NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SOILpak – southern dryland farmers - 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/south-dryland

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

PART A. INTRODUCTION

Introduction

The aim of this manual is to provide information that will help you to increase farm profitability by improving your farm management.

We hope that you, the farmer, will use this manual as a first source of information to identify the nature and causes of soil problems.

This manual is relevant to the dryland mixed cropping and grazing areas of the south-west slopes and plains and the grazing areas west of the high country tablelands.

The manual is not intended as an instruction book to be read from cover to cover—rather as a recipe book to dip into if you want to identify and deal with specific issues like acidity or the use of gypsum.

The manual suggests ways to overcome a wide range of soil limitations to plant growth. We hope this will help you to make decisions that will increase your long-term profitability while conserving your most valuable asset: your soil.

Although we offer practical ways to deal with financially important soil problems, the advice in this book is underpinned by a strong commitment to long-term stability in agriculture.

CHANGING

Agriculture in this area is only a few generations old, and the systems used to manage the land will continue to evolve and improve. We have only recently begun to understand that farming makes demands on the soil beyond those that can be satisfied by applying superphosphate. In many districts, liming to correct soil acidity has resulted in yield increases that rival those gained from the use of super. Many other technologies, like the use of canola to break the soil disease cycle, offer worthwhile long-term benefits.

Rainfall, weeds, disease, the need for year-round feed for stock and the need for a steady income may limit your options for change. Change is most easily managed if it is set within the context of a whole-farm plan. A farm plan enables you to identify those areas that are most in need of change. Look at your farm plan as a list of opportunities for easier and more sustainable management, rather than as a series of obligations.

CARING FOR YOUR SOIL

As we near the end of the decade of Landcare, many eyes are on the farming community. Much progress has been made in improving the countryside by replacing lost trees and healing the scars of erosion and salting. However, the long-term viability of agriculture depends on protecting and improving the fertility of the vast areas of soil. This will increase profitability at the same time, as it removes the underlying causes of soil erosion and dryland salinity.

Improvements in the conditions of the soil do not come overnight. Improving the structure and fertility of your soil is a process that can take many years. That is why you should start now.

SOIL MANAGEMENT

Dryland productivity depends on many factors. Where soil is concerned, there are three factors that we can influence strongly: soil fertility, effective water use and soil erosion control.

Managing soil fertility

This manual emphasises good soil management to maintain all aspects of soil fertility: chemical, biological and physical. Of these aspects of fertility, the single most important for southern NSW is soil acidity.

For all soil types, good management is concerned with providing the right chemical, biological and physical conditions for plant growth; soil chemistry, biology and physics are all inter-related. The flow diagram at left is an example of this inter-relationship.

Example of the inter-relationships between soil chemistry, soil biology and soil physics

Compaction

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Large pores destroyed

↓

Soil will not drain to admit air — *Soil physics*

↓ — *Soil biology*

Not enough oxygen, aerobic microbes inhibited. Anaerobic microbes thrive and convert nitrate to unavailable nitrogen gas — *Soil chemistry*

↓

Soil is deficient in available nitrogen

Managing soil chemical fertility includes the use of fertilisers to supply plant nutrients, legumes to fix nitrogen from the air, lime to raise soil pH, and gypsum to treat sodic clay soils.

Managing soil biological fertility means providing the chemical and physical conditions to encourage the right soil organisms. For example, a well structured soil provides aerated conditions. These conditions encourage microbes that mineralise nitrogen from organic matter, and discourage those microbes that convert plant-available nitrate into unavailable nitrogen gas.

The term biological fertility includes the activities of earthworms.

Managing soil physical fertility includes avoiding damage to soil structure and repairing damaged soil structure. For example, minimum tillage reduces soil disturbance; tillage at an appropriate soil moisture content maintains and improves soil structure.

Good soil management has economic benefits. Inappropriate soil management can lead to large yield losses (depending on the season, yield loss can be total crop failure). As well as reducing yield and increasing production costs, inappropriate soil management leads to lost opportunities in cropping. Worse, it can lead to loss of soil.

Good soil management improves your chances of getting good crop yields. There is no guarantee that a certain action will increase yield, because yield is influenced strongly by the season. In a favourable season, with the right amount of rain at the right time, even a poorly structured soil can produce a good crop. In a poor season, good soil structure maintains better growing conditions and gives a better chance of a good yield. For example, in a dry season, a well structured soil allows more rain to infiltrate and allows plant roots better access to stored water.

Effective water use
This manual emphasises good soil management to make the most of rain. This includes allowing better infiltration to store more water, and allowing better uptake of soil water by crops.

Controlling soil erosion
This manual emphasises good management of crops and soil, hand-in-hand with earthworks, to control erosion.

Erosion is influenced by surface cover, the stability of soil aggregates and the infiltration rate.

A1. About this manual

Southern Dryland SOILpak is a soil management manual. It applies to cropping and grazing areas with winter-dominant rainfall in the dryland Murray and Murrumbidgee catchments of New South Wales. The manual aims to held dryland farmers manage their soil for sustainable and profitable production.

The manual is divided into parts:

A The remainder of Part A describes an ideal soil, to give you a benchmark with which to compare your soils.

B Part B offers help where you may need a quick solution without long explanations.

C Part C explains the diagnosis of soil condition. Other chapters may direct you back to Part C.

D Part D deals with the practical part of soil management. It includes explanations to help you make decisions with more confidence.

E Part E is background reading for those with a further interest.

App The Appendixes contain facts that you may need less often and that would be out of place (or hard to find) in other chapters.

THE AIM OF THIS MANUAL

This manual is designed to:

- help farmers to understand soils
- help farmers, consultants and extension officers with soil management decisions.

The manual is not meant to be read from cover to cover. Turn to the part that interests you. Chapter B1 contains a trouble-shooting guide that will direct you to relevant chapters. Figure A1-1 shows you how to use the manual.

YOU CHOOSE

The manual gives you relevant information, not a set of answers. Those chapters that contain a list of options will follow a step-by-step format to guide you towards a decision. It is up to you to decide which option best suits your needs.

Your resources, the weather and your personal goals will influence your soil management decision. Similarly, insect, disease and weed control will limit the range of options.

THE FUTURE

The aim is to keep the information simple, relevant and accessible. The emphasis is on a system that is useful in the field.

The manual is in loose-leaf format to make it easy to update. Researchers can use this manual to identify areas requiring further research. New editions of the manual will include results of that research.

Figure A1.1 *User's guide to the soilpak manual*

Is this your first use of the SOILpak manual?

NO ↓		**YES** →	It may be useful to read the following chapter A1 About this manual.
NO ↓	Is there any specific soil problem that you are interested in?	**YES** →	See B1 Quick Help guide.
NO ↓	Do you wish to find out more about your soils?	**YES** →	See Looking at your Soils in Section C.
Do you require general soil information or Soil Management options?		**YES** →	See contents on previous page. See Section D on Soil Management.

A2. Ideal soil

PURPOSE OF THIS CHAPTER

To give a benchmark with which to compare soils on-farm

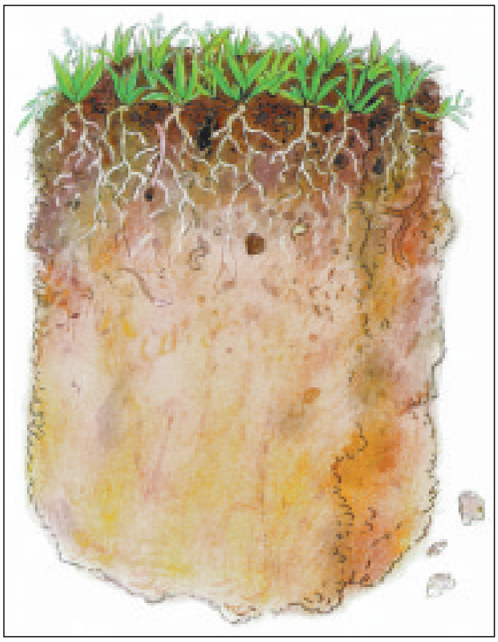
CHAPTER CONTENTS

- texture and structure
- soil organisms
- fertility
- soil acidity
- salinity and sodicity

ASSOCIATED CHAPTERS

You may need to refer to the following chapters:

- C1. Examining the soil profile
- D12. Soil management for increased water-use efficiency
- D3. Sodicity
- D2. Salinity



THE IDEAL SOIL

The ideal soil will, with a little help from its owner, support profitable crops and productive, healthy pastures beyond the foreseeable future.

This section considers some of the factors that contribute to healthy, productive soils.

Vine growers often use the French word 'terroir' to describe what they are looking for in their search for the ideal location for new vineyards. This concept recognises that the ideal is a blend of soils, climate and aspect.
The ideal soil does not exist in isolation from its environment or its use. Soil can be improved by careful management, but even an ideal soil can be damaged—or destroyed—by environmental factors or its owners mismanagement.

The ideal setting for good soil

Aspect and slope

The aspect (that is, the direction in which the soil slopes) is important to the productivity of the soil. In the south-east of New South Wales the north-west slopes are exposed to both the hot afternoon sun and the drying effects of the prevailing north-westerly winds. This hastens the degradation of soil organic matter and reduces the amount of water stored in the soil. Our ideal soil has an easterly aspect warmed by the morning sun and sheltered from the worst winds.

Slope is also important. Soils on flat ground suffer from waterlogging, because water does not run off quickly enough. Steep slopes leave the soil liable to water erosion. The ideal soil has a gentle slope. Steeper slopes can be made ideal by using conservation farming and building contour banks. Flat paddocks can be ideal if they are protected by drains and by landplaning of gilgai areas.

Soil uniformity

Variations in soil type across a paddock make management difficult, even though each soil is ideal in its own way. An ideal whole-farm plan will ensure that differing soils are fenced into paddocks that enable the best land-use of each soil.

Properties of the ideal soil

Soil texture and structure

The first requirement of an ideal soil is the ability to store rainfall and supply it to plants when needed.

This storage capacity is determined by a combination of the soil texture (the proportion of sand to clay) and the soil structure (the way the soil particles are clumped together to provide channels for water flow).

Very sandy soils drain too quickly and store little water for crops, while clay soils need substantial rain to wet them enough for seeds to germinate and crops to grow. The ideal soil is a loam containing a mixture of sand, silt and clay. This mixture is fixed and is the result of geological processes. However, the effect of soil texture can be modified by improving the soil structure. Ideal soil structure is found when the smaller soil particles are clumped together, so that they act as a loam.

In most areas water availability limits yield, so the ideal soil absorbs all the rain that falls on it. This can only happen where the soil surface is soft and uncrusted. The ideal soil has a granular surface structure and a high organic-matter content. The organic matter stabilises the surface aggregates, preventing their destruction by raindrops.

Once the rainwater has penetrated the surface it must flow deep into the soil to maximise the amount of water stored and to reduce the risk of waterlogging. The ideal soil has many large channels made by earthworms and decaying roots. Both roots and soil animals need oxygen from the air to survive. The ideal soil drains quickly, so that 24 hours after heavy rain at least 10% of the holes in the soil are refilled with air. This can only happen if the structure has been well maintained.

Soil organisms

The ideal soil is alive with tiny animals and micro-organisms. These feed on plant residues in the soil. They are in constant competition with each other for nutrients. Many use other organisms as their food source. Their activities bind the soil particles together, giving the soil structure and stability.

Soil micro-organisms are the eye of the needle through which the camel of plant residues must pass on its way to becoming nutrients for the next crop. A large mass of microbes in the soil is ideal for breaking down residues and releasing nutrients, which can only then be taken up by crop roots.

In the ideal soil, plant pathogens such as the take-all fungus are suppressed by the bacteria that feed on them. Crop rotation helps tilt this balance in favour of desirable organisms by reducing the carryover of fungal spores on crop residues, and by suppressing the weeds that may be alternate hosts for plant pathogens.

Soil acidity (soil pH)

The ideal soil has a balance of acidity (low pH) and alkalinity (high pH). This results in a pH between 6 and 7.5, and most crop plants grow well at these levels. Many soils of southern New South Wales have a pH($CaCl^2$) of less than 5. The production of nitrates is an acidifying process balanced by the alkali produced when the nitrates are taken up by plants. The harvesting of nitrogen in plant products and the leaching of nitrate below the root zone need to be balanced by the dissolution of alkaline soil minerals; an ideal soil has a high capacity to supply these minerals. Unfortunately, many soils in the higher rainfall areas have exhausted their supplies of these minerals; lime must be added to keep these soils in ideal condition.

Soil fertility

The ideal soil contains a good supply of plant and animal nutrients, but even more importantly it has a large nutrient storage capacity. Some nutrients are stored in organic matter and are made available by bacteria breaking down the plant and animal residues. Readily available nutrients are stored on the surfaces of soil particles. The ideal soil has a large capacity to store these nutrients, for example, a large cation-exchange capacity (CEC). Adding organic matter to the soil greatly increases its CEC, making it even more ideal. Fertility is also related to acidity. Excess acid in the soil may dissolve toxic amounts of aluminium, while excessive alkalinity may render the soil stores of zinc and copper so insoluble that plant and animal deficiencies result.

Salinity and sodicity

These twin curses have afflicted dry-country agriculture since early biblical times.

Salinity occurs where the soil solution contains too much dissolved salt (NaCl). Sodicity is a problem caused by an excess of sodium (Na) rather than calcium (Ca) adhering to the soil particles.

The ideal soil is well structured, so that rain can infiltrate and carry away salt that builds up in the surface soil. At the same time, crop water use should be great enough to ensure that little water escapes below the root zone to add to regional watertable problems.

Sodicity causes many of the soils in the region to behave in a less-than-ideal way. Where the soil contains more than 6% exchangeable sodium as a percentage of the total cation exchange capacity of the soil, the soil is likely to disperse when wetted. When a soil disperses, the fine clay particles swell up and separate from each other and are washed into the subsoil as a cloud of fine particles. This swelling and clay movement clog up the soil pores, reducing water and air entry. This inhibits root growth and slows drainage, making the soil heavier and harder to cultivate.

The ideal soil has less than 6% exchangeable sodium on the CEC surface. Soils that have more than this level can be made ideal by topdressing with gypsum. Gypsum dissolves with rain, preventing swelling and dispersion. This preserves the soil structure and creates good rooting conditions.

Soil contamination

The ideal soil is clean. Cleanliness implies freedom from agents than might make farm produce less attractive or less safe. It also implies freedom from contaminants that reduce plant or animal production.

Most cropped soils now contain small concentrations of cadmium and uranium applied as contaminants in superphosphate. Soils in higher rainfall areas often contain DDT applied years ago to control pests such as lucerne flea. Sheep-dip sites can contaminate quite large areas with very persistent arsenic.