KNOW YOUR SOILS

Part 3 Managing Your Soils

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KNOW YOUR SOILS

Part 3 **Managing Your Soils**

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Centre for Land Protection Research

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PREFACE

The soil is the lifeblood of your crop or pasture. This important asset supplies nutrients, water and oxygen to plants, supports machinery and animal traffic, and provides a medium for the decomposition of crop and pasture residues.

Soil management will affect land productivity and environmental sustainability. Maintaining the health of your soil to maximise productivity will require an awareness of soil characteristics and how they should be managed.

Farms may have a variety of soil types that require specialised management to optimise productivity and prevent land degradation. Different soil types occur for a variety of reasons, such as different geology, position in the landscape and drainage.

This booklet is the third in a series of three booklets called 'Know Your Soils'. The three booklets provide an easy and informative way for you, the farmer, to assess and understand your soil.

All three booklets are inter-linked and should be used together to achieve an understanding of the way your soil behaves and how it should be managed.

Part 1: Introduction to Soils - This booklet provides detailed background information on soil, including soil forming processes, soil profile descriptions, physical characteristics of soil, and soil management and land degradation issues.

Part 2: Assessing Your Soils - This booklet details eight exercises for you to carry out to assess some characteristics of your soil. The topics covered include: soil classing, the hole, soil colour and depth, stone size and percentage, soil texture, friability, soil slaking/ dispersion and soil pH.

Part 3: Managing Your Soils - This booklet allows you to use the information you have collected in Booklet 2, to interpret the behaviour and physical characteristics of your soil. Booklet 3 also provides management options for some limitations such as poor structure, poor internal drainage and acid soils.

When used together, all three booklets provide you with a logical way of assessing the characteristics of your soil, and most importantly, enable you to gain an understanding of your soil and how to manage it better.

You can use the 'Know Your Soils' booklets to monitor changes in the condition of your soil over time. Part 1 will assist in understanding your soil and Part 2 will help you describe your soil.

It is recommended that you do not use this series as a 'one off'. The routine use of 'Know Your Soils' every three to five years will allow you to observe patterns and changes.

By assessing two or three paddocks each year you can develop baseline information for each paddock and then re-sample to start the monitoring process. If you intend to monitor paddocks, it is important to re-sample as close as possible to the original sampling point. Early detection of changes through regular monitoring will enable problems to be managed and even prevented. This will reduce the detrimental effects of soil degradation on productivity and the environment.

It is also a good idea to independently monitor the chemical conditions of your soil in conjunction with this series. This will help you manage the application of fertilisers and allow you to work out if you have any chemical problems.

In this booklet you will identify limitations that can be managed. Limitations, such as subsoil acidification, are likely to change over time and are costly and difficult to treat. Monitoring pH, particularly at depth, will enable the early detection of subsoil acidification and provide an opportunity for prevention.

Recording sheets are located at the back of Part 2. These sheets will allow you to record the information you collect so you can refer to them when you re-sample. You can independently do the same with your chemical analysis.

Cross referencing between booklets

Each of the three booklets in the 'Know Your Soils' Series is numbered for ease of reference. All sections found in Part 1 have the prefix '1', for example, 1.1 Introduction to Soil and 1.5.5 Wind Erosion. Whereas 2.7 Soil Slaking/Dispersion Exercise is a practical activity found in Part 2; and Section 3.6 Determining Soil Drainage can be found in Part 3.

INTRODUCTION

This booklet follows on from Part 2 'Assessing Your Soils' in the 'Know Your Soils' Series. You must have completed all eight of the exercises in Part 2 before you can move onto this booklet. This booklet allows you to tie together the results of all the exercises and to assess your soil as a whole. From this, a management strategy for your soil can be developed as part of your Whole Farm Plan or Property Management Plan.

When working through the exercises in Part 3 you will apply the results of tests you conducted in Part 2 to develop a management strategy. You will determine whether any of the physical characteristics assessed earlier are going to limit plant growth and productivity. You will use a colour coding system to assess the severity of the limitation outlined below:

- Red: Major limitation
- Orange: Moderate limitation
- Green: Minor or no limitation

You will also begin to use terms such as 'inherent limitations' and 'treatable limitations'. Inherent limitations are those that cannot be easily altered. Therefore you will need to manage the soil around these limitations. Treatable limitations give you a greater flexibility depending on the type and level of limitation.

You may choose to try to increase productivity by increasing management and inputs or alternatively you may decide to decrease inputs or change systems. For example, if you have a soil type with poor structure (treatable limitation), and this is the only limitation, then additional inputs (gypsum) will possibly improve productivity if the soil is dispersive. However, if you have poor soil structure and also shallow soil (inherent limitation), applying gypsum will not be as beneficial to productivity, since the shallow soil will remain a limitation. This type of information will help you make informed decisions about managing your farm by better understanding how limitations interact. In the second example, you may decide that it is not worth investing in gypsum on this soil type. You can invest more in areas that only have treatable limitations and increase your profit margin by investing more in areas that are going to benefit and provide a dollar return.

You will need:

To complete the exercises in Part 3 you will need:

- The completed Soil Description Recording Sheets from Part 2.
- The blank Summary Recording Sheet (found below the Soil Description Recording Sheet on page 23 of Part 2).
- Red, green, orange, blue and yellow markers or pencils.

Before you start these exercises, write the depths you have on the Soil Description Recording Sheet onto the Summary Recording Sheet.

3.1 DETERMINING TOPSOIL AND SUBSOIL

When assessing your soil and how it functions, it is important to know the difference between the topsoil and the subsoil.

Every soil has a topsoil (unless it has been eroded or scraped off). The topsoil is the most organic-rich layer of the soil. It is the principal zone for water and nutrient uptake by plants. The depth and characteristics of the topsoil differ significantly from soil to soil. This is particularly the case with agricultural situations where topsoils could be removed by erosion or mixed with the subsoil during cultivation. The topsoil is the powerhouse for plant growth and should be protected.

The soil below the topsoil is known as the subsoil. The characteristics of the subsoil also differ greatly from soil to soil. To manage soil it is important to be able to identify the subsoil. It is essential to establish if the subsoil has any physical limitations that are preventing plant roots growing through it. If the plant roots are restricted from entering the subsoil they will be unable to access the water and nutrients that are held there. These plants are more likely to show water stress faster than if they were able to penetrate deep within the subsoil.

EXERCISE 3.1: DETERMINING THE TOPSOIL AND SUBSOIL

You may already be using the terms topsoil and subsoil. This exercise will help you more accurately describe at what depth the topsoil ends and the subsoil begins.

In some cases differentiating the topsoil from the subsoil is very obvious, other times it is very difficult to pick the difference. Below are three methods you can use depending on what type of soil you have. These methods are basically the same as you used in 2.3 Soil Colour and Depth Exercise, but this time you are combining depths to determine topsoil or subsoil.

Method 1: Obvious difference in colour and texture.

In some situations there is a significant change in texture and colour between the topsoil and the subsoil. The topsoil may be a darker colour (often brown) and of a light texture, while the subsoil is a brighter colour (with or without mottles) and has a higher clay content.

Figure 1 *The topsoil is darker in colour and light textured while the subsoil is brighter in colour and heavy textured.*

A variation of the above is when you have a pale layer above the clay. The pale layer is usually similar in texture to the layer above and is still referred to as the topsoil. The subsoil begins when both the texture and colour changes.

If the boundary between the topsoil and the subsoil is obvious, mark on the Summary Recording Sheet in the Topsoil/Subsoil column where the topsoil and the subsoil are found.
Shade the depth of the topsoil in blue and the subsoil in yellow.

Figure 2 *Included in the topsoil is the pale layer. The subsoil is directly underneath.*

Table 1 *Obvious changes in colour and texture indicate that the subsoil begins at 30 cm.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001
EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 2 *Using the information collected on the Soil Description Recording Sheet shade the topsoil in blue and the subsoil in yellow.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001
EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Method 2: Changes in structure down the profile.

If the colour and texture is consistent down the profile, there may be a difference in the friability between the topsoil and the subsoil. If, when conducting Exercise 2.3 Soil Colour and Depth, you were unable to use colour or texture as a guide for differentiating the depths, you would have measured where friability changed down the profile. It is highly likely that the first change in friability is the boundary between the topsoil and the subsoil.

If you can use this method, mark on the Summary Recording Sheet in the Topsoil/Subsoil column where you think the topsoil and the subsoil is found. Shade the depth of the topsoil in blue and the subsoil in yellow.

Table 3 *The change in friability at 20 cm indicates the difference between the topsoil and the subsoil.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 2
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-10	Black		C	Friable	Type 4	6.5
10-20	Black		C	Friable		6.5
20-30	Black		C	Hardsetting	Type 2	6.5
30-40	Black		C	Hardsetting		6.5
40-50	Grey		C	Hardsetting		6.5
50-60	Grey		C	Hardsetting		6.5
60+	Grey		C	Hardsetting		6.5

Position in the landscape: Flat.

Rooting Depth: Most Rye grass roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Clay becomes harder at 20 cm.

Table 4 *Using the information collected on the Soil Description Recording Sheet shade the topsoil in blue and the subsoil in yellow.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 2
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-10					
	10-20					
Subsoil	20-30					
	30-40					
	40-50					
	50-60					
	60+					

Method 3: Similar colour, texture and structure.

If the soil shows no apparent difference down the profile, there are usually subtle differences between the topsoil and the subsoil that you can see. For example, look at where most of the roots have accumulated, they are usually thicker in the topsoil. Or there may be subtle changes in structure - for example, you may have called the structure 'friable' but it may be more so in the topsoil.

Mark on the Summary Recording Sheet in the Topsoil/Subsoil column where you think the topsoil and the subsoil is. Shade the depth of the topsoil in blue and the subsoil in yellow.

3.2 ASSESSING TOPSOIL DEPTH

The topsoil is the principal zone of water and nutrient uptake by plants. The deeper a topsoil is, the better the soil is for plant growth and productivity. The depth of the topsoil cannot be easily increased, although poor management can easily erode it. Topsoil depth is an inherent limitation.

EXERCISE 3.2: ASSESSING TOPSOIL DEPTH

Having worked through the first step you have established the topsoil and the subsoil. Using this, on the Summary Recording Sheet shade the depth column in the appropriate colour:

Red: Topsoil less than 5 cm;

Orange: Topsoil greater than 5 cm deep with a pale layer,
topsoil between 5 cm and 15 cm deep without a pale layer;

Green: Topsoil greater than 15 cm deep without a pale layer.

Table 5 *Although the topsoil is 30 cm deep, you must shade the Topsoil Depth column orange as there is a pale layer.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 6 *Using the information collected on the Soil Description Recording sheet shade the Topsoil Depth column in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Interpreting topsoil depth

RED

- Shallow topsoil.
- Small volume of soil with the highest nutrient accumulation.
- The majority of roots will be in this small area.
- Possibly an indication of high erosion hazard of the topsoil.
- Water holding capacity is likely to be low. This increases the risk of crop or pasture failure or decreased yield in below average rainfall years.
- Cultivation may bring subsoil to the surface, thus mixing the soil.

Management options

- Erosion control measures may be required.
- Reduce tillage and maintain cover (stubble or pasture).
- Employ techniques to increase soil organic matter by maintaining a vegetative cover.
- Consider reducing inputs to the soil, as the shallow topsoil will limit productivity.
- Consider non-agricultural uses.
- Likely to be a soil of low productivity, and may be limiting to some crops or pasture.

ORANGE

- Moderate amount of topsoil.
- There may be problems with root penetration of some species deep within the profile. May be limiting to some crops or pastures.
- Possibly an indication of high erosion hazard of the topsoil.
- Water holding capacity is moderate and may result in crop or pasture failure in some years.

Management options

- Manage to preserve the amount of topsoil and to increase the amount of organic matter by maintaining a vegetative cover.
- Reduce tillage.
- Retain stubble.
- Employ erosion control measures.
- If another inherent limitation is identified, the soil is likely to be of low to moderate productivity. Low to moderate inputs to this soil type are recommended, as productivity will be limited as a result of the inherent limitations.

GREEN

- A good amount of topsoil for nutrient uptake by plant roots.

Management options

- Manage to preserve this depth of topsoil.
- Likely to be a soil with high productivity. High inputs to this soil type are likely to benefit production (providing there are no other limitations).

3.3 ASSESSING TOTAL SOIL DEPTH

Shallow soils limit the nutrient and water holding capacity of the soil, which can affect productivity and increase the risk of crop or pasture failure in below average rainfall years.

Shallow soil is an inherent characteristic and cannot be altered. As a manager you need to match the use of the land with the limitation of the shallow soil. This means ensuring that the amount of management you put into a shallow soil (for example applying superphosphate) is going to match the output you expect to get from the soil.

To assess the total depth of the soil you were required to note on the Soil Description Recording Sheet when you hit solid rock. This does not include 'floating rock' - this will be assessed in the stone content assessment.

EXERCISE 3.3: ASSESSING TOTAL SOIL DEPTH

Using the depths recorded in the Depth column of the Soil Description Recording Sheet, shade in the appropriate colour on the Summary Recording Sheet:

Red: Hit solid rock at 0-40 cm
Orange: Hit solid rock at 40-60 cm
Green: Solid rock deeper than 60 cm

Table 7 *Solid rock is deeper than 60 cm, therefore the Total Soil Depth column on the Summary Recording Sheet will be shaded green.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 8 *Using the information collected on the Soil Description Recording Sheet shade the Total Soil Depth column in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Interpreting total soil depth

RED

- Low water and nutrient holding capacity, therefore low productive capacity.
- Root growth will be restricted.
- May be a potential groundwater recharge area.

Management options

- Likely to be a soil of low productivity. It is recommended that you limit inputs to the soil, as productivity will be limited by the shallow soil.
- Consider non-agricultural alternatives for this soil.

ORANGE

- Moderate water and nutrient holding capacity.
- Some restrictions for roots.

Management options

- Likely to be a soil of low to moderate productivity. It is recommended that you apply low to moderate inputs to this soil type, as productivity will be limited by the shallow soil.

GREEN

- Good amount of soil for root exploitation.

Management options

- Likely to be a soil of high productivity. High inputs to the soil are likely to benefit production (providing there are no other limitations).

3.4 ASSESSING STONE CONTENT

Gravel, stone or rock in the first 30 cm of the soil is not only limiting to machinery, but it also limits the nutrient and water holding capacity of the soil as well as root growth.

Gravel, stone and rocks are inherent characteristics of the soil and cannot be easily altered. The land use needs to match the limitation of the stone, gravel or rock. There are no management options available to overcome this limitation, apart from matching inputs with outputs.

EXERCISE 3.4: ASSESSING STONE CONTENT

Using the information recorded in the Stone column in the Soil Description Recording Sheet, shade in the appropriate colour on the Summary Recording Sheet the gravel, stone or rock content in the top 30 cm of the soil:

Red:
- very rocky
- rocky
- slightly rocky
- very stony
- stony
- very gravelly
- >50% buckshot

Orange:
- slightly stony
- gravelly
- 20-50% buckshot
- some rocks

Green:
- some stone
- slightly gravelly
- some gravel
- 10-20% buckshot
- some buckshot
- none (blank)

Table 9 *There is 20-50% buckshot in the first 30 cm therefore the Stone column on the Summary Recording Sheet will be shaded orange.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 10 *Using the information collected on the Soil Description Recording Sheet shade the Stone column in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Interpreting stone content

RED

- Major limitation for machinery.
- Low water and nutrient holding capacity.
- Restricts root growth.

Management options

- Likely to be a soil of low productivity. Limited inputs to this soil type is recommended as productivity will be limited as a result of the high stone content.

ORANGE

- Some limitation for machinery.
- Moderate water holding capacity.
- Some restrictions for roots.

Management options

- Likely to be a soil of low to moderate productivity. Low to moderate inputs to this soil type is recommended as productivity will be limited as a result of the stone content.

GREEN

- No major limitation.

Management options

- Likely to be a soil of high productivity. High inputs to this soil type is likely to be beneficial to production (providing there are no other limitiations).

3.5 ESTABLISHING SOIL STRUCTURE

Assessing the structure of the soil is primarily achieved by looking at how many spaces (macropores) are between soil aggregates in the soil profile. It is the macropores that facilitate drainage, aeration and root growth. In this exercise we will assess the overall structure of the soil.

This is where the friability and dispersion results interlink. Generally a friable soil is not dispersive and macropores are abundant. Hardsetting soils, on the other hand, are commonly caused when the soil has slaked and/or dispersed and the macropores have been blocked by micro-aggregates or with the dispersed clay. The rooting depth is related to the structure. If the soil becomes hardsetting in the subsoil, many plants will find it difficult to get their roots into the subsoil due to the lack of macropores. The majority of the roots therefore are confined to the topsoil.

It must be noted that the rooting depth varies depending on the type of plants grown. Many of the perennial plants such as lucerne and phalaris, have deeper roots than most annual pastures and crops. If a species' roots are not going as deep as they are capable, you should investigate possible reasons. If the friability and dispersion results look adequate, there may be a chemical barrier (such as a pH change or high soil salinity) preventing the roots going down. This exercise will help you establish whether there are any physical problems with your soil, and also highlight soils that you should get tested in a laboratory to establish if there is a chemical problem at depth that is preventing plant growth.

To make an assessment of the overall structure of the soil profile, you need to look at how the plant roots are growing down the profile. This requires combining the rooting depth notes, the friability of the soil and the dispersion results.

EXERCISE 3.5: ESTABLISHING SOIL STRUCTURE

Using the friability, dispersion and rooting depth information recorded on the Soil Description Recording Sheet, shade the Structure column on the Summary Recording Sheet in the appropriate colour according to the following:

Red: Roots confined to the topsoil with very few going deeper.
AND/OR
Friability in the top 40 cm was recorded as hardsetting (except for the topsoil which can still be friable).
AND/OR
Dispersion was Type 1 or Type 2 in the subsoil and possibly the topsoil.

Orange: Roots confined to the first 40 cm with few going deeper.
AND/OR
Friability in the top 40 cm was friable, but the friability changes to hardsetting below 40 cm.
AND/OR
Dispersion was Type 3 in the subsoil.
OR
There is a hardsetting pale layer with a friable layer underneath and dispersion was Type 2, 3 or 4 in the subsoil.

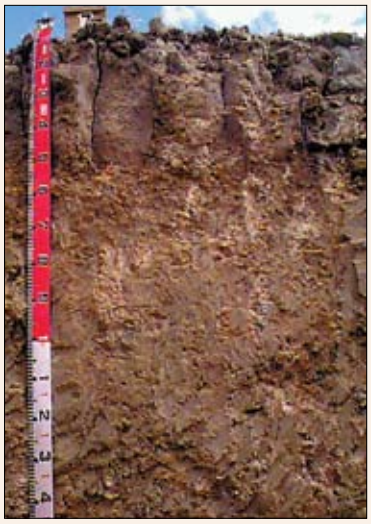

Figure 3 *The majority of roots are in the topsoil (0-10 cm). The friability is hardsetting from 10-50 cm. This layer is highly dispersive (Type 1). The Structure column of the Summary Recording Sheet would be shaded red for this soil type.*

Green:

Roots were recorded as growing freely throughout the soil.

AND/OR

Friability in the first 60 cm was loose or friable.

AND/OR

Dispersion was Type 4 throughout.

OR

Dispersion was not required because the soil was too sandy.

Figure 4 *The majority of roots are in the first 40 cm. The friability is hardsetting from 10-20 cm, but changes to friable after 20 cm. Dispersion at 20-40 cm is Type 2. The Structure column of the Summary Recording Sheet would be shaded orange for this soil type.*

Figure 5 *Roots grow freely through the soil, the whole profile is friable and there was no dispersion throughout (Type 4). The Structure column of the Summary Recording Sheet would be shaded green for this soil type.*

Table 11 *The pale layer is hardsetting (15-30 cm) but the 30-40 cm layer is friable and a Type 3 dispersion therefore the Structure column on the Summary Recording Sheet will be shaded orange.*

SOIL DESCRIPTION RECORDING SHEET EXAMPLE ONLY
PADDOCK: Top Paddock **HOLE No.: 1**
DATE: 12/05/2001

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 12 *Using the information collected on the Soil Description Recording Sheet shade the Structure column in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Interpreting soil structure

RED

- Major limitations for plant roots as they are usually confined to the topsoil.
- Susceptible to surface crusting if topsoil is dispersive.
- Subsoil dispersive.
- Profile possibly suffers from internal waterlogging.

Management options

- Apply gypsum* if the first 40 cm is dispersive (further tests should be carried out to determine how much gypsum to apply, or whether soil salinity is a problem).
- Include deep rooted crops in rotation.
- Use minimum tillage techniques.
- Maintain vegetative cover on the soil surface year round such as retained stubble or pasture cover.

ORANGE

- Some limitations for plant root growth. Few are able to penetrate deep within the subsoil.
- Hardsetting pale horizon can be an indication of internal waterlogging.
- May suffer from surface crusting if topsoil dispersive.
- Subsoil dispersive when cultivated in the moist state.

Management options

- Apply gypsum* if the first 40 cm is dispersive (further test should be carried out to determine how much gypsum to apply).
- Include deep rooted crops in rotation.
- Use minimum tillage techniques.
- Maintain vegetative cover on the soil surface year round such as retained stubble or pasture cover.
- Avoid cultivating soil when moist.

GREEN

- No major limitation for plant roots. Roots can penetrate deep within the profile.

* The soil will only be responsive to gypsum if it is dispersive.

3.6 DETERMINING SOIL DRAINAGE

The drainage of the soil is an important characteristic to assess, as many plants prefer well-drained soils. If a soil is poorly drained, sufficient oxygen cannot get to the plant roots which can stunt growth or kill the plant. Conversely, soils that are excessively drained can be limiting in drier environments or in dry years due to insufficient water holding capacity. How limiting the drainage is depends a great deal on the amount of rainfall. For example, a sandy soil that is in a high rainfall area may not be a limitation for agriculture in terms of drainage.

The colour of the soil is the main indicator of how the soil drains. Other important indicators are the presence of buckshot and stones and the texture of the soil. The dispersability and friability of the soil also has an impact.

The position of the soil in the landscape can impact on the internal drainage of the soil. As a general rule, soils on slopes and crests of hills are expected to drain better than soils on lower slopes or on drainage depressions. This is due to two main factors. Firstly, the slopes usually have a higher runoff rate than lower areas or drainage depressions. This leads to less rainwater infiltrating along the slopes and more water accumulating in the lower areas and infiltrating the soil. Another reason is that there is a trend for the soil on the slopes and crests to be shallower, meaning there is less soil to hold the water. The lower slopes, flat plains and drainage depressions tend to be deeper soils that can normally hold more water.
Refer to 1.4.1 Topography.

EXERCISE 3.6: DETERMINING SOIL DRAINAGE

You will determine your soil drainage by combining information collected in the Soil Description Recording Sheet namely:

- the colour
- the texture
- the presence of buckshot and other stones
- the position in the landscape
- the structure assessment you made in the previous exercise.

You will also be required to know broadly what your annual rainfall is. This becomes important if you have sandy soils.

Refer to Table 13 and shade the drainage column on the Summary Recording Sheet in the appropriate colour.

Table 13 *Determining soil drainage.*

	Colour	Pale layer	Mottles	Texture	Stone/Buckshot	Position in Landscape	Structure column in Summary Recording Sheet	Annual Rainfall
Red	Grey subsoil	May be present	May be present	Usually clay subsoil	May have buckshot	Drainage depressions, flats, lower slopes	Red or orange	All
Red	Black subsoil	Yes	May be present	Usually clay throughout	Yes	Drainage depressions, flats, lower slopes	Red	All
Red (excessive drainage)	Any colour	May be present	May be present	Sandy throughout	No buckshot	Dunes, slopes off dunes	Green	Less than 500 mm
Red (excessive drainage)	Any colour	May be present	May be present	Any texture	Hit rock at less than 40 cm	Usually crests and upper to mid slopes or rocky plains	Any	Less than 800 mm
Orange	Yellow subsoil	May be present	May be present	Commonly light topsoil over clay subsoil	May have buckshot	Any	Red or orange	All
Orange	Black throughout	No	No or slight	Usually clay throughout	None to slight buckshot	Any	Orange	All
Orange	Red subsoil	Yes	Yes	Commonly light topsoil over clay subsoil	May have buckshot	Any	Red or orange	All
Orange	Brown subsoil	Yes	Yes	Commonly light topsoil over clay subsoil	May have buckshot	Any	Red or orange	All
Orange	Any colour	May be present	May be present	Any texture	Greater than 50% gravel/stone/ rock and/or hit rock at 40-60 cm	Usually crests and upper to mid slopes or rocky plains	Any	All
Orange	Any colour	May be present	May be present	Sandy throughout	No buckshot	Any	Green	500-800 mm
Orange	Red subsoil	No	No	Commonly light topsoil over clay subsoil	None to very slight buckshot	Any	Red or orange	All
Green	Red subsoil	No	No	Any texture	No buckshot	Any	Green	All
Green	Brown subsoil	No	No	Any texture	No buckshot	Any	Green	All
Green	Any colour	May be present	May be present	Sandy throughout	No buckshot	Any	Green	Greater than 800 mm

Figure 6 *Grey soil, Structure column is shaded red, subsoil very clayey. The Drainage column of the Summary Recording Sheet would be shaded red for this soil type (due to poor drainage).*

Figure 7 *Sandy soil, located in a low rainfall area. The Drainage column of the Summary Recording Sheet would be shaded red for this soil type (due to excessive drainage).*

Figure 8 *Yellow, mottled subsoil, pale layer, Structure column is shaded orange, has light textured topsoil over clay subsoil. The Drainage column of the Summary Recording Sheet would be shaded orange for this soil type.*

Figure 9 *Red subsoil, no mottles or pale layer, Structure column is shaded green. The drainage column of the Summary Recording Sheet would be shaded green for this soil type.*

Figure 10 *Brown subsoil, no mottles or pale layer, Structure column is shaded green. The drainage column of the Summary Recording Sheet would be shaded green for this soil type.*

Table 14 *The subsoil is yellow with mottles and there is a pale layer with buckshot. The Structure column is shaded orange. There is also a strong texture contrast between the light textured topsoil (sandy loam) and a clay subsoil. Therefore the Drainage column on the Summary Recording Sheet will be shaded orange.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 15 *Using the information collected on the Soil Description Recording Sheet shade the Structure column in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Drainage is generally an inherent limitation of the soil. For example, excessively drained soils in low rainfall areas cannot be improved because the soil is either too sandy, too shallow or too stony. In some situations when the soil is poorly drained this may be overcome through sub-surface drainage. In many cases the management option to overcome the constraints may prove to be very expensive and should be considered in light of the other limitations of the soil (refer to 3.8 Managing the Soil as a Whole). This is particularly true for areas lower in the landscape where there is a high runoff rate from upslope.

Interpreting soil drainage

RED

- Major limitation for plant growth productivity.

Management options

Poor drainage

- Consider non-agricultural uses.
- Consider sub-surface drainage (if appropriate).
- If dispersive subsoil is close to the surface, apply gypsum.
- Include deep rooted crops in rotation.
- Minimum tillage.
- Plant appropriate trees.
- Divert runoff (where possible).

Excessively drained

- Minimum tillage.
- Maintain year round vegetation cover.

ORANGE

- Some limitations for plant growth and productivity.

Management options

- If dispersive subsoil is close to the surface, apply gypsum.
- Include deep rooted crops in rotation.
- Minimum tillage.
- No management considerations if the soil has greater than 50% stone/rock/gravel.

GREEN

- No major limitations.

3.7 INTERPRETING pH

Assessing the pH of the soil is the only chemical test you have conducted. Soil pH is a measure of the acidity or alkalinity of the soil. Acid soils are generally a treatable limitation (lime can be added), whilst alkaline soils is an inherent limitation (no economically feasible treatment option).

It is important to know the topsoil pH and also any changes in pH down the soil profile. Some soils have a major change in pH from less than 5.0 (water) in the topsoil to greater than 8.0 (water) in the subsoil. If deep rooted plants cannot handle alkaline situations, this would prove a barrier and the plant would not be able to exploit the water and nutrients deeper in the soil profile if the subsoil has a pH outside of the plant's pH tolerance range.

EXERCISE 3.7: INTERPRETING pH

Using the pH results on the Soil Description Recording Sheet, highlight the pH results for all layers of soil in the appropriate colour:

Red:
- pH less than 5.5
- pH greater than 8.5

Orange:
- pH 5.5 - 6.5
- pH 8.0 - 8.5

Green:
- pH 6.5 - 8.0

Table 16 *The topsoil is acidic, although the pH increases down the profile, therefore only the first layer will be shaded red, the second layer will be orange and the subsoil will be green throughout.*

SOIL DESCRIPTION RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Depth (cm)	Colour	Stone	Texture	Friability	Dispersion	pH
0-15	Brown		SL	Friable	Type 4	5.0
15-30	Pale	20-50% Buckshot	SL	Hardsetting		5.5
30-40	Yellow		C	Friable	Type 2	6.5
40-50	Yellow		C	Friable		6.5
50-60	Yellow mottled		C	Hardsetting		6.5
60+	Yellow	Some Rocks	C	Hardsetting		6.5

Position in the landscape: Lower slope (gentle slope).

Rooting Depth: The main pasture species is an annual Rye grass. Most roots are in the 0-15 cm horizon. About 30% go through to 30 cm and very few go deeper.

Notes: Colour changes at 15 cm to pale layer. Colour changes again at 30 cm. 30+ cm seems clayier.

Table 17 *Using the information collected on the Soil Description Recording Sheet shade the individual layers of the soil in the appropriate colour.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 1
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

Interpreting Soil pH

RED

- Strongly acid (pH less than 5.5).
- Strongly alkaline (pH greater than 8.5).

Management options, if shaded red due to acidity in the top 15 cm

- Consider the application of lime although this may not be economically feasible at lower pH levels.
- As a guide, lime rates to raise soil pH by 1 pH unit in the top 10 cm of soil are: sand 1-2 tonnes/hectare, loam 2-3 tonnes/hectare, clay 3-4 tonnes/hectare.*
- Grow acid tolerant species.
- Monitor the topsoil and subsoil pH every 3 to 4 years to monitor any changes in pH, for example, subsoil acidification.

Management options, if shaded green in top 15 cm and shaded red due to acidity below 15 cm

- The surface application of lime in an attempt to improve the subsoil pH is probably not economically feasible, as the downward movement of lime is quite slow.
- Have soil below 15 cm tested for aluminium, particularly if planning to grow lucerne.

Management options, if shaded red due to alkalinity in the top 15 cm

- Grow alkaline tolerant species.

ORANGE

- Acid (pH 5.5 - 6.5).
- Alkaline (pH 8.0 - 8.5).

Management options, if shaded orange due to acidity in the top 15 cm

- Consider the application of lime (regular monitoring required).
- Grow acid tolerant species. However, many species are tolerant of this pH range.

Management options, if shaded green in top 15 cm and shaded orange due to acidity below 15 cm

- The surface application of lime in an attempt to improve the subsoil pH is probably not economically feasible, as the downward movement of lime is quite slow.
- Grow acid tolerant species.
- Get soil below 15 cm tested for aluminium, particularly if planning to grow lucerne.

Management options, if shaded orange due to alkalinity in the top 15 cm

- Grow alkaline tolerant species.

GREEN

- Preferred pH range for many species (pH 6.5 - 8.0).
- Undertake topsoil and subsoil pH monitoring every 3 to 4 years to monitor any changes in pH, for example, subsoil acidification.

* Source: Managing Sodic, Acidic and Saline Soils.
Pichu Rengasamy and John Bourne, CRC for Soil and Land Management.

3.8 MANAGING THE SOIL AS A WHOLE

The completion of the Summary Recording Sheet now provides an overview of the strengths and limitations of your soil. Major limitations can be identified using the colours:

Red: Major limitation
Orange: Moderate limitation
Green: Minor or no limitation

Effective management of the soil requires assessing:

- all of the major limitations
- the limitations that can or should be treated (treatable limitations)
- the limitations that cannot be easily treated (inherent limitations)
- the financial risk of treating the limitations
- the financial risk of not treating the limitations.

This type of holistic assessment allows you to evaluate the risks, both financial and environmental of a range of management options. The risks of treating a paddock or soil type should be evaluated in terms of the whole property, preferably through a Property Management Plan.

It is worth considering here the two major types of limitations faced by land managers: inherent limitations and treatable limitations.

Inherent untreatable limitations

An inherent limitation is one that cannot be changed. A number of the soil aspects evaluated are inherent limitations namely:

- topsoil depth
- total soil depth
- stone content
- drainage (sometimes treatable)
- alkaline pH.

Inherent limitations cannot normally be changed due to logistical, financial or environmental reasons. For example, a shallow topsoil is an inherent limitation; it is not logistically (or financially) feasible to import topsoil on a paddock basis to increase the depth. Therefore, you as a land manager need to learn how to manage these limitations to minimise financial and environmental risks. In many cases, inherent limitations increase financial or environmental risks in those years that are climatically unusual. For example, a shallow topsoil may provide adequate plant growth in average and above average rainfall years. However, years that have below average rainfall may result in poor yields, decreasing financial returns (financial risk) and possibly soil erosion if insufficient groundcover remains (environmental risk).

Treatable limitations

Some of the soil aspects evaluated are, to some extent, treatable. Although poor structure and drainage are in many cases inherent aspects of the soil, there is often something you can do to manage the soil so the problems are not as limiting. Therefore they have been put into the treatable limitations category. The treatable limitations are:

- structure
- drainage (is more commonly an inherent limitation)
- acid pH
- other chemical limitations (not in this series).

A treatable limitation is one that can generally be changed by improved management such as adding lime to increase pH and gypsum to improve soil structure and internal drainage.

Interaction between limitations

The cost effectiveness, or financial risk, of improving a treatable limitation should be evaluated in light of the number and type of inherent limitations.

Those areas of the farm that have inherent limitations will generally be the less productive areas of the farm. The type and number of inherent limitations should provide a guide as to the likely financial returns from investment in altering your treatable limitations. A dollar invested in altering your treatable limitations is likely to have a greater return if there are fewer inherent limitations.

The desired outcome involves matching inputs and management to the productive capacity of the paddock. Better paddocks (those with fewer inherent limitations) are likely to have a lower financial risk with higher inputs, whilst poorer paddocks (more inherent limitations) are likely to be more financially risky to treat. It is important to note that although paddocks with inherent limitations can be financially risky if inputs are overcapitalised, these paddocks also need to be managed within their capabilities to minimise environmental risks. This includes reducing grazing pressures to maintain a protective vegetative cover, and using conservation cropping practices if the area is to be cropped.

It may be prudent to investigate changes in land use for areas with severe inherent limitations so that the land can produce more economic and environmental benefits. Changes may include farm forestry, revegetation for windbreaks, stock shelter or biodiversity. Such improvements may be cost effective in the longer term due to improved lambing, wind protection for crops or the harvesting of native vegetation products (e.g. firewood or honey).

Managing limitations

When you have worked through this series you will have a table highlighting limitations of the soil that can be treated (structure and acid pH) and inherent limitations that cannot be treated (topsoil depth, total soil depth, drainage, stone content and alkaline pH).

The treatable limitations are problems with the soil that we suggest can be rectified through improved management. In some cases however, the financial benefits of improving the treatable limitations will be low if there are inherent limitations that will supersede any improved treatment. That is, no matter how much you invest in improving the treatable limitations, the inherent limitations will always restrict agricultural productivity.

The following table provides an indication of the point at which the inherent limitations are so severe that it becomes financially unfeasible to try to improve the treatable limitations. The main treatable limitations are acid topsoils (can be improved by lime application) and poor structure in the top 40 cm (dispersible clay soils can be treated with gypsum). The effectiveness of attempting to manage the treatable limitations is strongly linked to climate and the type of inherent limitations.

It is important to note that these suggested financial risks are general and will vary according to your goals for the farm paddock.

Use Table 18 as a guide to assess the financial risk in treating a treatable limitation.

Table 18 *The relationship between the financial risk of managing a treatable limitation and the inherent limitations and rainfall for Victorian dryland agriculture.*

Rainfall	**Inherent limitation**	**Treatable limitation**	
		Acid topsoils - lime treatment	**Poor structure (top 40 cm) - gypsum treatment***
<450 mm (<18")	Shallow soil	High financial risk	High financial risk
<450 mm (<18")	Shallow topsoil	Moderate to high financial risk	Moderate to high financial risk
<450 mm (<18")	High stone content	Moderate to high financial risk	Moderate to high financial risk
<450 mm (<18")	Poor drainage	Low financial risk	Low financial risk
<450 mm (<18")	No inherent limitations	Low financial risk	Low financial risk
450-650 mm (18" - 26")	Shallow soil	Moderate to high financial risk	Moderate to high financial risk
450-650 mm (18" - 26")	Shallow topsoil	Moderate to high financial risk	Moderate to high financial risk
450-650 mm (18" - 26")	High stone content	Low financial risk	Low financial risk
450-650 mm (18" - 26")	Poor drainage	High financial risk	Low financial risk
450-650 mm (18" - 26")	No inherent limitations	Low financial risk	Low financial risk
>650 mm (>26")	Shallow soil	Low to moderate financial risk	Low to moderate financial risk
>650 mm (>26")	Shallow topsoil	Moderate financial risk	Moderate financial risk
>650 mm (>26")	High stone content	Low financial risk	Low financial risk
>650 mm (>26")	Poor drainage	High financial risk	Moderate to high financial risk
>650 mm (>26")	No inherent limitations	Low financial risk	Low financial risk

* Gypsum will only be effecive if the soil is dispersive.

Table 19 *Completed summary sheet in a greater than 650 mm annual rainfall area.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 3
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

The soil in Table 19 is in an area with greater than 650 mm annual rainfall. The soil is poorly drained (an inherant limitation) and acidic (a treatable limitation). The high rainfall means that the soil is prone to waterlogging (poor drainage) and this is more of a problem than the soil's acidity. It would be financially risky for you to try to raise the pH, since the plants are likely to still suffer from waterlogging. A better option may be to grow species that do not require well drained soils. If these plants are not acid tolerant, then the application of lime to raise the pH will be less of a financial risk because you have tried to overcome the inherent limitation by changing land use.

Table 20 *Completed summary sheet in a 450-650 mm annual rainfall area.*

SUMMARY RECORDING SHEET
PADDOCK: Top Paddock HOLE No.: 4
DATE: 12/05/2001

EXAMPLE ONLY

Topsoil Subsoil	Topsoil depth (cm)	Total soil depth (cm)	Stone	Structure	Drainage	pH
Topsoil	0-15					
	15-30					
Subsoil	30-40					
	40-50					
	50-60					
	60+					

The soil in Table 20 is in a 450-650 mm annual rainfall area. The soil has a high stone content and poor drainage (inherent limitations) and poor structure (a treatable limitation). You should carefully consider whether applying gypsum to try to improve the soil structure is a good management option, given the two inherent limitations. Table 18 indicates that for this rainfall zone, there would be low financial risk if the stone content was the only inherent limitation, but the drainage limitation makes applying gypsum to improve yields a moderate financial risk. You could choose to take the risk and try to improve yield, or you may determine that this is too risky because the poor drainage will still be a problem for plant growth.

Manageable limitations need to be assessed in light of inherent limitations (as above) but also in the light of other manageable limitations. This includes chemical limitations that have not been assessed using this kit. For example, optimum plant growth will not be achieved following treatment of an acid soil with lime if there is a significant phosphorous deficiency in the soil that has not been treated. Testing for soil chemical properties should be undertaken every three to five years.

The 'Know Your Soils' Series requires work, but it will help you understand what your soils need and what you can expect from them. Soils that are properly understood and managed will give you high yielding production, now and in the future.

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