# Diagnosing water repellence and pH constraints in sandy soils

## TAKEAWAYS

- **It is worthwhile identifying where and how severe water repellence and pH constraints exist across your paddocks.**
- **Paddock diagnostic zones can be determined using readily accessible imagery and/or production data and field-based testing processes are relatively simple.**
- **Diagnosis is the first critical step in predicting the crop response to, and the economic value of, available treatment options to combat constraints.**

## HOW WELL UNDERSTOOD ARE SANDY SOIL CONSTRAINTS?

It is well known that there are multiple soil constraints within sandy soils that contribute to yield loss across the Eyre Peninsula, Murray Mallee and Southeast South Australia. Physical and chemical constraints rarely occur in isolation and together restrict root growth and crop water use efficiency.

The extent and severity of constraints varies across sandy dune swale landscapes and there is substantial value in the use of zone-based diagnosis to identify:

- **WHERE DO THE CONSTRAINTS EXIST ACROSS THE PADDOCK?** How do constraints differ in paddocks between the dunes, mid-slopes and flats?

- **HOW DEEP ARE THE LAYERS AFFECTED BY CONSTRAINTS?** At what depths do the different constraints start and stop?

- **HOW SEVERE IS THE CONSTRAINT?** Is the constraint mild, moderate or severely production limiting?

There are a range of strategies that can be implemented to combat constraints. These range in effectiveness, longevity, and cost, so field-based diagnosis is the first step to effectively determine the economic value of the treatment options available.

## KNOW YOUR CONSTRAINTS

Two common physical and chemical constraints encountered in sandy soils are:

- water repellence and,
- subsurface acidity and alkalinity (pH) - the severity is often layer dependent.

**Water repellence**

Water repellence forms when waxes from decayed organic material (e.g. stubbles) coat grains of soil, making them repel water (Figure 1), which inhibits water entry into the soil profile. This leads to patchy crop establishment and a staggered germination of weeds, reducing yield potential at the start of the season.

Photo: Bill Davoren, CSIRO

**Figure 1. Repellent sand grains inhibiting water droplet infiltration.**

**pH**

pH is a measure of the concentration of hydrogen (H+) and hydroxyl (OH-) ions in a soil solution and indicates that a soil is acidic (low pH), neutral or alkaline (high pH).

pH variation through the soil profile can occur. It's important to understand this variation as nutrient availability and crop type tolerance can be affected, resulting in potential plant deficiencies or toxicities (Table1).

pH is commonly measured in water (using a 1:5 soil to water solution) or in calcium chloride (soil to $CaCl_2$ solution). Whilst both measures are accurate, pH results measured in water are often 0.5 – 1.0 units higher; remember this when interpreting results between years or from different labs.

Photo: Chris Davey, YP Ag.


**Figure 3. Paddock pH indicator testing, The ideal range is between 6.5 and 7.5. Acid layers** will show as bright green or yellow colours. **Alkaline layers** will be deep purple.

**Table 1. Potential impacts of low and high pH.**

| ACIDITY | ALKALINITY |
|---|---|
| • Toxic amounts of aluminium can be released into the soil solution, stunting root growth and limiting nutrient availability (particularly phosphorous), along with changes in microbial activity.<br>• Current farming practices promote the development of discrete bands of acidity in the soil, commonly between 5 and 15 cm.<br>• Lentils, beans and barley are more sensitive to acidity than wheat. | • Carbonate and bicarbonates of calcium and/or sodium accumulation can impact phosphorus and trace element availability.<br>• Excessive presence can cause plant toxicity.<br>• Often co-occurs with other constraints including sodicity, salinity and/or boron toxicity. |

## HOW TO TEST

**Establish paddock diagnostic zones**

Paddock diagnostic zones can be determined using:

- **AERIAL IMAGERY** in Google Earth Pro can provide an indication of soil type and zone differences, such as dunes and swales. Utilise 'historical imagery' to inspect changes over time.
- **SOIL PROXIMAL SENSORS** such as electromagnetic induction (EMI) can identify changes in soil properties, which are often strongly correlated to paddock productivity. Analysis after collection is required to confirm the cause of variation (i.e. soil type, moisture content, salts). Learn more on precision soil mapping at SPAA.
- **PLANT PRODUCTION MEASURES** such as normalised difference vegetation index (NDVI) and/or grain yield and protein maps can identify production zone boundaries. Access free and current NDVI imagery at IrriSAT.

**Paddock Testing**

Once the diagnostic zones are established (usually three to five in each paddock), there are some easy paddock testing options available to test for pH and repellence (Table 2). The best time to conduct these tests is in late summer or early autumn when the soil is dry.

**Table 2. Preparation and testing procedures to determine water repellence and pH.** The soil must be dry to accurately test for repellence; late summer to early autumn is ideal.

| | WATER REPELLENCE | pH |
|---|---|---|
| **EQUIPMENT** | • Medicine/eye dropper (chemist)<br>• Deionised water or rainwater<br>• Sample bags and buckets | • Shovel/ post-hole digger<br>• pH indicator dye and powder (Soil pH kit)<br>• Tape measure |
| **PREPARATION** | • Carefully scrape off all organic matter and the top 2-3mm of the topsoil layer at each diagnostic zone testing site.<br>• The area should be free of standing stubble (i.e., in the interrow), weeds and plant roots. | • Dig 3-5 holes to 40cm within each diagnostic zone to create a vertical soil profile face. |
| **TESTING** | **SURFACE TESTING**<br>• Using an eye dropper, place three similar sized large droplets on the surface, dropped from the same height.<br>• Record the time it takes to infiltrate to determine repellence (see: Ranking Results).<br>• Repeat three times at each diagnostic site.<br>• Consider repeating this at different depths in the soil (i.e., at the depth of sowing).<br><br>**TESTING 0-10CM TEST – A COMPOSITE**<br>• Collect multiple samples from:<br>    • 0 - 5cm of soil – place in bucket #1<br>    • 5 - 10cm of soil – place in bucket #2<br>• Mix each bucket thoroughly and place in labelled sample bags.<br>• Place the soil in a tray and allow to air dry.<br>• Once dry, use the eye dropper to repeat the surface testing process and record the infiltration times. | • Apply pH indicator dye according to kit instructions onto the soil surface; apply the powder and let the colour develop.<br>• Once the colour reaction is complete, use the diagnostic indicator card to determine the pH.<br>• You can also use a dig stick soil probe, removing an intact soil core and apply the same procedure to assess the pH change.<br>• With a tape measure, identify the position of any pH changes and acid layers.<br>• Take a photograph with your phone and mark the location by dropping a pin in maps. |

**More precise testing**

If water repellence and acidity is present within diagnostic zones and considered severe (Sandbox rating 2) following paddock tests, additional soil sampling and accurate laboratory pH measurement are recommended.

**Water repellence:** follow the instructions above for collecting composite samples for the 0-5 and 5-10 cm layers, placing samples in labelled bags. Send to a laboratory (no need to dry first), requesting the molarity of ethanol drop test (MED). Use the interpretation criteria in Table 3 to assign a severity ranking.

**Acidity:** the collection of soil samples for laboratory testing will depend on the position of the acid layer; 0-5, 5-10 and 10-20 cm depths are commonly recommended, although 0-5, 5-15 and 15-25 cm may be more appropriate. Collect multiple samples from within each zone, combining the appropriate layer depths in a clean and labelled bucket. Thoroughly mix the composite samples and retain 250g to send to a laboratory, requesting pH (calcium chloride), organic carbon and soil texture assessments. This information will help you identify the best lime rate to treat the problem. If your soils contain aluminium, you might also request a test for this (silver grass, sorrel and annual ryegrass are all indicators of acidity and aluminium in soils – look out for these too).

## RANKING RESULTS

Use the diagnostic criteria in Tables 3 and 4 to assess the severity of each constraint and assign a Sandbox Rank for each paddock zone. You can use this information to find experimental results for sites with a similar constraint profile in SandBox/OFT, the online platform that houses results from the GRDC Sandy Soils Research Project (CSP00203).

**Table 3. Severity of water repellence** based on the time of water infiltration (a) and the lab-based assessment using the Molarity of Ethanol drop test MED (b).

| Sandbox Rank | Severity | (a) Water droplet infiltration time | (b) MED |
|---|---|---|---|
| 0 | Non-repellent | Water infiltrates dry soil in 5 seconds or less | 0 |
| 0 | Mild | Takes > 5 seconds but <60 seconds to infiltrate | 0.2 -1 |
| 1 | Moderate | Takes 60 to 240 seconds to infiltrate | 1.2 – 2.2 |
| 2 | Severe | Takes more than 4 minutes to infiltrate | 2.4 – 3.0<br>3.2>3.8 very severe |

**Table 4**. **Severity of acidity and alkalinity**, as determined using pH indicator dye and a colour chart, which is roughly equivalent to the pH in water (a) and measured in a 1:5 solution of calcium chloride at the lab (b).

| | Sandbox Rank | Severity | (a) pH indicator kit | (b) pH CaCl |
|---|---|---|---|---|
| ALKALINITY | 2 | Severe | >9.0 | >8 |
| | 1 | Moderate | 8.5 | 7.5 |
| | 0 | Mild | 8 | 7.0 |
| | 0 | Neutral-Ideal | 7.0 | 6.5 |
| ACIDITY | 0 | Mild | 6.5 | 6.0 |
| | 1 | Moderate | 6.0 | 5.5 |
| | 2 | Severe | <5.5 | <4.8 |

### USEFUL RESOURCES

For further information on how to test and treat water repellence refer to the ***Soil Quality: 7 Soil Water Repellence*** ebook: https://books.apple.com/au/book/soil-quality-7-soil-water-repellence/id1610874097

For further information on testing procedures for acidity and result interpretation visit **www.acidsoilssa.com.au**

**Physical Soil Constraints Fact Sheet**
https://grdc.com.au/resources-and-publications/all-publications/factsheets/2022/physical-soil-constraints-fact-sheet

**Diagnosing High Soil Strength Fact Sheet**
www.for ag comms to make.com.au

**Diagnosing Sandy Soil Nutritional Constraints Fact Sheet**
www. For ag comms to makex2.com.au