Use of a dielectric tensiometer and other soil moisture sensors to measure soil drying by roots of wheat

Dick Jenkins and Martin S. Goodchild
Delta-T Devices Ltd., 130 Low Road, Burwell, Cambridge, CB25 OEJ, UK.

W. Richard Whalley, Christopher W. Watts, Colin P. Webster and Martin A. J. Parry
Rothamsted Research, West Common, Harpenden, St Albans, AL5 2JQ, UK.

Abstract

In this poster we demonstrate the use of a non-linear pedotransfer function (PTF) which predicts penetrometer resistance of soil from the easily measurable soil properties of matric potential, soil saturation and soil bulk density. Data for this work was collected over a 2-month wheat growing period from an open-field test site using a novel prototype dielectric tensiometer and capacitance measuring soil moisture sensors (ML2x & PR2) from Delta-T Devices Ltd. By applying this data to the PTF model proposed by Whalley et al. (2007) it has been possible to predict penetrometer resistance of soil, over a matric-potential range of –20kPa to –300kPa. These results are in good agreement with open-field test site penetrometer measurements. The instrumentation and data processing techniques presented in this poster demonstrate a useful method for future root penetration studies.

Experimental method

The sensors were installed in rain-fed experimental plots at Woburn UK and sensor values were logged frequently over the wheat growing season. Resistance of soil measurements were taken using a soil penetrometer at frequent intervals throughout the growing season. The experimental plots had either 100kg of Nitrogen /ha or 200kg of Nitrogen /ha applied.

Measuring matric potential

A prototype dielectric tensiometer sensor from Delta-T Devices Ltd., the DT160, measures the dielectric properties of ceramic blocks that are in equilibrium with the matric potential of the surrounding soil. By using a carefully developed calibration method for the ceramic blocks, the sensor measures actual soil matric potential in a similar manner to a water filled soil tensiometer. Furthermore dielectric tensiometer sensors have the advantage that they are able to vastly exceed the "air entry point" value of a water filled tensiometer (c. -90kPa) and carry on accurately measuring matric potential beyond this value to in excess of -300kPa. Unlike the water filled tensiometer, dielectric tensiometers recover from these high negative potentials upon the soil re-wetting (as demonstrated in the following graph). The dielectric tensiometers have universal calibrations so are field replaceable. The matric potential measurements obtained by the DT160 compared well with water filled tensiometers (where possible).

Measuring soil moisture

Volumetric Water Content sensors supplied by Delta-T Devices Ltd UK including the ML2x ThetaProbe, PR2/6 Profile Probe and the newly available SM300 volumetric and soil temperature sensor.

Measuring resistance of soil

The penetrometer used in this work to measure resistance of soil was first developed at Penecuik Scottish Institute of Agricultural Engineering (now unavailable).

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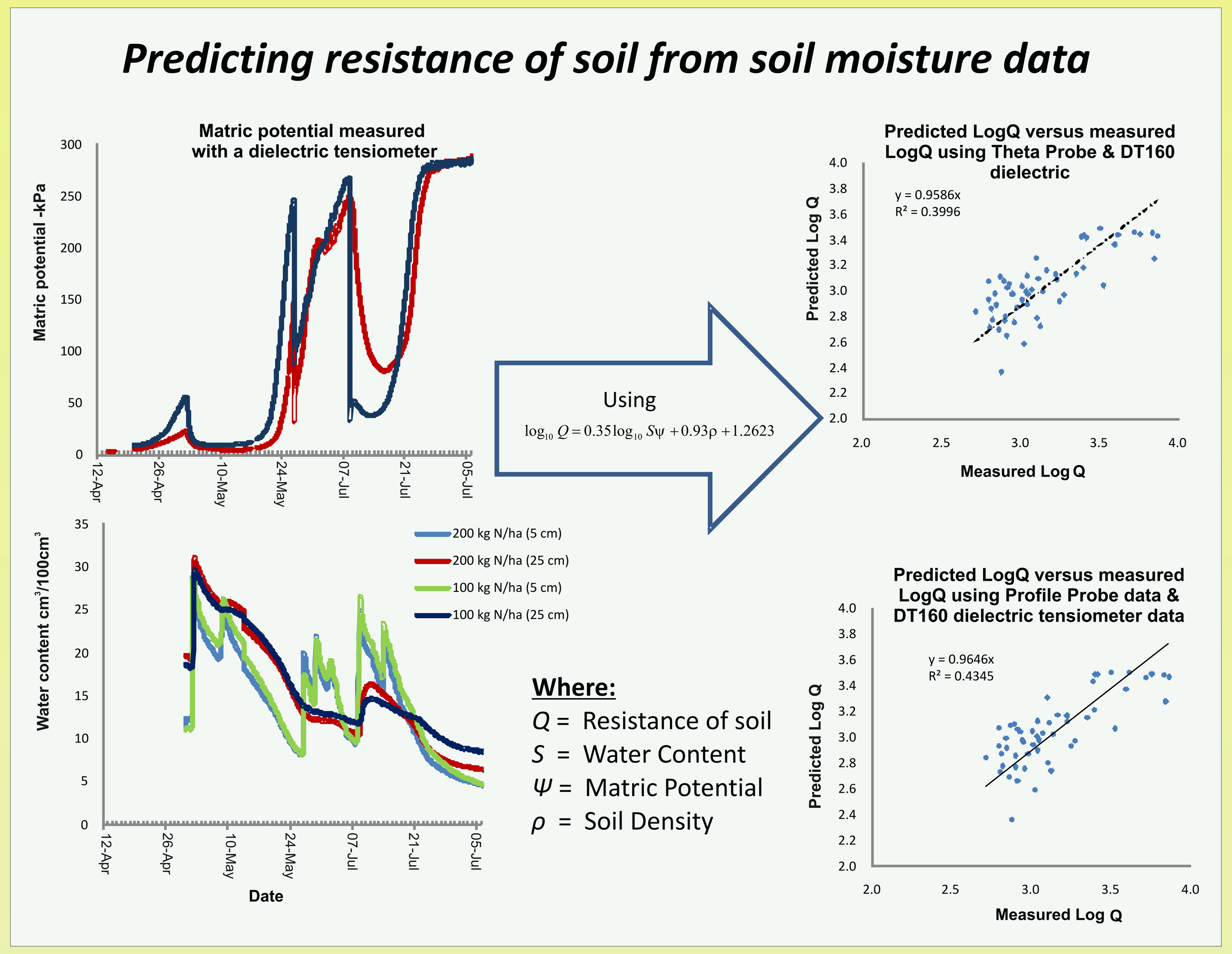

Data Analysis

By taking penetrometer resistance of soil measurements (Q) and recording the corresponding matric potential and soil moisture measurements it is possible to compare measured $\log_{10}Q$ with Predicted $\log_{10}Q$ (using a PTF) where: Predicted $\log_{10}Q = 0.35 \log_{10}S\psi + 0.93\rho + 1.2623$. The graphs above show good 1:1 relationships and confirms the use of a PTF to predict penetrometer resistance of soil.

Conclusions

In this work we have demonstrated that the penetrometer resistance of soil can be predicted with a PTF using matric potential, soil saturation and soil bulk density data collected from an open-field test site during a wheat growing period.

Data from a prototype dielectric tensiometer and commercially available soil-moisture sensors from Delta-T Devices Ltd. has been successfully used to predict the penetrometer resistance of soil and further verifies the PTF model proposed by Whalley et al. (2007). Using matric-potential and soil moisture sensors with a PTF model to predict the strength of field soil may provide a useful tool for future root penetration studies.

A prototype dielectric tensiometer from Delta-T Devices Ltd. has enabled reliable real-time prediction of penetrometer resistance of soil over a much wider range of matric potential than is possible with a water filled tensiometer. The experimental method and results have provided verification of the use of dielectric tensiometer technology as well as its implementation in the design of the prototype sensor.

References

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