
Photo: Evan Collis, GRDC

Sandy soils: an issue of size

Key facts

- Sandy soils represent about 30% of cropping soils across south-eastern Australia.
- Soils with a high sand content (and low clay content) are inherently low in fertility and their ability to store moisture.
- Management practices that boost the water-holding capacity of sandy soils will have a significant impact on crop water use efficiency (WUE) and subsequent crop and pasture productivity.

The size of the soil particle drives many of the issues associated with sands; either directly or indirectly. Sandy soils are characterised by a dominance of large, coarse particles and a low clay content (<5%).

Coarse-textured soils represent about 30% of cropping soils across the low-rainfall cropping regions of south-eastern Australia.

A typically-low clay content reduces the ability of sandy soils to physically protect organic matter (OM), resulting in its rapid decomposition and associated release of high rates of carbon (C) into the atmosphere as caron dioxide (CO_2), rather than being sequestered in the soil. This process is exacerbated by the low nutritional status of sandy soils.

Most of the challenges associated with agricultural production on sandy soils are linked to their inability to capture and store moisture. Improving the water-holding capacity of sandy soils will have associated benefits for agricultural production, including better water-use efficiency (WUE).

Water-holding capacity

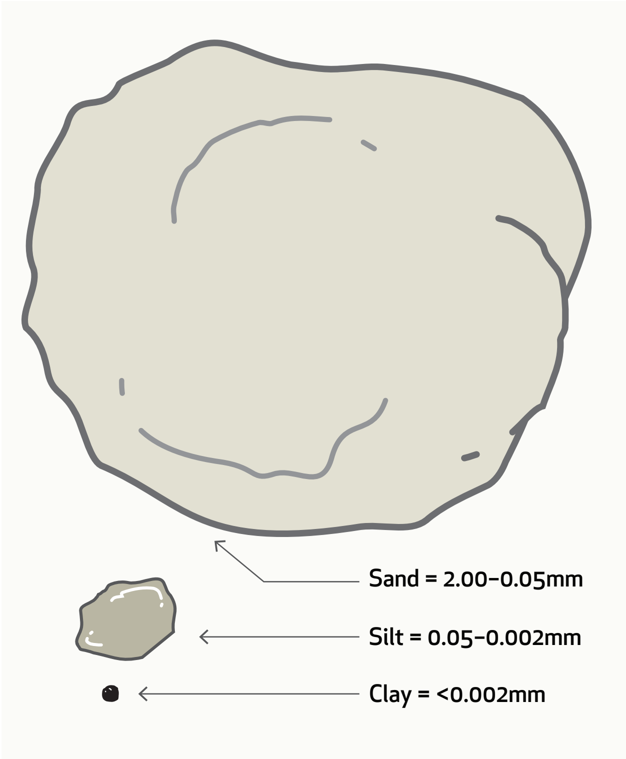
The water-holding capacity of a soil is directly related to the ratio of surface area to volume. While the surface area per grain of sand is large compared with clay, the surface area to volume ratio is far higher for clay (Figure 2).

As a result clays are better able to store rainfall as it soaks through the soil layers, while water rapidly passes through coarse-textured sands. Infiltration and drainage rates of >200mm per hour have been recorded for Mallee sands, which is at least double the rates for heavier-textured swale soils. A simulated rainfall event, equivalent to 125mm, on a Mallee sand showed that applied water had moved to a depth of 2m over four days and all of this moisture had drained below 2m after one week.

The actual speed at which water moves through the soil profile is directly related to the proportion of sand, silt and clay particles (known as soil texture). Consequently, crops in finer-textured soils (soils with a high clay content), which can capture and store water easily, do not need to root as deeply as those on coarse-textured soils (soils with a high proportion of sand) to access the same amount of water.

As a result, the opportunity to capture and store rainfall throughout the year on sandy soils is far lower than finer-

Figure 2. A comparison of sand, silt and clay particles



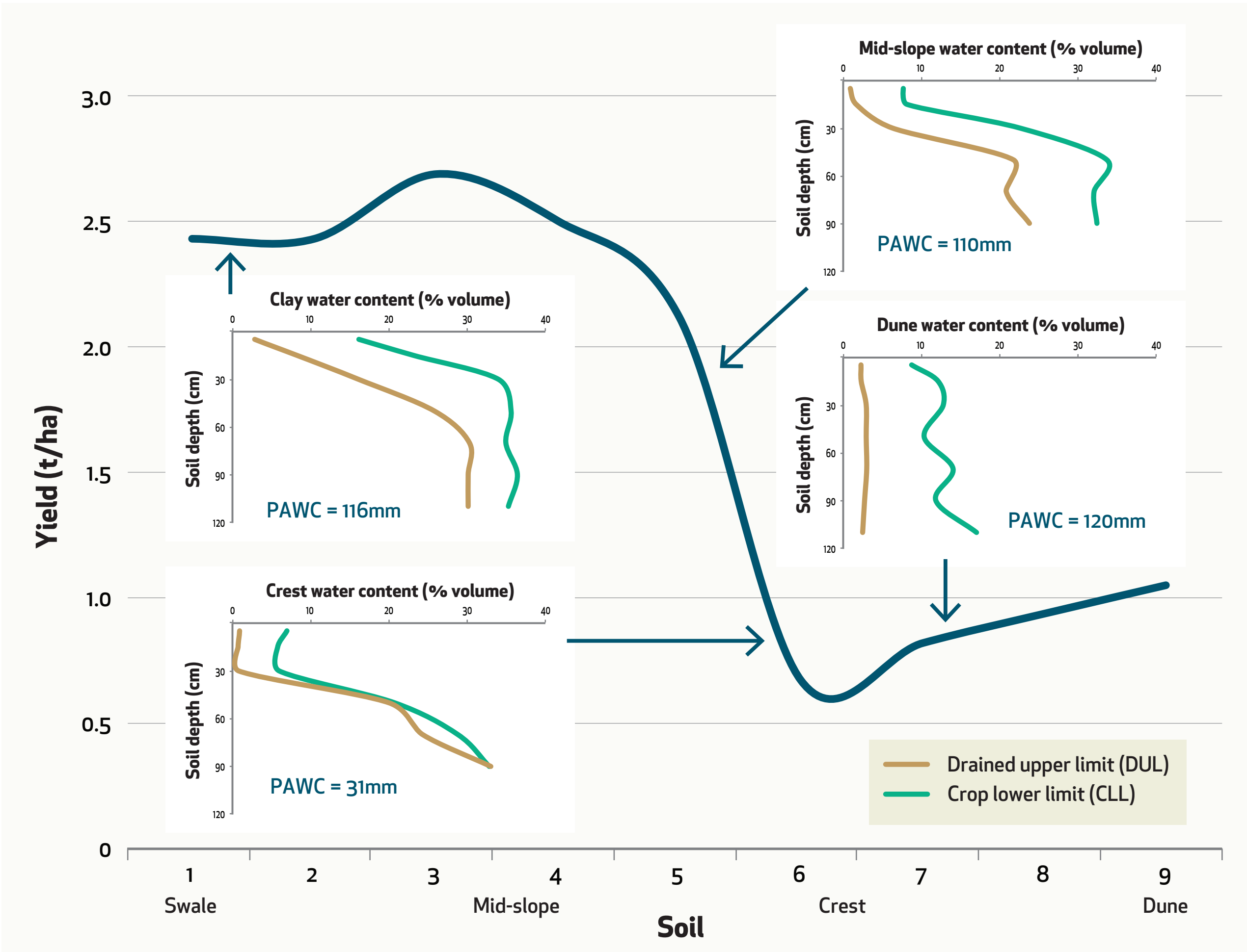
textured clay-based soils. For crops to reach their water-limited yield potential on sandy soils they require regular rainfall throughout the growing season.

Compounding the challenge of their inherently-low water-holding capacity is a bleached layer, which often occurs at variable depths within the profile of many sandy soils, restricting the roots of plants to penetrate and access moisture and nutrients at depth, further limiting the potential crop yield.

Mallee Sustainable Farming Project (MSF) data revealed that water extraction on a sandy rise was restricted to approximately 45cm at Karoonda, South Australia, whereas water extraction continued to at least 1m on the adjacent mid-slope and swale (which contained a higher proportion of clay). As a result, the potential plant-available water capacity (PAWC) for crops grown on the crest of the sandy rise was only 31mm compared with 116mm in the lower-lying swale (Figure 3). In a large rainfall event, the crest of the sand dune simply cannot store as much as the mid-slope or the swale for future crop growth.

However, in the absence of a bleached subsoil layer, crops growing on sandy soils can develop roots at depth, where they can extract moisture deeper in the profile. Crops on these soil types can outperform those on heavy clay soils, in seasons of low rainfall, where moisture is tightly held limiting the ability of plants to extract soil moisture.

Figure 3. A typical dune–swale system at Karoonda, SA showing the difference in plant available water capacity (PAWC) at four sites across the system



This theoretical supposition is supported by anectodal information local grower experience, where crops on sandy soils have produced higher yields during dry years compared with those grown on the swale.

The total water-holding capacity of any soil will depend on a range of factors, including water-repellence, soil OM levels, and chemical and physical subsoil constraints.

Growers can influence water-holding capacity through a range of management approaches, which are outlined in the following chapters.

Measuring soil moisture

Understanding the current water-holding capacity and soil moisture status at any given point during the growing season allows growers to develop management strategies to optimise crop production.

A range of soil moisture measuring technologies is available, including soil moisture probes.

Soil moisture probes provide a continuous reading of soil water in a visual format, allowing growers to understand what happens to soil water during the year, the rooting depth of the crop and the effects summer rain events and poor summer weed control can have on stored soil moisture.

A capacitance type probe with a data logger can cost about $5000 plus annual maintenance and a mobile network connection.

Water use efficiency

Ultimately, the opportunity to increase the productivity of sandy soils, and indeed any landscape, is to improve crop WUE. Water use efficiency is a measure of the capacity of a farming system to convert water stored in the soil and rainfall that falls throughout the growing season into plant biomass and/or grain.

The following formula provides a simple and useful way to calculate WUE for crop production efficiency:

TOP: In dry years, crops on sandy dunes can outperform those on the moisture-limited low-lying swales. Photo: Emma Leonard, GRDC

ABOVE: Soil moisture probes allows growers to better understand current soil moisture status, supporting proactive management. Photo: Alistair Lawson, GRDC

A complex challenge

Looking at soil moisture in isolation can be misleading without understanding the complex range of factors that limit crop production.

The agricultural production challenges surrounding sandy soils are complex and interrelated. Key to their management is to avoid viewing any one aspect in isolation. Doing this risks failing to address the challenges as a whole (Figure 4).

Growers can maximise productivity on sandy soils by understanding the challenges and developing a management strategy that addresses the key limiting factors, which may include: water repellence, soil fertility, weeds, pests and diseases, erosion, frost, seeps and subsurface compaction.

$$\text{Crop WUE kg/ha/mm} = \frac{\text{grain yield (t/ha)}}{\text{crop water supply (mm)} - \text{soil evaporation (mm)}}$$

Figure 4. The complexity of managing sandy soils