DIAGNOSING SANDY SOIL CONSTRAINTS: WATER REPELLENCE AND PH EXTREMES

FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

SOUTHERN AND WESTERN REGIONS

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Measuring constraints on sands to inform management

Photo: Bill Davoren, CSIRO.

Figure 1. Repellent sand grains inhibiting water droplet infiltration.

KEY POINTS

- Diagnosis of soil constraints is the first critical step in predicting crop response and the economic value of management options
- Understanding where and how water repellence and acidity or alkalinity constrain crop performance will help you derive the most cost-effective management practices
- Constraint zones within a paddock can be determined relatively easily using readily accessible imagery and production data and field-based testing processes

Multiple soil constraints commonly occur on sandy soils across the southern region, especially in the low rainfall zone. 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 paddocks (especially among 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 and across the landscape.
- **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 limiting production?

There are a range of strategies that can be implemented to combat constraints, which vary in effectiveness, longevity, and cost. Field-based diagnosis is the first step to effectively determine the likely economic value of the management practices available.

Know your constraints

Two common constraints encountered in sandy soils are:

- water repellence; and
- subsurface acidity (low pH) or alkalinity (high pH).

Water repellence

Water repellence forms when waxes from decayed organic material (for example stubbles) coat grains of soil, making them repel water (Figure 1), which inhibits water entry into the soil, and promotes run off. Compared to loams or clays, sands are more prone to repellence because the soil particles are larger with a smaller surface area. This leads to patchy crop establishment and a staggered germination of weeds, reducing yield potential at the start of the season.

pH extremes

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 is common. It's important to understand this variation as nutrient availability 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).

Photo: Chris Davey, YP Ag

Figure 2. 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 soil pH.

ACIDITY	ALKALINITY
• Toxic amounts of H+ stunts root growth and limits nutrient availability (particularly phosphorous), along with changes in microbial activity • Toxic forms of aluminium can also be released in some acid soils, exacerbating the issues above • Lentils, faba beans and barley are more sensitive to acidity than wheat	• Excessive alkalinity can cause plant toxicity and reduce root growth • Carbonate and bicarbonates of calcium and/or sodium accumulation can impact phosphorus and trace element availability • Often co-occurs with other constraints including sodicity, salinity and/or boron toxicity

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 laboratories.

Excessive acidity (pH<5.5 in calcium chloride) typically occurs in the 5-15cm soil layer which can be corrected with applications of lime. Excessive alkalinity (pH>9.0) typically occurs in the subsoil below 20cm and is more difficult to manage.

How to test

Paddock diagnostic zones

Paddock diagnostic zones can be determined using:

- **AERIAL IMAGERY** in Google Earth Pro can provide an indication of soil type (for example colour) 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. Soil analysis is required to calibrate the EM readings with soil properties and understand the cause of variation (i.e. soil texture, 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 measure repellence and pH within each zone (Table 2). The best time to conduct these tests is in late summer or early autumn when the soil is dry.

More precise analysis

If water repellence and/or acidity is identified within the paddock diagnostic zones and is considered severe (Sandbox Score 2, see below) careful soil sampling and accurate laboratory measurement are recommended before management options are considered – consult your agronomist.

Water repellence: Follow the instructions in Table 2 for collecting composite samples for the 0-5 and 5-10cm 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 score.

Acidity: the collection of soil samples for laboratory testing will depend on the position of the acid layer; 0-5, 5-10 and 10-20cm depths are commonly recommended, although 0-5, 5-15 and 15-25cm are also useful. Traditional 0-10cm sampling used for nutrient analysis may not identify acidity in the 5-15cm layer. 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

TABLE 2. Preparation and testing procedures to determine water repellence and pH. The soil must be dry to accurately test for repellence.

	WATER REPELLENCE	pH
EQUIPMENT	• Shovel • Medicine/eye dropper • Deionised water or rainwater • Sample bags and buckets	• Shovel or dig stick • pH indicator dye and powder (Soil pH kit) • Tape measure
PREPARATION	• Carefully scrape off all organic matter and the top 2-3mm of the topsoil layer at each diagnostic zone testing site • The area should be free of standing stubble (ie in the inter-row), weeds and plant roots	• Dig 3-5 holes to 40cm depth within each diagnostic zone to create a vertical soil profile face.
TESTING	**SURFACE TESTING** • Using an eye dropper, place three similar sized large droplets on the surface, dropped from the same height e.g. 20-30 mm • Record the time each drop takes to infiltrate to determine repellence (see: Score Results below) • Repeat three times at each diagnostic site • Consider repeating this at different depths in the soil (i.e. at the depth of sowing) **TESTING 0-10CM – A COMPOSITE** • Collect multiple samples from: - 0 – 5cm of soil – place in bucket #1 - 5 – 10cm of soil – place in bucket #2 • Mix each bucket thoroughly and place in labelled sample bags • If samples are wet, place the soil in a tray and allow to air dry (for example over 1-2 warm days) • 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 • Once the colour reaction is complete, use the diagnostic indicator card to determine the pH • With a tape measure, identify the position of any pH changes and acid layers • You can also use a dig stick soil probe, removing an intact soil core and apply the same procedure to assess the pH change

pH (calcium chloride), organic carbon and soil texture assessments. This information will help you identify the best lime rate to treat acidity. 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, so look out for these too.

Score results

Use the diagnostic criteria in Tables 3 and 4 to assess the severity of each constraint and assign a 'Sandbox Score' for each paddock zone. You can use this information to find experimental results for sites with a similar constraint profile in the SandBox tool, an online platform that presents results from the GRDC Sandy Soils Research Project (CSP1606-008RMX (CSP00203). Severe constraints need to be addressed as soon as possible, while moderate constraints should be monitored – see useful resources for more information.

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 Score	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 to 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 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 laboratory (b).

	Sandbox Score	Severity	(a) pH indicator kit	(b) pH CaCl2
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**

GRDC fact sheet: ***Diagnosing Sandy Soil Constraints: High Soil Strength* (South-West)** (2022) - grdc.com.au/diagnosing-sandy-soil-constraints-high-soil-strength-south-west

GRDC fact sheet: ***Diagnosing Sandy Soil Constraints: Nutrition* (South-West)** (2022) - grdc.com.au/diagnosing-sandy-soil-constraints-nutrition-south-west

GRDC fact sheet: ***Soil acidification Fact Sheet*** (2021) grdc.com.au/soil-acidification-fact-sheet

GRDC fact sheet: ***Soil wetter* (National)** (2022) grdc.com.au/soil-wetter-national

GRDC fact sheet: ***Seeding Sandy Soils* (National)** (2022) grdc.com.au/seeding-sandy-soils-national

GRDC Update Paper (2022) – ***Strategies to close the yield gap on three water repellent sandy soils in South Australia*** - grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/07/strategies-to-close-the-yield-gap-on-three-water-repellent-sandy-soils-in-south-australia

GRDC Update Paper (2022) ***Nutrition management on ameliorated sands*** grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/08/nutrition-management-on-ameliorated-sands

MORE INFORMATION

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