Soil hydraulic and salinity restrictions to water availability in very sandy soils

Thesis submitted by

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Summary of thesis

This study tried to evaluate the veracity of Grant and Groenevelt (2015) assertion that the inflection point on the water retention curve (WRC), plotted on semi-log scale, marks the onset of hydraulic stress in plants grown in sandy soils. That is, as the soil dries during drainage and evapotranspiration, there comes a point (argued to be the inflection point) when the unsaturated hydraulic conductivity cannot keep up with plant demand for water; thus, plants begin to suffer. Interest in the inflection point stemmed from the need to find unbiased criteria to weight the water capacity downward in the integral water capacity (IWC) model of Groenevelt et al. (2001) to account for soil hydraulic restrictions. If the inflection point was truly a good indicator of the onset of plant stress, then the matric suction at this point can easily be found from the fitting parameter, k_o (m), in Grant and Groenevelt (2015) water retention model; by coincidence it can also be found from the fitting parameter, 1/α (m) in the water retention model of (Van Genuchten 1980).

The experimental components of this study consisted of two main parts: In the first part, water retention curves for a range of different sands and sandy soils were prepared, their inflection points identified, and two points on either side of the inflection point (wetter and drier) identified (**Chapters 3 and 4**). In the second part, wheat plants were grown in a glasshouse to Zadoks et al. (1974) growth stage 21 in pots of the different sands held, constant, at three different soil water suctions: at, above and below the inflection point (**Chapter 5**).

Detailed water retention curves were prepared using multiple replicates (up to 20) of four sands and two sandy soils (Very coarse sand, Coarse sand, Medium sand, Fine sand, Very fine sand, and Sandy loam) placed in small rings on ceramic pressure plates at different matric suctions ranging from saturation to 25 kPa or greater. Each of the individual sets of water retention data (up to 20) were fitted to the water retention models of Groenevelt and Grant (GG), and Van Genuchten (VG), and the inflection points identified from the appropriate fitting parameters. As might be expected, the different models produced slightly different inflection points, but these indeed corresponded pretty well (but not precisely) with k_o and 1/α respectively. There was a strong inverse correlation between the mean particle size of the sands and sandy soils, and the values of k_o and 1/α; that is, the inflections points shifted to greater matric suctions as mean particle size decreased, such that the Very coarse sand had the smallest values of ko and 1/α while the Sandy loam had the largest values of k_o and 1/α.

Because the VG model fitted the measured water retention data slightly better than did the GG model, the parameters from the VG model were chosen to identify the soil water conditions for

the plant experiments. The matric suction at the inflection point, h_i (m), was identified from $1/\alpha$, and this corresponded with the maximum differential water capacity, $C(h_i)$. The wetter, h_w, and drier, h_d, matric suctions were chosen to correspond with the matric suctions at 90 % of the maximum differential water capacity (on either side of the inflection point). The value 90 % was chosen as being close to the inflection point yet falling outside its 95 % confidence interval. The (up to) 20 estimates of hw, hi and hd were used to identify the corresponding volumetric water contents directly from the water retention curves, and these were averaged and converted to gravimetric water contents that could be used to set up the soil water conditions in the pot study.

Following a 6 x 2 x 3 completely randomised factorial design, litre-sized pots of each sand or sandy soil (5 replicates) were set up at the three different water contents corresponding to hw, hi and hd, (covered in plastic beads to minimise evaporation) and wheat seeds (2 different genotypes) planted and grown in them to growth stage 21. To keep soil water contents constant, daily pot weights were recorded and then water added (calibrated for increasing plant mass over time) to replace water evapo-transpired. The measure of plant response to the soil water conditions was the mass (fresh and dry) of shoots and roots.

Although one of the wheat genotypes performed significantly better than the other (consistent with the literature), the F-test or analysis of variance (ANOVA) indicated that the wheat genotypes never responded to the soil moisture conditions or matric suction effects at or surrounding the inflection point. Possible reasons for the lack of response to the soil moisture conditions may be related to the choice of the wet and dry-side matric heads, particularly on the dry side; that is, the matric suction on the dry side of the inflection point, which corresponded to 90 % of the maximum water capacity, may not be sufficiently dry to induce a hydraulic stress. Contrast to this, was the source of variation that arose from the three and two factor interaction effects on the dry weights of shoot and root respectively, which showed significant differences. However, this was not convincing enough for one to accept the null hypothesis of the study due to the inconsistent nature of trends observed in the dry weights obtained at or surrounding the inflection point matric suction. On this basis, the importance of the inflection point as a marker of hydraulic stress in plants is not rejected at this stage – further research is needed.

Declaration statement

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, 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.

In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Date	**Justice Okona Frimpong**

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