WATER REPELLENCY

Key points

- Water repellency results from waxy organic compounds coating soil particles.
- Sandy soils (<5% clay) are most susceptible to water repellency.
- Claying sandy soils can help to alleviate water repellency, although significant amounts may be required.

Background

Water repellent soils occupy more than 5 million hectares of western and southern Australia (Roper, 2004). Decomposition of hydrophobic (or water repelling) waxy materials originating from plant residues can coat soil particles preventing the infiltration of water into the soil profile (figure 1; Van Gool & Moore, 1999). Soils with a small surface area (e.g. sand) are more prone to water repellency as it takes less hydrophobic material to coat individual particles, compared to silt or clay.

Figure 1: *Water droplet on surface of non-wetting soil.*

The result of water repellency is generally uneven water distribution in the soil profile which leads to patchy and uneven plant emergence (figure 2). Moving from an alternately wet and dry soil can make it difficult to control the depth of sowing causing further problems with establishment (Blackwell, 1996). Water can remain ponded on the soil surface to be evaporated or lost as runoff. Lack of plant cover and heavy autumn or summer rains can result in significant runoff and erosion on sloping sites.

Causes of water repellence

1. Native vegetation creates waxy, water repellent residues, so newly cleared agricultural land and native landscapes will be more susceptible to non-wetting.
2. In arable farming systems, pasture and grain legumes such as clover, medic, lucerne, and lupins which contain higher amounts of plant waxes form water repellent compounds. Cereals do not form water repellent residues so it's worth breaking a long pasture phase on susceptible soils to prevent build-up of hydrophobic material.
3. Fungi can also produce water repellent residues, particularly under perennial pastures such as lucerne.
4. As waxy substances in plants are not effectively broken down by their passage through the sheep (Blackwell 1996), sheep camps tend to be more water repellent because of the accumulation of organic matter.

The susceptibility of a soil being or becoming water repellent will be determined not only by the presence of hydrophobic material, but also soil texture (Hunt and Gilkes, 1992). Coarsely textured sandy soils that contain less than 5% clay are very susceptible to becoming water repellent. In a study done by Harper and Gilkes (1994), it was found that water repellency only occurred in soils with <10% clay and was most severe for soils with <5% clay. Although not as common, water repellency can occur in certain soils with a finer texture if the soil has a strongly aggregated structure (Moore, 1998). The repellency occurs when the aggregates become coated in hydrophobic material (Harper and Gilkes, 1994). In Western Australia, soils in coastal sand-plain regions generally have the greatest risk of water repellency.

Even though the breakdown of organic matter creates water repellent residues, there is generally no direct relationship between total soil organic carbon and water repellency. It is the type of organic matter present that influences the soils' susceptibility to water repellence.

Detecting water repellency

There are two main methods for measuring soil water repellency:

1. The time taken for a droplet of water to penetrate the soil.
2. The concentration of an ethanol solution needed to penetrate the soil in under 10 seconds. The higher concentration of ethanol needed, the more severe the water repellency.

Hunt and Gilkes (1992) also described visual indicators of water repellence in the field—patchy pasture growth or crop emergence, early growth in depressions where water can pond, shallow wetting of the soil surface and water erosion. Staggered weed germination can also be an indicator of a water repellent soil.

As water repellence is related to organic matter, it is often confined to the upper soil layers, especially in minimum till systems. Standard sampling of the top 10cm for analysis may "dilute" the water repellent layer, thereby skewing the results. For most accurate determination of water repellence the top 3–5 cm should be analysed.

Managing water repellency

Although options exist to manage non-wetting in water repellent soils, the economic cost and logistics of management may out-weigh the potential benefits.

Claying

Adding clay to hydrophobic layers should increase the soil surface area therefore lessening water repellency (Moore and Blackwell, 1998). The aim is to increase the clay content in the surface of the soil profile to at least 5%—this can sometimes require a substantial addition of clay (at least 100 t/ha). Dispersive clay (preferably kaolinitic) that will incorporate quickly is preferred.

It is important to assess the profitability of claying on a case by case basis. For example, previous studies conducted in Esperance (David Hall; DAFWA) observed that some "gutless" sands had very little potential to increase their production, even when water repellency was alleviated. This is a result of this soil type having low water holding capacity, low organic matter and nutrient content and being prone to wind erosion—all of which are likely to constrain potential grain production. Therefore, in this case, the increase in yields after claying would not be enough to produce a positive economic return. On more responsive soil types with higher yield potential, claying is likely to be more economically viable.

Other methods for managing water repellence include:

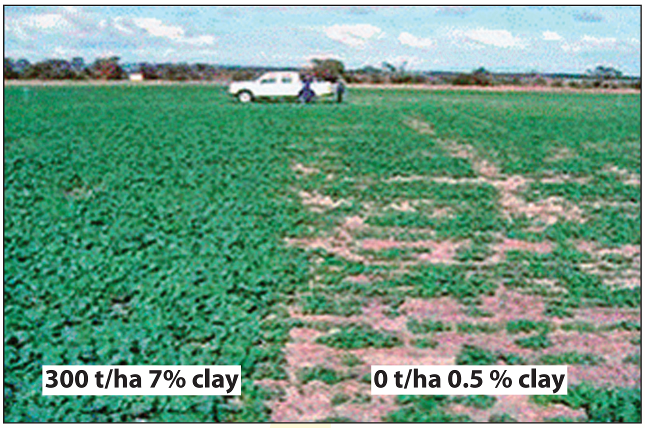

Figure 2: *Symptomatic expression of non-wetting resulting in patchy plant growth (right hand side). Differences in plant establishment demonstrated as a result of claying a southcoast water repellent soil (photo courtesy of David Hall, DAFWA).*

- Furrow sowing—creating furrows when seeding traps water, preventing loss from runoff and allowing it to enter the soil. Risks associated with this strategy include collapse/movement of soil from ridges into the furrow burying the seed deeper than intended, or large rainfall events causing water movement in the furrow resulting in rill erosion or seed exposure (Moore and Blackwell, 1998).
- Grow species adapted to water repellent soils to increase preferential water flow into soil.
- Soil wetting agents (generally not economical for broad-acre farming).
- Wax degrading bacteria capable of breaking chemical bonds (generally not economical for broad-acre farming).
- Decreasing the proportion of legumes in rotation.

Further reading and references

Blackwell P (1996) Managing water repellent soils. Department of Agriculture, Western Australia Farmnote No. 109/96. (online)

Carter D and Hetherington R. (2006) Claying water repellent soils. Department of Agriculture and Food, Western Australia Agdex 514. (online)

Harper RJ and Gilkes RJ (1994) Soil attributes related to water repellency and the utility of soil survey for predicting its occurrence. *Australian Journal of Soil Research*. **32**: 1109-24.

Hunt N and Gilkes B (1992) 'Farm Monitoring Handbook'. The University of Western Australia, Crawley, Western Australia.

Moore G (1998) Water repellence In 'Soilguide. A handbook for understanding and managing agricultural soils'. (ed. G Moore), Department of Agriculture, Western Australia Bulletin 4343: 53-63.

Roper MM (2004) The isolation and characterisation of bacteria with the potential to degrade waxes that cause water repellency in sandy soils. *Australia Journal of Soil Research* **42**: 427-433.

Van Gool D, Tille P and Moore G (1999) Land evaluation standards for land resource mapping. Department of Agriculture, Western Australia Resource Management Technical Report #298 (3rd ed.) (online)

Authors: **Jessica Sheppard** (Avon Catchment Council), **Fran Hoyle** (Department of Agriculture and Food, Western Australia), **Dan Murphy** (The University of Western Australia)

This soilquality.org.au fact-sheet has been funded by the Healthy Soils for Sustainable Farms programme, an initiative of the Australian Government's Natural Heritage Trust in partnership with the GRDC, and the WA NRM regions of Avon Catchment Council and South Coast NRM, through National Action Plan for Salinity and Water Quality and National Landcare Programme investments of the WA and Australian Governments.