

**Plant Availability of Water in Soils Being Reclaimed from the
Saline-Sodic State**

Thesis submitted by

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ABSTRACT

The work reported in this thesis was motivated by a desire to improve our ability to estimate the amount of plant available water in soils beyond the classical methods enveloped in the terms —Plant Available Water” (PAW) and —Leaf Limiting Water Range” (LLWR). It took the view that soils can be considered to be water ‘capacitors’ that are influenced primarily by the physical properties of the soil. The soil properties of particular concern in this work were the soluble salt concentration in the soil water, poor soil aeration in wet soils, rising penetration resistance and declining hydraulic conductivity in drying soils. Their effects on soil water availability were embodied the model proposed by Groenevelt et al. (2001; 2004) called the *integral water capacity* (IWC). The theoretical framework for the IWC-model is quite strong, if not intuitive, but there is little published evidence to date to evaluate its integrity using real plants growing in real soils. There is also little information to enable one to calculate plant available water in soils being reclaimed from the saline-sodic state. The work reported in this thesis therefore aimed to address four main questions:

Question 1 (Chapter 2)

When soil salinity, aeration, strength and hydraulic conductivity are all taken into account, how much soil water is available to nominally ‘salt-sensitive’ plants when calculated using the IWC model of Groenevelt et al. (2004)?

Undisturbed soil samples were collected from the profile of a saline soil whose texture gradually became heavier with depth. Water retention, soil resistance, soil aeration and soil salinity were all measured and used to prepare appropriate weighting functions to attenuate the differential water capacity and obtain different estimates of plant available water down the soil profile. All weighting functions attenuated the water capacity and reduced the IWC to varying degrees, each of which produced smaller estimates of plant available water than the classical PAW model. Weighting due to salinity caused by far the greatest individual reduction in IWC, followed by soil resistance, soil aeration, then hydraulic conductivity. The combination of all factors, of course, reduced IWC the most. However, replication of the findings (and therefore a statistical evaluation of the effects) was not possible, so these findings must be treated as tentative for now. Furthermore, many of the weighting functions were applied with little or no knowledge of the real magnitude of their parameters based upon real plant behaviour. To take this into account, weighting functions were proposed for each limiting soil property having functional forms that included plant-specific parameters, whose magnitude can be varied widely for different plants. The plant-specific

parameters attenuate the water capacity severely when a plant species is sensitive to a restricting soil property and not as severely when a plant species is not sensitive to it.

Question 2 (Chapter 3)

To what extent do the (laboratory-based) estimates of soil water availability using IWC coincide with the (field-based) measurements of soil water use by real plants?

A field experiment was conducted on a saline soil, in which a water budget was constructed to a depth of 1.5 m and a crop of relatively salt-tolerant perennial Rhodes grass (*Chloris gayana* cv. Pioneer) was grown to full canopy before stopping all water inputs. The volumetric water content was monitored regularly (using a specially calibrated neutron moisture meter) as the crop transpired water over several months until it eventually died from water stress. The total change in water content down the profile was determined by the difference in water contents at the time of saturation and those at the time of permanent plant wilting. The predicted and measured amounts of available water were compared with the classical PAW model and it was concluded that the magnitude of attenuation proposed by Groenevelt et al. (2004) was too severe. Some effort was made to adjust the plant-specific slope parameters, β , A , and τ , but with no real knowledge of the magnitude of these parameters for different plants, it was considered futile to expend much time adjusting the parameters without new information about real plants.

Question 3 (Chapter 4)

When saline-sodic soils are ‘reclaimed’ toward the non-saline, calcic state, to what extent does soil water availability change (in terms of IWC) without significant soil disturbance in the process?

A column-leaching experiment was conducted in the laboratory using re-packed soil cores leached first with a saline solution (isotonic with field conditions) then with various different salt solutions to determine the extent to which changes in the pore size distribution would be accompanied by measurable changes in salinity, soil strength, hydraulic conductivity and aeration – and thus, plant available water (IWC). Fifty-four different average water retention curves were prepared in this experiment, and the curves were differentiated to produce water capacities that were weighted according to procedures outlined in Chapter 2. As in Chapter 3, it was found that the salinity weighting function caused the greatest reduction in IWC and was probably too severe. It was also found that the other factors reduced the water capacity somewhat, in declining order of importance: salt > aeration > strength > hydraulic conductivity. It was a surprise to find that with no disturbance

of the re-packed soil samples, the structure of the soil was able to be changed to a small extent without disturbing it mechanically, simply by changing the composition of the leaching solution.

Question 4 (Chapter 5)

To what extent does the response of plants to increasing salt concentration mimic the peculiar shape of the weighting function proposed by Groenevelt et al. (2004)?

Plants of two different types (Faba beans, *Vicia faba* cv. Fiord; and Rhodes grass, *Chloris gayana* cv. Pioneer) were grown in a glasshouse in either pots of salt-solutions or in soil having different salt concentrations. The idea was to develop a weighting function for salinity based upon measured plant growth responses to varying salinity, and compare this with the peculiarly shaped weighting function for salt proposed by Groenevelt *et al.* (2004). The growth reduction pattern due to salt was similar for both plants, so the relative growth of each plant was plotted as a function of the total water potential. It was found that the relative growth of the solution-grown plants coincided with those for the soil-grown plants, which implied the plants responded in the same way to both osmotic and matric stresses. Relative growth responses were then fitted to a (rather inadequate) model, which was then used in a weighting function that included both plant- and soil-specific fitting parameters. The results produced a more gentle attenuation of the water capacity than the model of Groenevelt et al. (2004), which suggests there is considerable room to adjust the 'reflection coefficient' in their model. Finally, the typical 'bent-stick' model used to describe plant response to salinity was found to be out-dated and should be replaced by a more modest, smooth decline in plant growth with increasing salt concentration.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Dated: _____

Duy Nang Nguyen

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