problem. Red-brown earths have duplex texture profiles. Red earths become gradually more clayey with depth. They are sandier than red-brown earths, and so are more freely drained.

While the root zone should be permeable, the deep subsoil should have minimal permeability as excessive deep drainage may cause watertables to rise. Crop rotations should aim to minimise the amount of water draining to the deep subsoil.

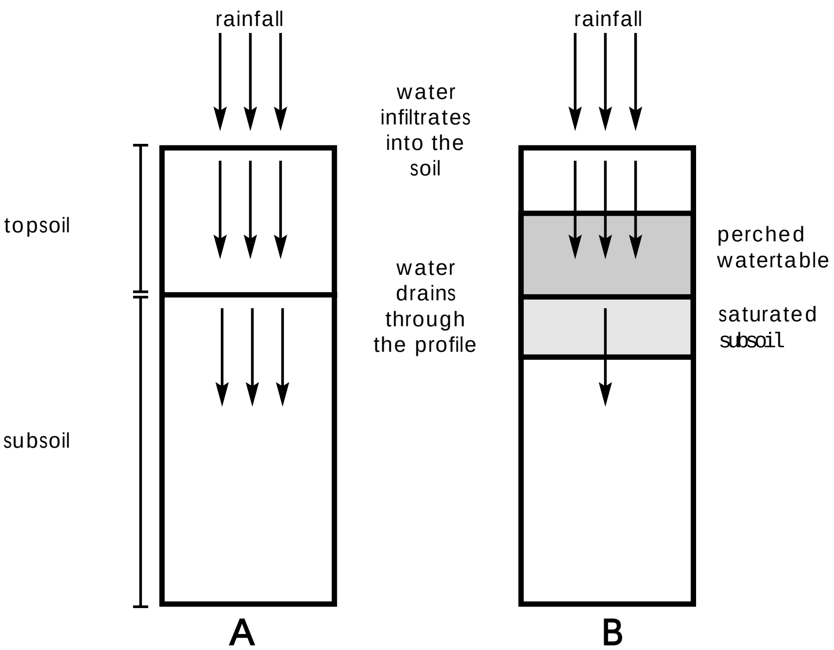
Plant available water capacity (PAWC)

Plant available water capacity (PAWC) is a measure of the maximum amount of water that a soil can store to be used later by plants. It is expressed as millimetres of plant available water in the whole root zone. Under dryland conditions large values of PAWC delay the onset of drought stress in crops.

It would be extremely valuable if a soil could store enough water to provide a crop with adequate water through the entire growing season. In reality, however, stored water is never enough for maximum yield; and rainfall during the growing season is also required.

Improved soil and farm management can significantly increase the amount of water a soil can store for the next growing season, decreasing the dependence on rainfall during the growing season. Practices such as fallowing, stubble retention and weed control can enhance water storage in all soil types.

Figure A2-2. Soil profiles with different internal drainage characteristics



Soil A has free drainage while soil B has restricted drainage. This could be because the subsoil of soil B is much more clayey than its topsoil, or the subsoil is sodic.

PAWC is related to soil texture, which is determined by the relative amounts of sand, silt and clay in the soil. PAWC is poor in shallow soil over bedrock, in sandy soil and in soil with dense sodic subsoil.

The ability of crop roots to access the available soil water is reduced by poor soil structure. Poor soil structure may also reduce the ability of water to enter a soil and redistribute.

Slope, surface drainage, waterlogging and flooding

An appropriate slope and spacing of erosion control banks will ensure good surface drainage and reduce waterlogging without a high risk of erosion.

The greater the slope you are farming, the higher the risk of erosion under heavy rainfall. Contour banks and the careful management of surface cover minimises erosion risk. If you are cropping a fairly steep area, choose a crop that will tend to hold the soil (e.g. a fibrous rooted crop rather than a taprooted crop) and retain the stubble.

On a level surface, ponding or flooding can occur. This results in poor air flow through the soil to the plant roots and can be disastrous during the seedling stage. A gentle slope is ideal so that excess water is drained before waterlogging affects the crop. Raised beds can help surface drainage, but are virtually non-existent on dryland farms in Central Western NSW.

SUITABILITY OF SOIL STRUCTURE FOR SEEDLING ESTABLISHMENT

Rapid and uniform seedling emergence is most likely to occur where the surface tilth is friable, and has fine water-stable clods and natural aggregates. Water-stable aggregates do not collapse upon wetting. Clod diameter adjacent to seed should be in the range of 0.5 to 2.0 mm for seed germination.

Some red-brown earths and red earths have surface soil that slakes and disperses (collapses into a slurry) upon wetting. When the structure collapses infiltration rates are reduced, and the soil is more likely to become waterlogged during a fall of rain. Without adequate aeration seedling establishment will be poor.

Another problem of a topsoil that collapses upon wetting is that it sets hard on drying. Topsoil with a low clay content (less than about 35% clay), insufficient organic matter (less than 2% organic matter) and poor biological activity is particularly prone to hardsetting. This restricts seedling emergence.

Cracking clays generally have a surface structure that regenerates itself by swelling and shrinking as the soil is wetted and dried (this expresses itself most beneficially in the group of cracking clays referred to as being self-mulching). This provides ideal seedbed conditions if the soil is protected from mechanical compaction. Red-brown earths and red earths are not self-mulching and cracking in their topsoil is very limited.

Even in soil with strong shrink-swell behaviour, an excess of sodium attached to the clay particles (sodicity) makes the seedbed dispersive and more prone to waterlogging, hard when dry and too cloddy when tilled.

Organic mulches (e.g. cereal straw) on top of the seed-bed protect it from the damaging effects of raindrop impact, and may help to reduce slaking and dispersion when the soil is wet. Mulches encourage soil biota (e.g. ants, termites and earthworms) which regenerate soil structure by producing burrows and stabilising soil aggregates.

Suitability of soil structure for root growth

Crops are more likely to produce high yields when their roots are able to grow freely and access water and nutrients throughout the root zone. Root growth will not be restricted in a soil with pores large enough for root tips to enter and in soil that is not mechanically strong enough to prevent radial expansion.

Root growth is retarded by the same factors that restrict seedling growth (see previous section 'Suitability of soil structure for seedling establishment').

Nutrition

To ensure that plant growth is not retarded an ideal soil would have nutrient levels that are sufficient without being toxic. Fertility status is often low for red-brown earths and red earths, particularly in nitrogen and phosphorus. Cropping these soil types rapidly depletes them of nutrients and measures need to be taken to correct deficiencies.

Total and available nitrogen levels are usually low (especially after several crops). To obtain satisfactory yields in the future, rotations that include a legume crop and/or pasture phase should be implemented (this also ameliorates some of the poor physical properties of red-brown earths and red-earths). Applications of a nitrogen fertiliser may also be required. Timing of fertiliser application is important. Stubble management also has a role in the management of nitrogen levels.

The three major plant nutrients are nitrogen, phosphorus and potassium. Plants need moderate amounts of calcium, magnesium and sulfur. Trace elements include iron, manganese, zinc, copper and boron. Plant nutrient deficiencies need to be rectified to provide an ideal soil for dryland cropping, but determining the exact quantities and the application of the nutrients is not easy.

Salinity

Most grain crops are fairly tolerant of salinity. However, if the soil is highly saline, expect a yield loss or a crop failure. Crops that are particularly sensitive to salinity include most of the legumes (peas, beans, clovers and medics), horticultural crops (vegetables and fruit) and maize.

Salinity is high enough to affect the yields of many crops when EC_e (the electrical conductivity of a saturated extract) exceeds 4 deciSiemens per metre (dS/m).

An ideal soil has low salinity, but not zero salinity. If there were no dissolved salts, clay would disperse in water and the soil structure would be unstable. Additionally, a soil with zero salinity would not provide plant nutrients (plants absorb nutrients as dissolved salts).

pH

Ideally the pH of the soil will be between 5.0 and 8.0 (measured in calcium chloride solution) because most commercially grown plants grow best when the pH is in this range.

The pH of a soil is very important for plant nutrition because pH affects the availability of nutrients to plants. Below pH 5.0, aluminium becomes more soluble and may reach concentrations which are toxic to plants. Plant nutrients which become unavailable as pH decreases include molybdenum, calcium, nitrogen and phosphorus. As pH increases plant nutrients such as manganese, iron, copper and zinc become unavailable.

Erosion control

The risk of soil loss by water and wind erosion is reduced if the soil surface is protected by a straw mulch. Surface cover should be at least 30%, preferably anchored. At the beginning of a fallow, surface cover should be 70%, to allow for breakdown of stubble during the fallow.

Soil variability and microrelief

To allow efficient management of each crop area as a single unit, it is highly desirable that the soil of the area be fairly uniform. A complex distribution of soil types with differing tillage and fertiliser requirements, for example, cannot be managed optimally using traditional broadacre farming methods.

In some parts of the dryland farming region of Central Western NSW cracking clays are associated with red-brown earths and red earths. If the latter are hardsetting they can have a poor intake of water compared to the cracking clays and there are often different fertiliser and herbicide requirements for the two.

Gilgai microrelief (sometimes found in association with cracking clays), even when levelled, can also provide a complex mosaic with

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See Chapters C1 to C9 for more information on the tests mentioned in Tables A2-1 to A2-3.

former mound and depression sites giving differing crop performance which may persist for many years.

FEATURES OF AN IDEAL SOIL FOR DRYLAND FARMING-TECHNICAL SPECIFICATIONS

Part C of this manual describes how to measure and interpret soil properties that influence the growth of dryland crops and pastures. A summary of target values is shown in Tables A2-1 and A2-2.

A summary of nutrient 'critical limits' is presented in Table A2-3.

Table A2-1. Summary of key soil properties influencing the growth of dryland crops and pastures, based on wheat 'critical limits'

Process	Soil property	Specification
water movement	clod diameter	<6% (topsoil)
		<0.5 mm (dust fraction)
	SOILpak score	**>1.5 (topsoil)**
	<0.5 (deep subsoil)	
	ASWAT score	**0**
seed germination	clod diameter adjacent to seed 0.5 to 2 mm	100%
	SOILpak score	**>1.5 (topsoil)**
	ASWAT score	**0**
	temperature	5–35^{o} C (optimum = 23^{o} C)
	electrical conductivity (EC_e)	<5 dS/m
	pH	6–7
root growth	macroporosity	
	(percentage pores >30 µm diameter)	>15%
	penetrometer resistance	<1 MPa
	clod diameter 0.5–10 mm	100%
	SOILpak score	**>1.5 (all depths)**
	ASWAT score	**0**
	temperature	10–35^{o} C (optimum = 26^{o} C)
	electrical conductivity (EC_e)	<6 dS/m
	pH	6–7
activity of earthworms and microbes	organic residues	10 t/ha/year
erosion control	clod diameter >2 mm	
	(on the soil surface)	100%
	organic residues	> 30% cover

> = greater than, < = less than.

Table A2-2. Summary of chemical factors affecting soil structural stability in water

Soil factor	Values associated with stability (low ASWAT scores)	Values associated with instability (high ASWAT scores)
exchangeable sodium percentage (ESP)	< 2	> 2 (low EC) > 15 (high EC)
electrochemical stability index ($EC_{1:5}$ / ESP) (ESI)	> 0.05	< 0.05
ratio of exchangeable calcium to exchangeable magnesium (Ca/Mg ratio)	> 2.0	< 2.0 (particularly < 1.0)
calcium carbonate ($CaCO_3$) content, %	> 0.3	< 0.3
organic matter: —total, %	*	*
—labile, %	*	*

> = greater than, < = less than.
* Critical limits for organic matter (OM) content have not yet been established for soil used for dryland farming. However, in terms of soil structural condition, the more OM there is (particularly labile OM) the better, if accompanied by an adequate supply of calcium ions.

Table A2-3. Soil test levels below which nutrient levels may be deficient

Nutrient		Extraction method *	Critical level (mg/kg)
nitrogen **	NO_3	aqueous buffer	20–25
phosphorus	P	bicarbonate	10–20
sulfur **	S	Ca dihydrogen orthophoshate	5–10
iron ***	Fe	DTPA	2
		EDTA	80
manganese	Mn	DTPA	2
zinc ***	Zn	DTPA	0.5
		EDTA	4
copper ***	Cu	DTPA	2
		EDTA	2
boron ***	B	magnesium chloride	1.5
		calcium chloride/mannitol	0.4
		hot water	0.15
			(cmol(+)/kg)
calcium	Ca	ammonium chloride	20–35
magnesium	Mg	ammonium chloride	10–12
potassium	K	ammonium chloride	0.38 (150 ppm)

* Different laboratories may use different extraction methods.
** Nitrogen and sulfur are both dynamic nutrients. Values can vary through the year, depending on such factors as soil temperature and moisture.
*** Soil tests for trace elements are unreliable. This table gives only a rough guide to critical levels.

Table A2-4. The desirable ranges of cations, expressed as a percentage of the CEC of the soil

Cation	Desirable range (% of CEC)
calcium	65–80
magnesium	10–15
potassium	1–5
sodium	< 1
aluminium	< 5

Source: NSW Agriculture & Fisheries, 1989.

Table A2-5. The interpretation of Ca/Mg ratios

Ca/Mg ratio	Interpretation
< 1	Ca deficient
1–4	Ca low
4–6	balanced
6–10	Mg low
> 10	Mg deficient

Source: Ekert, 1987.

For cations, the balance between the various elements is as important as the actual concentrations. Table A2-4 gives the desirable ranges of cations, expressed as a percentage of the cation exchange capacity (CEC) of the soil.

Values of exchangeable magnesium greater than 20% may induce potassium deficiency. Conversely, values of exchangeable potassium above 10% may result in magnesium deficiency. The desirable level of exchangeable sodium percentage (< 1%) is well below the critical level (5%) for clay dispersion. The desirable levels of calcium (65–80%) and magnesium (10–15%), besides providing adequate nutrition, also minimise clay dispersion.

The calcium/magnesium (Ca/Mg) ratio is also important. Table A2-5 shows the meaning of different Ca/Mg ratios. A ratio of less than 2 and particularly less than 1 is thought to favour clay dispersion.

A3. District soil management problems

Gilgandra
Dubbo
Narromine
Tottenham
Trangie
Warren
Nyngan
Hermidale
Nymagee
Tullamore
Peak Hill
Trundle
Bogan Gate
Parkes
Forbes
Condobolin
West Wyalong
Ungarie
Lake Cargelligo
Rankins Springs
Hillston
Goolgowi

PURPOSE OF THIS CHAPTER

This chapter describes the main soil management problems of Central Western NSW.

CHAPTER OVERVIEW

The following points are covered:

- hardsetting and crusting
- compaction
- dust creation
- salinity
- sodicity
- shrink-swell potential
- organic matter
- acidity
- nutrient availability.

Other chapters to refer to:

- Chapter E1: 'Soil used for dryland farming in Central Western NSW'.

INTRODUCTION

In Central Western NSW, dryland farming is predominantly carried out on red soil types (red-brown earths and red earths). The status of key soil properties of these soil types is highlighted in this chapter.

Soil landscape maps are being prepared for the Dubbo, Narromine and Forbes 1:250,000 map sheets. Derivative maps, based on the main soil types in the soil landscape maps are being made for three key soil properties: pH, sodicity and salinity. The maps indicate problem areas, and are being produced by the Department of Land & Water Conservation and NSW Agriculture. Reports with information about the maps will also be available.

SOIL MANAGEMENT PROBLEMS OF CENTRAL WESTERN NSW

Texture, organic matter and hardsetting severity

The texture of the topsoil of the red soil types of Central Western NSW makes them prone to crusting and hardsetting. Although the texture of the soil means that the soil is potentially hardsetting in its natural state, the problem is exacerbated when the soil is farmed. Hardsetting is usually seen as the major soil management problem when farming red soil in Central Western NSW.

Not all red soil in Central Western NSW is hardsetting but the problem is widespread. Hardsetting and crusting severity also varies according to agricultural practices, and usually can be avoided with good soil and crop management.

Management practices that prevent organic matter decline, or increase organic matter content in the soil can help to reduce the severity of hardsetting and crusting. Leaving stubble standing; therefore keeping root systems intact, and encouraging biological activity also lessens the severity of hardsetting. Crusting can be prevented by having a protective surface cover on the soil.

Hardsetting is not as severe, or may not be present, in a virgin soil because of adequate surface cover, organic matter levels and biological activity, even though the texture of the soil may make it susceptible to hardsetting.

Compaction

While hardsetting is a natural phenomenon, compaction is the result of a weight on the soil surface compressing the soil. Compaction can be caused by machinery (vehicles, tractors, harvesters, tillage and sowing implements) and livestock, especially when the soil is wet. Compaction by both of these means is a major problem facing farmers in Central Western NSW.

The loamy topsoil of the red-brown earths and red earths slumps when wet and naturally sets hard upon drying. Traffic across them when wet only compounds the problem. Hard layers near the surface, and with a low porosity, result.

Compaction is a major problem where the soil has been cultivated using conventional methods (including uncontrolled traffic) for many years, and organic matter levels are low. Compaction problems can be reduced with a greater understanding of the nature of red soil and adoption of farming methods such as:

- minimum- and no-till
- stubble retention

- controlled traffic
- removal of livestock when the soil is wet.

However, problems caused in previous years may also need to be rectified.

Dust

There is a very small range of soil water contents suitable for tillage in red soil. If it is too dry, dust is created; if too wet, compaction occurs. When tilled at water contents below the plastic limit, finely-divided dust may be created which is easily lost by wind erosion. When wet, dust becomes hardset and impermeable. Dust may also be created by the hooves of sheep on dry soil.

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See Chapter C3 for more information on soil moisture (before tillage), soil texture and available water.

Salinity

Dryland salinity is not a major problem in Central Western NSW. There are localised problems throughout the region. Salinity could become a problem in the future if farms are not well managed. Along with salinity comes erosion problems and a decline in yields and water quality.

Localised salinity problems are often associated with a particular geology. Salinity can occur where drainage is restricted (e.g. Ootha) and it is becoming evident at the margin between light and heavy alluvial country. Overall salinity is more of a problem on the Lachlan River side of the Ranger Hills, than on the Bogan River side. There are a number of saline scalds on red soil in the Macquarie Valley, and the problem is becoming more widespread.

Sodicity

Much of the red soil of Central Western NSW has a sodic layer. Red-brown earths with sodic subsoil cover much of Central Western NSW.

Sodicity is a major challenge for farmers because sodic soil disperses in water. Associated problems include erosion, poor infiltration and/or internal drainage.

Shrink-swell potential

The shrink-swell potential of the red soil types of Central Western NSW is small. This is because their dominant clay mineral type is kaolinite. Kaolinite does not expand much when wet. Consequently they are not self-mulching. If the soil is hard or compacted because of poor soil management, the ability of a red soil to regenerate itself through cracking is weak.

The cracking clays in Central Western NSW crack when dry and are often self-mulching.

Organic matter

The amount of organic matter found naturally in the topsoil of red soil in Central Western NSW is low, and is particularly low when paddocks are subjected to repeated cultivations each year and stubble is not retained. Tillage causes organic matter to break down more quickly than if the soil is left undisturbed (tillage exposes more organic matter to oxygen than when it is undisturbed) and, if stubble is not retained, there will be no additions to soil organic matter.

If only small amounts of organic matter are present, then other soil problems such as hardsetting, compaction and low biological activity may be exacerbated.

Acidity

Acidity, like salinity is becoming more of a problem in Central Western NSW. Here, acidity means that the soil is too acidic for the optimal growth of most plants, rather than simply a pH less than 7. In their natural state, red-brown earths and red earths are neutral or alkaline in their subsoil. Natural lime is sometimes found in their subsoil.

Modern agricultural practices such as improved legume pastures are the main cause of topsoil acidity in Central Western NSW and pH should be monitored carefully. Canola and lucerne are particularly sensitive to acidity.

Nutrient availability

Chemical fertility of the soil in Central Western NSW is often poor. The problem is exacerbated by the fact that nutrients are not usually replaced at the same rate as their removal by crop or livestock. This is particularly true for nitrogen.

SOIL MANAGEMENT PROBLEMS OF THE CONDOBOLIN DISTRICT

On the Bogan and Lachlan floodplains sodicity is a problem. The soil has a tendency to disperse upon wetting. Hardsetting is also a concern in the area.

Compaction problems are starting to be recognised and dealt with. Most of the area is affected by compaction.

There has never been a thorough pH survey of the area but the pH is lower in the topsoil than many believe. The average pH (in calcium chloride) in the topsoil (0–10 cm) is approximately 6. Acidity is of more importance in the eastern part of the area because canola is sensitive to acidity. There are no routine applications of lime in the area.

Soil chemical fertility is poor. Nitrogen levels are low and the problem is worse when legume pastures are not incorporated into rotations. Pastures also help to increase organic matter levels.

Salinity is a localised problem, for example at Ootha and Kiacatoo. The watertable rose at Ootha in the 1950s and salinity has become recognised at Kiacatoo in the last 10 years. Salinity around Lake Cargelligo is associated with the lake. This is because of seepage from the lake into the soil due to an artificially high head of water in the lake. Irrigation in the Jemalong irrigation area between Forbes and Condobolin is creating salinity problems for dryland farmers.

SOIL MANAGEMENT PROBLEMS OF THE GILGANDRA DISTRICT

Common with the rest of Central Western NSW, hardsetting soil and low organic matter levels are a widespread problem in the Gilgandra area.

The soil around Gilgandra is sodic in some places. There are also some acidity problems. Important issues are liming and acid tolerant plants. Trials, investigating the benefits of lime on sodic, slightly acid soil, are being run.

Sulfur deficiency in pastures has been identified, and phosphorus is also widely deficient.

SOIL MANAGEMENT PROBLEMS OF THE FORBES DISTRICT

The red soil to the east of Forbes (around Mulyandry and Eugowra) is lighter (sandier) than the red soil to the north and west of Forbes. In the eastern parts of the Shire, water erosion, poor chemical fertility and acidity are the major soil management problems. Red soil is often found on sloping country and water erosion occurs when surface cover is inadequate. Deficiencies of phosphorus, and sometimes sulfur, limit crop and pasture growth. These deficiencies limit the fixation of nitrogen by pasture legumes, which in turn limits the nitrogen nutrition of subsequent cereal crops. The parent material (sedimentary rocks and granite) and coarse texture of the soil in this area makes them naturally acidic. Pasture legume growth and product removal has further acidified the soil in many places to the point where it needs to be limed to maintain productivity.

To the north and west of Forbes soil sodicity, and associated crusting, has led to poor seedling emergence in many instances. Soil compaction and poor water infiltration are also problems. Again, phosphorus is deficient and nitrogen deficiency is often associated with poor phosphorus nutrition of legume pastures. Acidity is emerging as a problem. Salinity, associated with the watertable rising is a problem in the Jemalong-Warroo irrigation area.

SOIL MANAGEMENT PROBLEMS OF THE WEST WYALONG DISTRICT

There are three main soil types in the West Wyalong district; red-brown earths, red clays and grey clays. Each soil type covers about 30% of the district area, which is roughly 270 km east-west and 120 km north-south.

Minor soil types of the district are ironstone soil, gravel clays and an undefined ‘wattle soil’ which covers 1% of the district area.

The pH in the topsoil of the red soil types is 4.5 to 6.0, and pH generally increases with depth. Two percent of the red soil types are at risk of acidifying from intensified farming in the higher rainfall areas of the district. The grey clays have a pH of 6.0 to 8.0 in the topsoil.

Structural decline of the soil is a major issue in the district, with 30% of the red soil hardsetting and 30% of the grey clay increasing in sodicity.

This structural decline is due to farming practices that exceed climatic and soil limits. Cropping phases of more than 3 years, followed by poor quality winter annual pastures degrade the local soil.

Salinity is an issue of increasing concern to the community. The main concern is of salt patches arising within the district, as a result of farming practices in neighbouring districts.

GETTING HELP

All of the problems identified above can be overcome, or at least eased, by good land management.

See Chapter B1 for assistance with any of the soil management problems relating to:

- poor seedling establishment

- disappointing yields and profitability
- excessive costs due to too much cultivation
- erosion.

Also in Part B are ‘Quick help’ sections to deal with specific on-farm soil management problems.