FACT SHEET

UNDERSTANDING SUBSOIL CONSTRAINTS
in low rainfall cropping areas of South Australia

KEY POINTS

- Physical and chemical subsoil constraints are common in lower rainfall cropping soils in SA
- Tests are available to detect many of these issues
- Selection of improved genetics is available for some constraints and further work is still required

Low rainfall cropping soils across South Australia have large areas where soils contain subsoil constraints to production. They can be physical limitation or chemical toxicities or imbalances which can reduce the ability of roots to grow and extract moisture. Subsoil constraints are often seen in late winter or early spring when roots are growing deeper into soils to chase moisture.

As part of the Agricultural Bureau SA project funded through the Future Drought Fund several sites which were tested highlighted where subsoil constraints were evident. This fact sheet describes these constraints, outlines if tests are available, shows examples and briefly mentions management options. Some of the information provided in this fact sheet was sourced from Hughes and Woodard (2021) and Harding and Hughes (2023) references.

Types of constraints and tests available

Subsoil constraints can be either physical or chemical and can have a significant impact on soil water storage and use, nutrient regimes and crop growth and yield. Some of the more common constraints are outlined in *Table 1 & 2*. Soil data collected through the Agricultural Bureau of SA Inc project through funding from the Australian Government's Future Drought Fund program. Acknowledgement is given to the contributing farmers in the Lowbank, Wunkar and Point Pass/ Robertstown branches.

Table 1. Soil physical constraints

Soil Physical Constraints		
Stones / gravel	Throughout profile	Stones or gravel can occur in bands throughout the soil profile can take up the volume of the soil that reduces the available water holding (AWHC) capacity of the soil and impede root growth.
Rubbly broken calcrete	20-60 cm	Rubbly broken calcrete takes up the volume of the soil and reduces AWHC and soil fertility. Root growth is moderate throughout the calcrete layers. Observe from digging holes and pits.
Laminar impermeable calcrete	20-100 cm	Difficult for plant roots to penetrate apart from the cracks and holes. Can severely restrict plant available water when close to the surface. Observe when digging -hard to penetrate with a shovel.
Hard pan / high soil strength	15-50 cm	Some soils can physically have a high bulk density (>1.5 g/cm3) that impedes root growth and decreases oxygen and water movement in the soil. This is common in sandy soils in lower rainfall cropping areas where soil are inherently at risk to compaction and often develop a weakly compacted A2 layer (hardpan) resulting in poor growth. Root growth is reduced when the penetration resistance is greater than 2.5 MPa. Test with a penetrometer when soil is wet. Deep ripping or other soil modification techniques can reduce soil strength.

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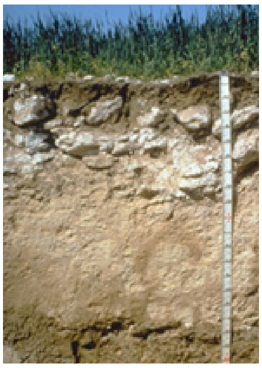
Table 2. Soil chemical constraints in subsoil

Chemical Constraints		
High free lime (carbonates)	Throughout profile or in subsoil layers	Calcium carbonate can occur throughout the profile (calcareous) soils or in other soils can be concentrated in the subsoil layers. High carbonate levels (greater than 8%) can increase soil pH and reduce the availability of phosphorus, zinc, manganese and copper. Test by 1-2 drops of hydrochloric acid and observe the reaction. The strength of the effervescence will determine the amount of free lime present.
Toxic layers – salt, boron, high pH	20-100 cm	Salt and boron occur where fine lime accumulates in the sub-soil. These become limiting to plant growth when ECe (salt) is greater than 5 dS/m or boron >15 mg/kg occurs. Laboratory soil tests are required to determine these limitations- ensure samples tested by depth down profile to see where issues come in. Considerable tolerance to boron and subsoil salt has been bred into SA wheat and other crop varieties.
High aluminium in alkaline layers	40-100 cm	High aluminium can occur in high alkaline layers affecting plant growth.When aluminate Al(OH)4- is greater than 0.8 mg/L and pH (water) is greater than 9.0. Research is still determining the impact of this issue and commercial testing availability poor.
Extreme alkalinity	10-60 cm	Extreme alkalinity is associated with various nutrient imbalances and often poor root growth. pHwater levels of greater than 9.2 are used a rough guide when extreme alkalinity maybe impact root growth. This can occur in combination with other issues such as high Exchangeable Sodium % (ESP >6-15 %). Some initial screening of tolerance has been undertaken to these issues by SARDI and University of Adelaide plant breeders.
Hard shallow sodic clays	10-30 cm	Hard sodic clays are encountered in some soils and restrict root growth and can lead to short term water-logging. While work in the wetter areas has shown good responses to adding organic amendments to these clays this has yet to be demonstrated in lower rainfall cropping areas

Subsoil examples, many observed in the ABSA drought project



Stones and broken calcrete

- roots often grow through broken calcrete but the rock fragments can reduce the water holding capacity of the soil.

Laminar Calcrete

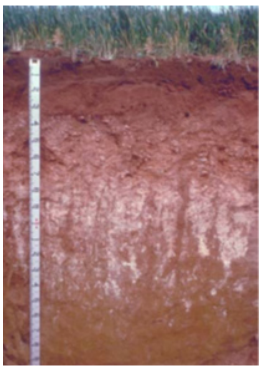
- more difficult for roots to penetrate, some farmers are using rock crushers, observed in several profiles near Robertstown, Wunkar and Yumali and impacts on the surface.

Hard pan

– common on whiter sandy soils, poor root growth and high bulk density – *note Northern Mallee sands often contain more clay than this one.* Below: response to deep ripping on white sand near Yumali.

Shallow topsoil over sodic clay over lime

- Observed in places around Robertstown to Point Pass- if the clay structure could be improved root growth may increase.



Boron Toxicity and Subsoil Salt

- often occurs at depth in calcareous loamy soils particularly when underlayed by an impermeable clay as per this example. At Wunkar and Lowbank eight sites had subsoil salinity issues with EC1:5 > 4 mS/m. Two sites had high levels of Boron (>15mg/kg) and the potential for B toxicity. High salinity and Boron can appear around 40-70cm in this type of profile. Extreme alkalinity (pHw>9.2) can often be associated with these layers as well. Photo *(left)* shows classic Boron toxicity symptoms in a strip of barley sown in a wheat trial.

Harding, A and Hughes, B (2023) Subsoil Constraints in the NY Landscape Board. NYLB fact sheet Hughes, B and Woodard, D (2021) The potential to increase the crop productivity by treating hostile subsoils, GRDC regional update proceedings. Yorketown July 2021.

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