It does not matter how much water my soil holds. The Osmotic Discussion.

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Abstract
Measuring the water volume in the soil is important to determine the irrigation requirements. The current trend of using "poorer quality water" or even slightly saline water (e.g. waste water, drainage water, storm water, tail water, the only water available in drought times, etc.) for irrigation may produce long term irrigation/soil problems or affect crop yields. Recent journal publications indicate that consideration to the osmotic potential (amongst other soil water factors: bulk density effects, soil textures, hysteresis, etc) of the water potential (water energy) needs attention.

Discussion
Irrigation can be scheduled by one or more three basic methods of measurement: volume, time or energy. Predominately time is use (e.g. 20 minutes watering), followed by volume (e.g. mm of water) and occasionally energy (negative kpa or suction).

A manager, generally without knowing it, will use two methods together (i.e. time and volume), to improve the precision of water applied. Further knowledge of the energy of water, particularly the osmotic component, under some situations (salty water or salty soils) will aid the water use effectiveness / precision of the manager.

This available water (AW) in the soil can be generally characterised as the difference between water held in the soil at permanent wilting point (PWP) and soil water field capacity (e.g. Leeper and Uren 1993). Other concepts include those as proposed by Reid et al (1984) using the term extractable water. These are usually measured as a VOLUME by, or over a soil depth.

E.g.: AW = FC - PWP

$$EW = DUL - LL$$

And other concepts

The actual definition of field capacity (or DUL) and PWP (or LL) terminology can be in some management areas an important consideration as to defining the available water (or EW).
Some definitions include:

1/ The field capacity (or EW) of soil -"the water content of the soil 2 days after heavy rain or irrigation in the absence of irrigation" pg 94 (Leeper and Uren 1993).
2/ The permanent wilting point – "The stage at which plants cannot obtain useful water" pg 91 (Leeper and Uren 1993).

Others include a measured total energy potential e.g. – 10kpa, -33kpa or -100kpa for field capacity and -1500kpa for PWP. This use of energy potential is appropriate when considering that plants "see", or use water within this energy context. Unfortunately plants like humans tend to be lazy and prefer to use water from nearest the surface first. (Discussions see Campbell 1988).

As plant roots are "generally" more abundant near the soil surface (compared to the OVERALL root depth), this predisposes the plant water uptake of the accessible (or free pF) water from the surface first, then through the following depths under uniform soils. Other considerations can include soil structure affects (even in the same "genetic and taxonomic view" Droogers et.al. 1997), or plant root water resistance (Hulugalle and Willatt 1983), and due to soil water potential difference (laterally or vertically)were water is lost from the roots back into the soil (e.g. see Baker and van Bavel 1986).

Soil water matrix and osmotic potential can also affect the growth of plant root diseases (Cook and Papendick 1972) and potentially nematodes.

Water energy or potential has been defined (Hanks 1992) “as the amount of work that a unit quantity of water in an equilibrium soil-water (or plant - water) system is capable of doing when it moves to a pool of water in the reference state at the same temperature”.

In equation form this is, $\psi_W = \psi_M + \psi_S + \psi_P$

where; ψ_W is the water potential

ψ_M is the matrix potential

= vertical distance between a point in the soil and the water level of a manometer connected to this point.

ψ_S Is the solute or osmotic potential or the effect of salts (including nutrients) on water energy.

ψ_P Is the pressure potential. = the vertical distance from a point in question to the free water surface (water table elevation)

This water volume to energy concept can be further defined using moisture release curves. (e.g. Milthorpe & Moorby 1975 Pg 16)

Other factors that influence the relationship between moisture content and **matrix** potential include hysteresis, capillary rise, water flow (saturated and unsaturated), water vapour, soil structure, evaporation rate (for details see Hanks 1992 and Miyazaki 1994), soil texture, soil structure, soil water repellency and soil bulk density (McKechnie 1997).

Whilst available elements (e.g. Na and Cl) are used to determine soil salinity issues, recent journal discussions are looking at the soil water osmotic potential to determine a whole of plant response to salinity (e.g. Ben-Gai et al 2008). Rengasamy(2010) also recorded that although Na and Cl can affect Crop growth due to Ion specific salinity, total water salinity (ECw), soil saturated salinity (ECse) do affect the soil water available for plant uptake.

This includes the effect of “salts” reducing the availability of water uptake by plants by increasing the water potential (Table 1 and Diagram 1), thus reducing plant water use effectiveness.

As the use of recycled water, storm water and natural waters with varying “salt content” are being used; consideration to this osmotic potential may need to be considered to determine whole crop (crop, turf, parkland) response to the various water use indicators.

Conclusions

It does matter how much water my soil holds, but further consideration needs to be given to the method of measurement (or assessment), the soil characteristics (bulk density, hysteresis, water content, etc.) and more into the future the osmotic potential which all add to total water volume available calculation to the plant, whilst the volume of water in the soil stays the same.

Further verification of the osmotic affect for your local conditions (particularly soil type – chemistry) and management practices is required.

References

Baker, J. M. and van Bavel, C. H. M. 1986. Resistance of plant roots to water loss. Agron. J. 78: 641 – 644.

Ben-Gai, A Borochov – Neori, H Yermiyahu, U & Shani, U 2008, 'Is osmotic potential a more appropriate property than electrical conductivity for evaluating whole-plant response', *Environmental and Experimental Botany,* vol 65, pp. 232 – 237.

Campbell, G. S. 1988. Soil Water potential measurement: An overview. Irrigation Science. 9: 265 – 273.

Droogers, P., van der Meer, F. B. W., and Bouma, J. 1997. Water accessibility to plant roots in different soil structures occurring in the same soil type. Plant and Soil 188: 83 – 91.

Hanks, RJ. 1992. *Applied Soil Physics, Soil and water Applications*. (Second Edition. Springer-Verlag New York Inc).

Hazelton, P. A. and Murphy, B. W. ed. 1992. What do all the numbers mean? A guide for the interpretation of soil test results. Department of conservation land management. Sydney.

Hulugalle, N. R., and Willat, S. T. 1983. The role of soil resistance in determining water uptake by plant root systems. Aust. J. Soil. Res. 21: 571 – 574.

Leeper, GW & Uren, NC 1993 *Soil Science*. 5th edn. Melbourne University Press.

Milthorpe, FL & Moorby, J 1975 *An Introduction to Crop Physiology*. Cambridge University Press.

McKechnie, D 1997. *A study of the evaluation of variability in the turf environment*. Thesis Graduate Diploma Agricultural Science. The University of Sydney

Miyazaki, T. 1993. *Water Flow in Soils*. Marcel Dekker, Inc. New York.

Rengasamy, P 2010 'Soil processes affecting crop production in salt-affected soils'. *Functional Plant Biology*. Vol 37, pp. 613 -620.
OTHERS

Reid RL 1990. *The Manual of Australian Agriculture*. Butterworths.

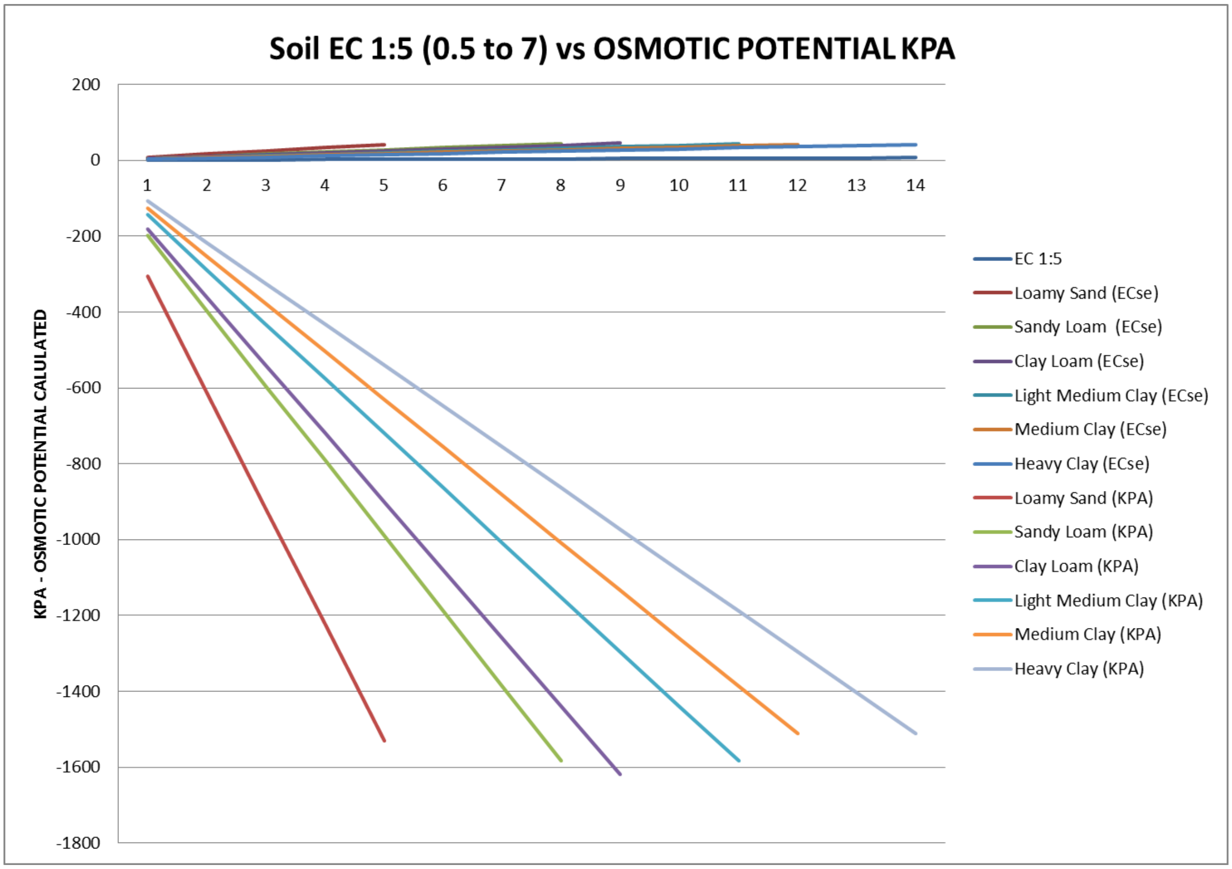

Diagram 2: Soil EC 1:5 to osmotic potential calculated with data from Hazzleton and Murphy 1992 and Rengasamy (2010).

EC 1:5	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**
Loamy Sand (ECse)	8.5	17	25.5	34	42.5									
Sandy Loam (ECse)	5.5	11	16.5	22	27.5	33	38.5	44						
Clay Loam (ECse)	5	10	15	20	25	30	35	40	45					
Light Medium Clay (ECse)	4	8	12	16	20	24	28	32	36	40	44			
Medium Clay (ECse)	3.5	7	10.5	14	17.5	21	24.5	28	31.5	35	38.5	42		
Heavy Clay (ECse)	3	6	9	12	15	18	21	24	27	30	33	36	39	42

Table 1: Soil EC 1:5 to Soil ECse, calculated with data from Hazzleton and Murphy 1992 and Rengasamy (2010).