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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

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DIAGNOSING AND AMELIORATING PROBLEM SOILS
(Decision Tree on How to Diagnose and Ameliorate Problem Soils)

Second edition, August 2005

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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

1. Is the texture of the soil sandy throughout the profile?
   - Yes: Go to step 1
   - No

2. Is the topsoil non-wetting (a drop of water takes >10 seconds to be absorbed by the soil)?
   - Yes: Go to step 1
   - No

3. Does the soil get waterlogged (water within 30 cm of surface and crop leaves yellowing)?
   - Yes: Go to step 2
   - No

4. 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

5. Is the soil crusting, hardsetting, surface sealing or cracking?
   - Yes: Go to step 4
   - No

6. 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.
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.)

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.

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)?

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

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

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)?

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

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.
Does the soil get waterlogged to affect crop yields (water within 30 cm of the surface and the crop leaves turning yellow)?

Yes → Is there a drainage outlet or opportunity to drain the land?

No → Go to step 3

Yes → Drainage is not possible. Try to prevent water coming onto the land by intercepting the water upslope with earthworks and redirecting it into farm dams.

No → Is the land saline [EC_{(1.5 \text{ water})} more than 0.6-0.8 \text{ dS/m (60-80 mS/m)}]?

Yes → There is no significant benefit from raised beds as the soil is too saline. Explore salinity management options.

No → Raised beds can be beneficial with improved drainage.

Is there a clay layer within 15 cm of the surface?

No → There is no significant benefit from raised beds unless 5 t/ha (or more) gypsum is incorporated.

Yes → Is the clay layer very dense, dispersive and/or is the pH_{w} > 8.5?

Yes → Raised beds with proper drainage can be beneficial.

No → Refer to dispersion test in step 4 (see Appendix 2 for details).
Soil pH (Acidic or Sodic Soils)

Step 3

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
- 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
- Yes

Does the clay content increase with depth to a sandy loam or a loam within 30-40 cm?
- No
- Yes

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)?

- **Yes**
  - When the soil is completely dry, are there surface cracks more than 10 mm wide?
    - **Yes**
      - Is the soil self-mulching (i.e. breaks into crumbs or small peds/structural units)?
        - **Yes**
          - 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.
        - **No**
          - 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.
    - **No**
      - Go to step 5
- **No**
  - Go to step 4b
Does the soil set hard or form a surface seal or a surface crust on drying?

Yes

No

Does the soil disperse, slake or slake and disperse (see note at bottom of page on test for dispersion and/or slaking)?

Disperses

Slakes and disperses

Will respond to gypsum. Ripping may cause trafficability problems unless gypsum can be slotted into rip lines. The effect of ripping may not last if gypsum is only applied to surface. May need to apply Cu, Zn & Mn and more P than in other areas. If applying gypsum, add more N than normal. Boron toxicity may be a problem in some alkaline soils. If boron-toxic, grow tolerant crops and varieties.

Slakes

May or may not respond to gypsum. Do test strips. Increasing organic matter by no-till crop establishment and stubble retention is recommended.

Note: Refer to Appendix 2 for details of test for dispersion and slaking, as well as, management options for slaking and/or dispersing soils.
Traffic pans, hardpans and other restrictions to root growth

Is the soil texture sandy (sand, loamy sand or clayey sand) to a depth of 35-40 cm?

- Yes
  - When the soil is wet, try pushing a steel rod about 8-10 mm in diameter into the soil. If there is a traffic pan, some resistance to penetration will be felt as it passes through the traffic pan, after which it will go through easily again. **Is there a traffic pan within 40 cm?**
    - Yes
      - Deep ripping recommended. The effect of ripping would last longer with tramline farming.
      - **Caution:** Rip sodic clay layer only if gypsum can be applied into rip line.
    - No
  - No, sandy loam or heavier.

- No
  - Is there a detectable compacted layer on a pit face (test with a magnifying glass or probing with a knife blade or hand shovel) within 30 cm, as opposed to a texture contrast layer as in a duplex soil? Compaction may go deeper than 30 cm depending on the nature of traffic. **Is there a detectable compacted layer on a pit face (test with a magnifying glass or probing with a knife blade or hand shovel) within 30 cm, as opposed to a texture contrast layer as in a duplex soil? Compaction may go deeper than 30 cm depending on the nature of traffic.**
    - Yes
      - Ripping may be helpful. Do a structural stability test as in step 4 for gypsum responsiveness. The effect of ripping would last longer if traffic is on tramlines.
    - No

Beyond ripping depth is there a dense poorly structured subsoil, calcrete pan, siliceous pan, red-brown hardpan, clay pan, cemented gravel or bedrock within 80 cm?

- Yes
  - Nothing much can be done. Tailor inputs according to yield potential.
- No

Is there a detectable compacted layer on a pit face (test with a magnifying glass or probing with a knife blade or hand shovel) within 30 cm, as opposed to a texture contrast layer as in a duplex soil? Compaction may go deeper than 30 cm depending on the nature of traffic.

- Yes
  - Ripping may be helpful. Do a structural stability test as in step 4 for gypsum responsiveness. The effect of ripping would last longer if traffic is on tramlines.
- No

Deep rip if possible. If subsoil is sodic, may need gypsum.

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: milliSiemens 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.
SOIL FIELD TEXTURE CARD

PROCEDURE FOR FIELD TEXTURING SOILS

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.

<table>
<thead>
<tr>
<th>Texture Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLAY</td>
<td>Plastic bolus like putty, smooth to touch, becomes stiffer as clay content increases, forms ribbon of 50–75 mm or more.</td>
</tr>
<tr>
<td>CLAY LOAM</td>
<td>Coherent plastic bolus, smooth to manipulate, forms ribbon of 40–50 mm.</td>
</tr>
<tr>
<td>SANDY CLAY LOAM</td>
<td>Strongly coherent ball, feels sandy, forms ribbon of 25–40 mm.</td>
</tr>
<tr>
<td>LOAM</td>
<td>Feels smooth &amp; spongy, forms ribbon of about 25 mm.</td>
</tr>
<tr>
<td>CLAYEY SAND</td>
<td>Clay sticks in fingers, very slightly coherent ball, minimal ribbon 5–15 mm.</td>
</tr>
<tr>
<td>LOAMY SAND</td>
<td>Very slightly coherent ball, minimal ribbon about 5 mm.</td>
</tr>
<tr>
<td>SAND</td>
<td>Cannot form a ball. Non-coherent.</td>
</tr>
</tbody>
</table>
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 set into a compact mass on drying in most soils.

**Dispersion:**
- Dispersion is the breakdown of soil aggregates into individual mineral particles – sand, silt, and clay.
- Dispersion causes the soil to become cloudy or muddy when wet rapidly.

*Test for slaking:* Take a small piece of a dry soil clod about 1 cm in size and drop it gently into a glass of distilled or rain water. 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 raindrops or cultivation or stock trampling; take a handful of pulverized soil (after removing gravels), moisten it with distilled or rain water and mix it and knead it thoroughly for 4-5 minutes. The soil will then disperse (generally higher the pH or sodicity, higher the gypsum requirement). If the soil disperses without remoulding (highly dispersive) and is suitable for test strips, then test for gypsum responsiveness as follows:

<table>
<thead>
<tr>
<th>gypsum responsiveness</th>
<th>soil properties</th>
<th>management options</th>
</tr>
</thead>
<tbody>
<tr>
<td>highly dispersive (disperses without remoulding)</td>
<td>+ +</td>
<td>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.</td>
</tr>
<tr>
<td>dispersive (disperses after remoulding)</td>
<td>+ +</td>
<td>Apply 2.5-5 t/ha gypsum. Adopt no-till with stubble retention. Remove stock during wet periods.</td>
</tr>
<tr>
<td>slaking ?</td>
<td>+</td>
<td>Do test strips. May or may not respond to gypsum. Increase organic matter by no-till and stubble retention. Remove stock during wet periods.</td>
</tr>
<tr>
<td>slaking and dispersing ++?</td>
<td>++</td>
<td>Do test strips. May or may not respond to gypsum. Increase organic matter by no-till and stubble retention. Remove stock during wet periods.</td>
</tr>
</tbody>
</table>

**Soil Structure Test**

Appendix 2
CONTACT INFORMATION

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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