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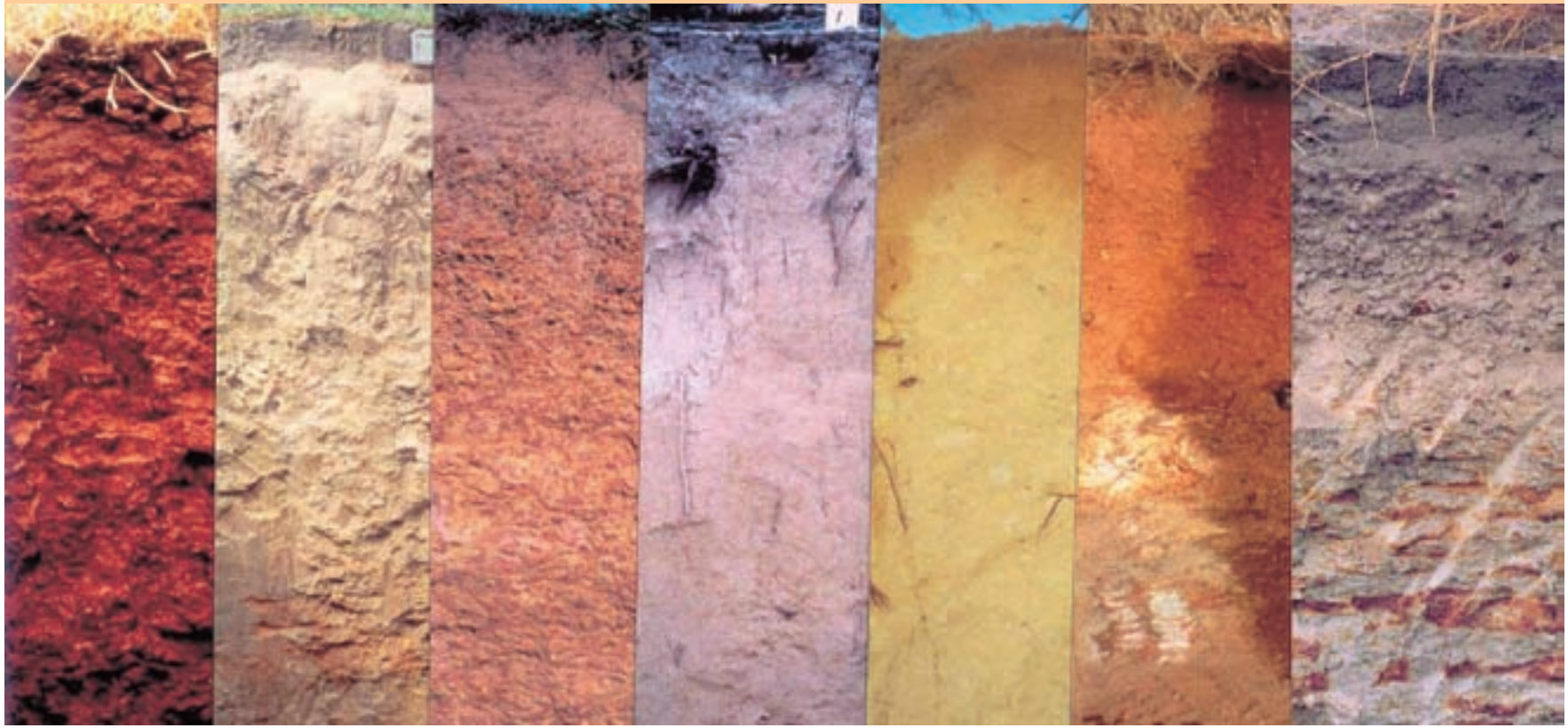
Diagnosing and ameliorating problem soils : decision tree on how to diagnose and ameliorate problem soils

Department of Agriculture and Food, Western Australia

DIAGNOSING AND AMELIORATING PROBLEM SOILS

(Decision Tree on How to Diagnose and Ameliorate Problem Soils)



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Diagnosing and Ameliorating Problem Soils
(A decision tree on how to diagnose and ameliorate problem soils)

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INTRODUCTION:
Most cropping paddocks in Western Australia have lower yielding areas within paddocks that perform poorly in most years. If the agronomy and management are good, the poor yields are usually due to soil-related problems. Some of these problems can be corrected or reduced by adopting certain proven practices. However, it is important to identify and quantify the problem so that decisions can be made on whether amelioration is possible and economically feasible.

OBJECTIVE:
The objective is to provide a simple decision tool for farmers and advisers to use in identifying and quantifying soil problems in agricultural soils in Western Australia. It could be used outside Western Australia by including local soil problems.

PROCESS:
Work through the decision tree step by step to identify and quantify the soil problems in poor performing paddock zones and to decide the feasibility of amelioration. It is necessary to eliminate the reasons for poor yield due to agronomic and management problems before using this diagnostic key on soil problems.

Note: To evaluate the economic feasibility of amelioration, use the ICV economic analysis tool (Graeme McConnell, Planfarm, which is included in the web version of this booklet).

INDEX FOR THE DIAGNOSTIC KEY ON SOIL PROBLEMS

Is the texture of the soil sandy throughout the profile? → Yes → **Go to step 1**

No

Is the topsoil non-wetting (a drop of water takes >10 seconds to be absorbed by the soil)? → Yes → **Go to step 1**

No

Does the soil get waterlogged (water within 30 cm of surface and crop leaves yellowing)? → Yes → **Go to step 2**

No

Is the pH_{Ca} of either the topsoil or subsurface soil within 50 cm, less than 4.5 or more than 7.5? → Yes → **Go to step 3**

No

Is the soil crusting, hardsetting, surface sealing or cracking? → Yes → **Go to step 4**

No

Is the rooting depth restricted by rock, a dense clay layer, hardpan (red-brown, calcrete, siliceous etc.), cemented gravel or a traffic or plough pan? → Yes → **Go to step 5**

No → **Then the low yields are due to nutritional problems or root diseases. Do soil & tissue tests next season.**

Step 1

Non-wetting sandy soils and pale deep sands

From any poorly performing area of a paddock, can you make a coherent soil ball, that can be held between thumb and forefinger [from any soil layer (horizon) up to 1 m depth] by mixing the soil with water and kneading? (Use TopCrop Soil Texture Card. *In high and medium rainfall zones, if there is unglazed gravel in the profile it may still be productive*.)

→ No → This is a poor pale deep sand. There may not be economic benefit from amelioration. Cull the area from cropping and find an alternative land use. If not possible to cull, reduce inputs.

↓ Yes

Is the topsoil non-wetting (a drop of water placed on the soil after scraping off the top 2-3 mm remains as a bead for more than 10 seconds)?

→ No → **Go to step 2**

↓ Yes

Is the rainfall from April to October less than 175 mm?

→ Yes → Claying is beneficial only in wet years. Negative response in dry years. Furrow seeding with or without banded surfactant is an option.

↓ No

Does test solution No. 2 from LMS water repellency test kit get absorbed into the soil within 10 seconds (2 molar ethanol or 12 mL of industrial grade methylated spirits made up to 100 mL with water can be used)?

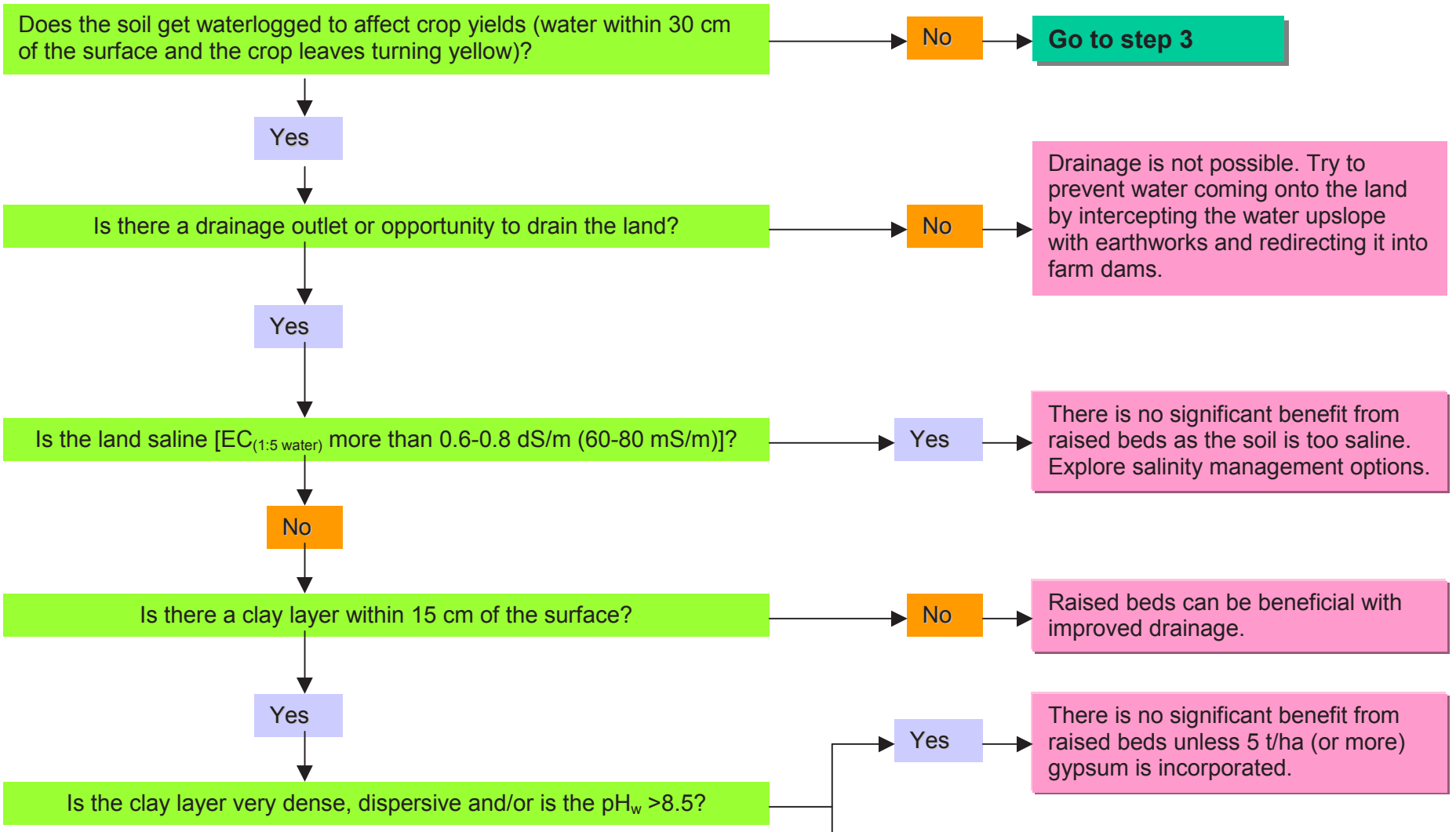
→ Yes → Moderate yield increase and good weed control from claying. Furrow seeding with or without banded surfactant is an option.

→ No → Substantial benefit in yield and weed control from claying. Furrow seeding with or without banded surfactant is an option.

For information on texturing a soil see Appendix 1 for TopCrop Soil Texture Card.

Step 2

Waterlogging



Refer to dispersion test in step 4 (see Appendix 2 for details).

Step 3

Soil pH (Acidic or Sodic Soils)

Is the soil pH_w >8.3 in any layer to 50 cm depth (more than about pH_{Ca} 7.5)?

→ Yes → **Go to step 4.** At high pH boron toxicity and Cu, Mn, and Zn deficiencies may occur. Soil and tissue test. If boron toxic, grow tolerant crops and varieties.

↓ No

Is the soil pH_{Ca} <4.5 in any layer to 30 cm. depth?

→ No → No urgent need to lime. If the pH is close to 4.5, liming to prevent further acidification is beneficial which will also improve nutrition and increase crop options. As lime takes time to move down the profile and the pH of the surface soil needs to be raised above pH 5.5 before it moves down, liming before the problem arises will prevent future yield decline.

↓ Yes

Is the soil pH_{Ca} between 4.3 and 4.5 in any layer to 30 cm?

→ Yes → Liming recommended. Good yield response in acid-sensitive crops such as barley.

↓ No, <4.3

Is the soil colour yellow, brownish yellow or reddish yellow?

→ No → Very good yield response to liming in most crops, except lupins. Better nutrition and more crop options. The lower the pH and/or higher the clay, the higher the lime rate.

↓ Yes

Does the clay content increase with depth to a sandy loam or a loam within 30-40 cm?

→ No → Good yield response to surface application of lime is expected with time. The lower the pH and/or higher the clay content, the higher the lime rate required. Grow aluminium-tolerant crops and varieties.

→ Yes → Surface application of lime not effective in the short to medium term. Deep banding with ripping and some surface application may be helpful. High rates required. Grow aluminium-tolerant crops.

Note: Refer to Farmnotes on soil acidity and liming published by the Department of Agriculture, Western Australia.

Step 4a

Hardsetting, crusting, surface sealing or cracking soils

Is the soil texture within 30 cm of the surface heavier than a loamy to clayey sand (i.e. sandy loam or heavier)?

No → **Go to step 5**

Yes

When the soil is completely dry, are there surface cracks more than 10 mm wide?

No → **Go to step 4b**

Yes

Is the soil self-mulching (i.e. breaks into crumbs or small peds/structural units)?

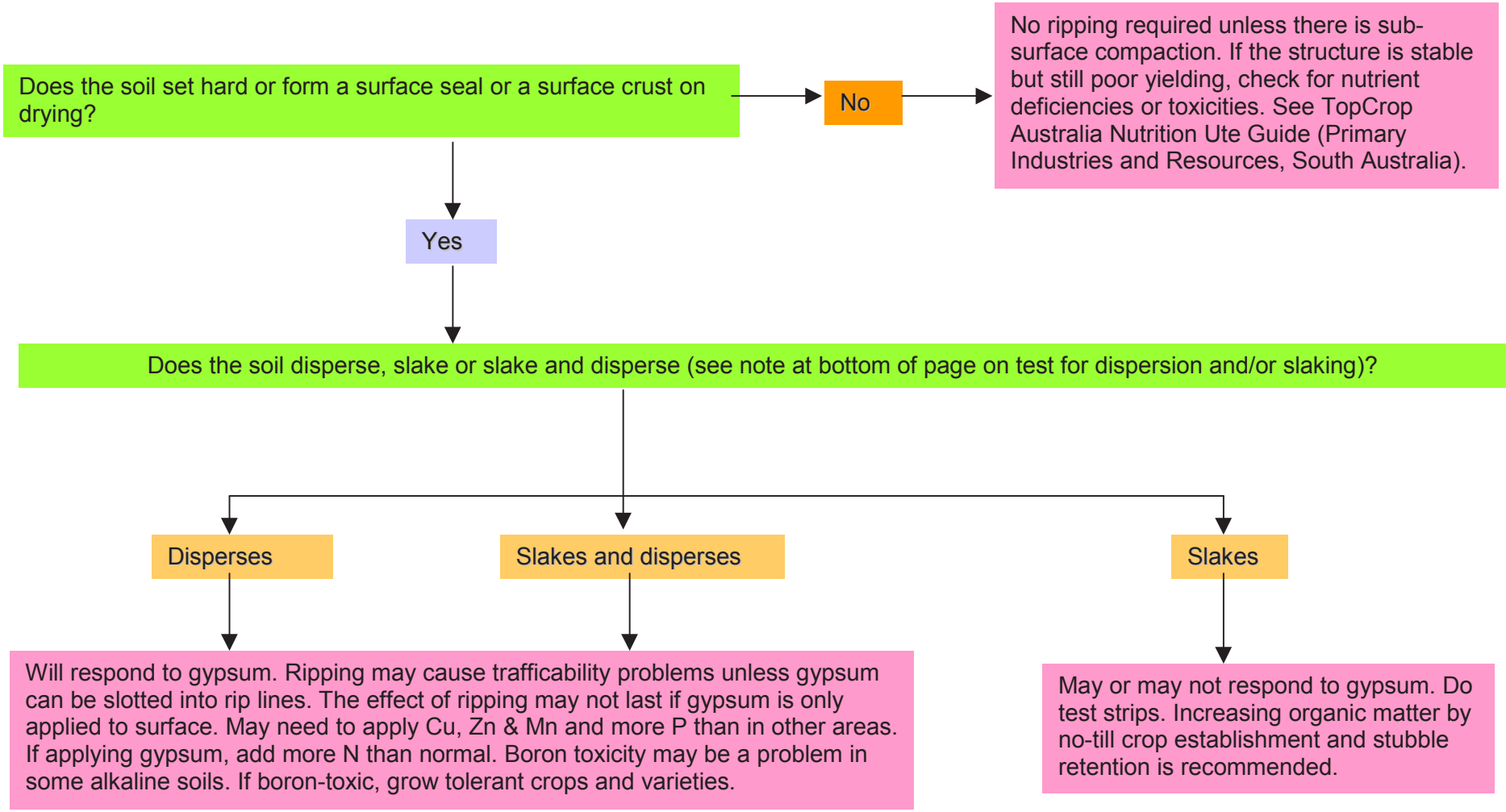
No → Test for dispersion (Appendix 2). If dispersive, apply gypsum. Work the soil only at correct moisture content. No-till with stubble retention and removing stock during wet periods is recommended.

Yes

This soil should be productive if managed properly. Periodic soil analysis for exchangeable sodium percentage (or cation ratios) is recommended and if sodium levels are increasing relative to calcium, topping up calcium levels with gypsum would maintain the soil in good condition. If there are gilgais (which some farmers call crabhole clay), raised beds may be an option, but maintenance may be on-going and costly. If poor yielding, check for nutrient deficiencies and toxicities.

Step 4b

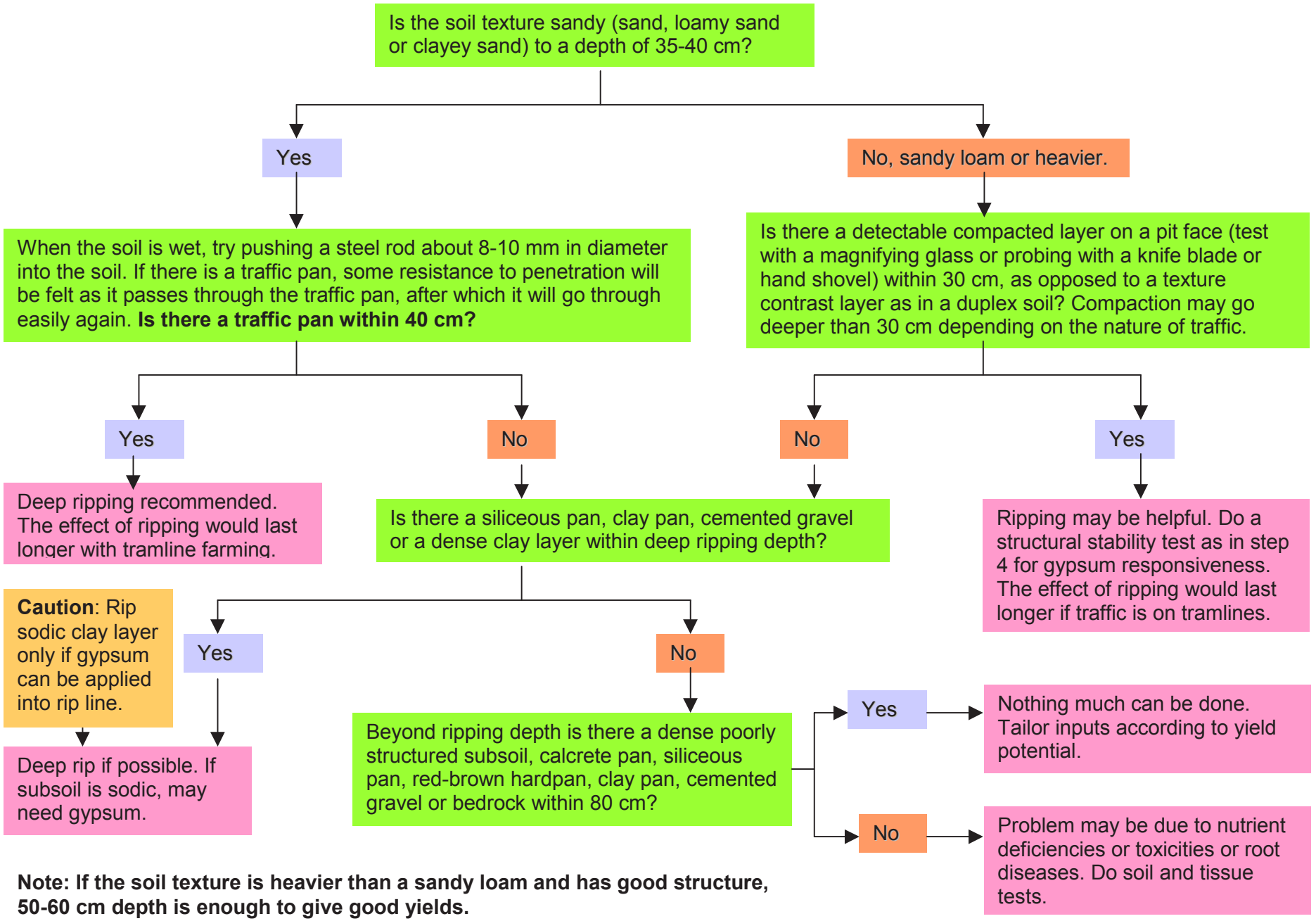
Hardsetting, crusting or surface sealing soils



Note: Refer to Appendix 2 for details of test for dispersion and slaking, as well as, management options for slaking and/or dispersing soils.

Step 5

Traffic pans, hardpans and other restrictions to root growth



Note: If the soil texture is heavier than a sandy loam and has good structure, 50-60 cm depth is enough to give good yields.

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GLOSSARY

ICV economic analysis tool: Invest (in amelioration) Cull (from cropping) or Vary (inputs) economic analysis tool developed by Graeme McConnell, Planfarm Pty Ltd, 4 Clive Street, West Perth, WA 6005.

LMS: Land Management Society, Western Australia.

pH_w: soil pH measured in water at a soil to solution ratio of 1:5 w/v.

pH_{Ca}: soil pH measured in 0.01M calcium chloride at a soil to solution ratio of 1:5.

$EC_{(1:5)}$: electrical conductivity measured in water at a soil to solution ratio of 1:5 w/v, which is a measure of salinity.

dS/m: deciSiemens per metre – standard unit of measuring electrical conductivity.

mS/m: milliSeimens per metre – unit of measuring EC (used commonly in WA). 1 dS/m = 100 mS/m.

ESP: Exchangeable Sodium Percentage-exchangeable sodium fraction expressed as a percentage of cation exchange capacity.

Gilgais: depressions and mounds formed on soil surface due to shrink swell (cracking) clays.

Tramline farming: also called controlled traffic farming, a crop production system where machinery wheel tracks are confined to defined tramlines to reduce soil compaction in other areas by matching equipment widths.

Appendix 1

SOIL FIELD TEXTURE CARD

PROCEDURE FOR FIELD TEXTURING SOILS

The texture of a soil reflects the size distribution of mineral particles finer than 2 mm If it is gravelly, remove the gravel.

1 Take a sample of soil that will sit comfortably in the palm of your hand from the layer of soil to be textured.

2 Form a *bolus* of soil by moistening the sample with water and kneading it. Knead the soil for 1-2 minutes while adding more water or soil until it just fails to stick to the fingers. The soil is now ready for shearing (ribboning). Note how the bolus feels when kneading it.

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

The behaviour of the bolus and of the ribbon determines the field texture. Do not determine the texture grade solely on the length of the ribbon.

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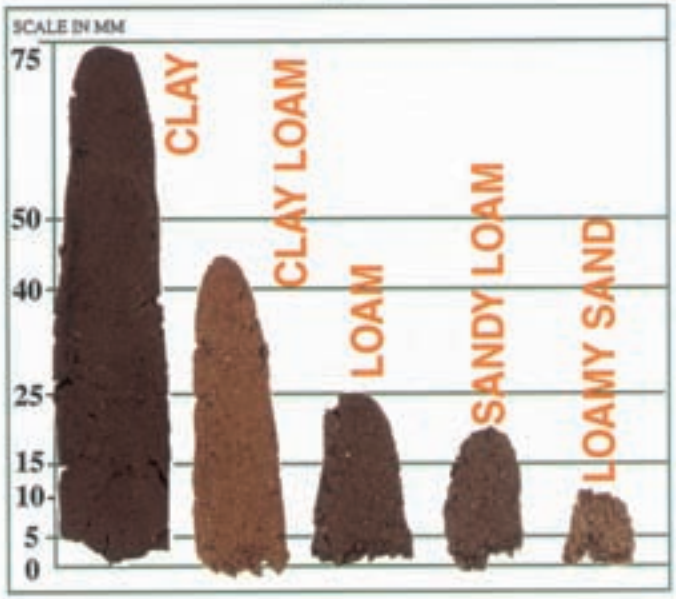
TOPCROP AUSTRALIA



SCALE IN MM

CLAY	Plastic bolus like putty, smooth to touch, becomes stiffer as clay content increases, forms ribbon of 50–75 mm or more.
CLAY LOAM	Coherent plastic bolus, smooth to manipulate, forms ribbon of 40–50 mm.
SANDY CLAY LOAM	Strongly coherent ball, feels sandy, forms ribbon of 25–40 mm.
LOAM	Feels smooth & spongy, forms ribbon of about 25 mm.
SANDY LOAM	Coherent ball, feels sandy. Minimal ribbon 15–25mm. Sand grains visible.
CLAYEY SAND	Clay stain on fingers, very slightly coherent ball, minimal ribbon 5–15 mm.
LOAMY SAND	Very slightly coherent ball, minimal ribbon about 5 mm.
SAND	Cannot form a ball. Non coherent.

Appendix 2

Soil Structure Test

Structural stability in soils with clay contents greater than a loamy sand or a clayey sand can be evaluated by the following tests for **dispersion** and **slaking**.

Slaking:

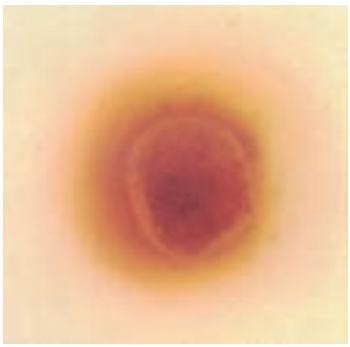
- Slaking is the disintegration of dry soil aggregates into tiny pieces when wet rapidly.
- Slaking causes the soil to slump and then it sets hard into a compact mass on drying in most slaking soils.

Dispersion:

- Dispersion is the breakdown of soil aggregates into individual mineral particles – sand, silt and clay.
- When dispersion occurs, clay particles get suspended in water making it cloudy or muddy.
- Dispersion causes surface sealing or crusting or hardsetting, which reduces water infiltration and increases run-off, leading to erosion.

Test for slaking: Take a small piece of a **dry** soil clod about 1 cm in size and drop it gently in to a glass of *distilled* or *rain water* (**rain water from concrete tanks not suitable**). The clod will disintegrate into tiny pieces with air bubbles escaping. If it slakes, it will happen within a few minutes.

Test for dispersion: Leave the sample from slaking test undisturbed for 24 hours to see whether the soil disperses without remoulding (highly dispersive). For soils that need an input of energy for dispersion, such as the impact of rain drops or cultivation or stock trampling; take a handful of pulverised soil (after removing gravel), moisten it with *distilled* or *rain water* and mix it and knead it thoroughly for 4–5 minutes with the fingers while adding more water if required. Make a small ball about 8–10 mm in size, drop it into a clear glass of distilled or rain water and leave it for 24 hours. If the soil is dispersive the water around the soil will be cloudy or muddy. If not, it will be clear or settled to the bottom.



Dispersing soil

Slaking soil

Gypsum responsiveness

Soil properties	Response to gypsum	Management options
Highly dispersive (disperses without remoulding)	+ + +	Apply 2.5–5 t/ha gypsum (generally higher the pH or sodicity, higher the gypsum requirement). Adopt no-till with stubble retention. Remove stock during wet periods.
Dispersive (disperses after remoulding)	+ +	Apply 2.5–5 t/ha gypsum. Adopt no-till with stubble retention. Remove stock during wet periods.
Slaking	?	Do test strips. May or may not respond to gypsum. Increase organic matter by no-till and stubble retention. Remove stock during wet periods.
Slaking and dispersing	++?	Do test strips. Response to gypsum is variable. Increase organic matter by no-till and stubble retention. Remove stock during wet periods.

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An electronic version of this booklet can be found at: www.agric.wa.gov.au

The web version of this booklet has quick links to the ICV economic analysis tool, tramline farming, relevant Farmnotes and photos of some problem soils

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