Are you irrigating your farm as though its soil is all the same?

By Marnus Ferreira
Senior Soil Scientist
Agri Technovation

Charles Kellogg, an American naturalist, said that "Essentially, all life depends upon the soil... There can be no life without soil and no soil without life; they have evolved together." Scientifically, this sentiment is proven true over and over again.

One tablespoon of soil contains more organisms than there are people on earth; in a handful of soil, you could find 10 - 50 billion aerobic bacteria, up to 100 million different fungal cells (similar to mushrooms) including strands of fungal hyphae that connect them into a functioning network, hundreds or thousands of arthropods and micro-arthropods and thousands of different algae, protozoa, and nematodes (Source: growjourney.com).

Consequently, soil which consists of 25% air, 25% water, 45% mineral particles and about 5% organic matter, is an extremely complex and diverse substance. Currently, there are 73 classified soil forms in South Africa (Soil Classification Working Group, 1991). This means that farming processes, like irrigation, should take soil's intricacies into account.

The complexities matter

The soil's physical properties consists of the mineral particles sand, silt and clay. An interconnected pathway of gaps exists between the matrix of mineral particles and the organic matter in soil. These gaps are filled with air, water or ideally, a mixture of both.

Without the insights of soil classification, the physical properties and soil types can't be accurately identified and grouped according to their irrigation suitability and preference, which is why it is such an important process. It is also crucial to consider the water infiltration rates and percolation, which is affected by the texture, (the relative proportion of sand, slit and clay in the soil) and structure of the soil (the arrangement of soil particles into aggregates for irrigation scheduling.

• Infiltration rate

Infiltration rate influences the ideal irrigation rate (the rate at which water is given to the soil). Soils with a low infiltration rate require lower irrigation rates to ensure maximum infiltration and minimal surface runoff. On loamy soils the infiltration rate is lower than sandy soils, but lateral movement is more extensive than on sandy soils. Sandy soils have a faster infiltration rate than loamy soils, whereas loamy soils infiltrate faster than clay soils (Hill and Sumner, 1964; Dagadu and Nimbalkar, 2012).

• Percolation

Percolation simply refers to the rate at which water moves downward in soil (Hill and Sumner, 1964). Percolation rate is directly dependent on particle size – which in turn determines the surface area; the larger the surface area of the particle, the lower the percolation rate. Small particles (such as clay) have much larger surface areas than large particles, like sand. On average, clay particles have a surface area of 800 m2/g, silt an area of 11 m2/g and sand between 0.5 - 0.05 m2/g (Nadeau, 1985; Pennel, 2017). Therefore, 10g of clay has the equivalent surface area of a rugby field!

In essence, the infiltration rate is the rate at which water moves *into* the soil matrix from the outside. Percolation rate is the rate at which water moves once *inside* the soil

Apart from soil texture and structure, soil depth should also be accounted for when it comes to irrigation. Soil can consist of various layers of texture, structure, coarse fragments and depth of the water table. Some layers are nearly impenetrable for roots and water, so irrigation must be adjusted to separately irrigate soils with these types of limitations. If a shallow water table exists, those soils will reach saturation much quicker than soils that have a deep water table. There is also a risk of over-irrigation and drowning roots on such soils. It is important to ridge soil that contains shallow limiting layers in order to avoid over-irrigation and maximise rooting depth.

Why water holding capacity matters

Water holding capacity is the ability of soil to retain moisture. This is largely related to the particle size and its distribution within that soil. The size of the particle chiefly governs its surface area, which in turn determines its ability to retain moisture.

• Field Capacity

Field Capacity is the stage where macro pores (large pores between particles) in soil are filled with both air and water, but the micro pores (small pores between particles) are still filled with water (Veihmeyer and Hendrickson, 1949). This usually occurs a couple of days after good rains. The time it takes for the macro pores to drain excess water and fill with air is, of course, dependent on soil physical properties, such as texture, structure and limiting layers.

• Wilting Point

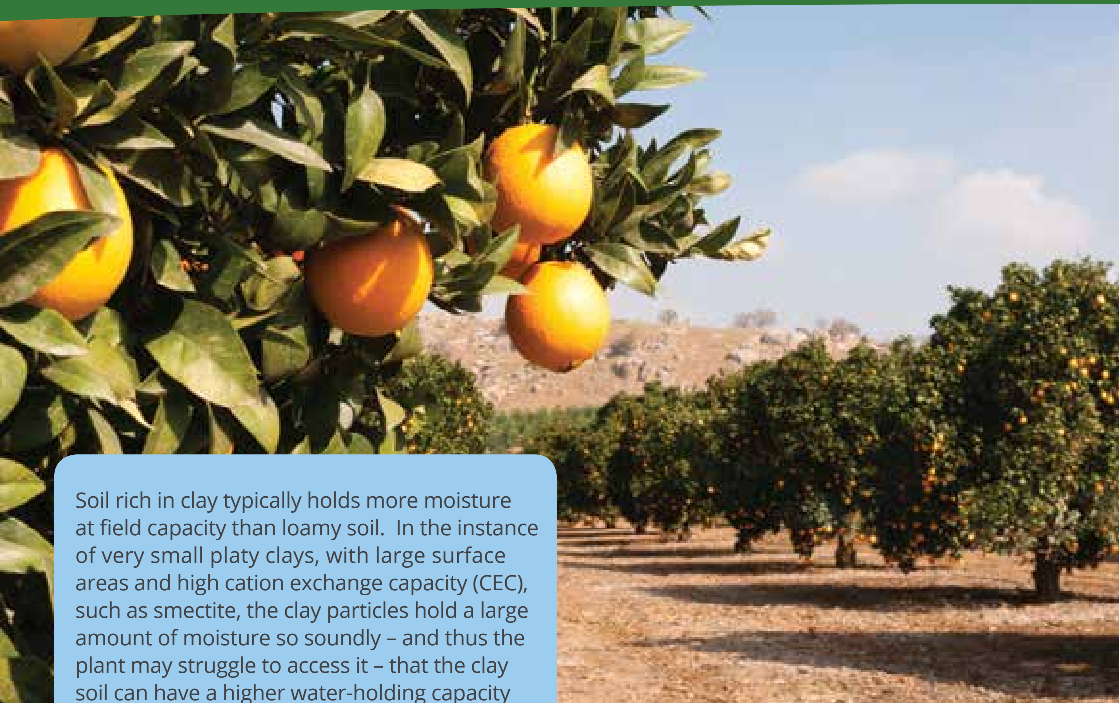
Wilting Point is the stage where both macro pores and micro pores are predominantly devoid of water and filled with air, and the only remaining moisture adheres to surrounding particles (Veihmeyer and Hendrickson, 1949). This type of soil moisture is unavailable to plants and leads to wilting.

• Plant Available Water Capacity (PAWC)

PAWC is the amount of water available to the plant between these two stages.

>>

from previous page



Soil rich in clay typically holds more moisture at field capacity than loamy soil. In the instance of very small platy clays, with large surface areas and high cation exchange capacity (CEC), such as smectite, the clay particles hold a large amount of moisture so soundly – and thus the plant may struggle to access it – that the clay soil can have a higher water-holding capacity but lower PAWC than loamy soil (Lambooy, 1984).

Clay soils hold moisture for longer periods than sandy soils and therefore require less frequent irrigation, but potentially for longer periods. This is due to clay soils' inherently low percolation rate - it takes a significantly longer time for moisture to move downward. Therefore, clay soils are easily drowned when over-irrigated.

Sandy soils have the lowest PAWC because most of the particles present are so large (and thus have a small surface area compared to clay and silt) that the moisture holding capacity is low. However, for these reasons sandy soils are well-drained, which is advantageous for crops that cannot tolerate long periods of saturation. Sandy soils require more regular irrigation for shorter periods, as the percolation rate is high.

To irrigate correctly and effectively it is recommended to install moisture monitoring probes on representative soil types and adjust scheduling accordingly.

Complex substance; Simple solution

As the basis of farming, it is important to understand soil and all its complexities. By acknowledging that a farm is not made from a homogenous mass, producers can ensure that their farms' differing types of soils are irrigated according to each of its varying requirements. This approach lowers the risks of over-irrigating, which wastes a precious resource such as water and incurs unnecessary operational expenses. On the other hand, it avoids the damage that under-irrigation can cause to a crop and consequent financial losses.

The information gained by doing soil classification is applied to irrigation in the following ways:

For a new development:

- Entire irrigation layout;
- Advice on most suitable irrigation type;
- Grouping soils with similar physical properties into irrigation blocks;
- PAWC maps of the area to assist with precise scheduling;
- Pivot positioning;
- Soil moisture probe position recommendations to ensure representative soil moisture measurements;
- Soil amelioration to ensure irrigation efficacy;
- Identification of drainage sites.

For an existing development:

- Advice on most suitable irrigation type and possible adjustments;
- Soil moisture probe position recommendations to ensure representative soil moisture measurements;
- Subdivision of irrigation blocks based on soil variation;
- PAWC maps of the area to assist with precise scheduling;
- Post-plant soil amelioration to ensure irrigation efficacy;
- Identification of drainage sites.

Fortunately, although soil is a complex substance, the solution doesn't have to be.

By simply starting the season with a soil classification process, a once-off investment, producers can gain all the knowledge and insights needed about this life-sustaining material. From there, an irrigation programme can be identified that optimises and preserves this life-sustaining material for many generations to come.

Resources:

The Infiltration Capacities And Percolation Rates For Some Natal Sugar Belt Soils, J. N. S. HILV & M. E. Sumner, p. 121: Proceedings of The South African Sugar Technologists' Association, 1964.

Relationship between cation exchange capacity, clay content and water retention of Highveld soils, Astrid M. Lambooy, South African Journal of Plant and Soil, 1:2, 33-38, 1984.

Infiltration Studies of Different Soils Under Different Soil Conditions and Comparison Of Infiltration Models With Field Data, J. S. Dagadu & P. T. Nimbalkar, International Journal of Advanced Engineering Technology, Vol.III, Issue II, Apr – Jun, 2012.

The Physical Dimensions of Fundamental Clay Particles, P. H. Nadeau, Clay Minerals 20, p. 499-514, 1985.

Methods of Measuring Field Capacity and Permanent Wilting Percentage Of Soils, F.J. Veihmeyer & A.H. Hendrickson, 1945.