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An algorithm for temperature correcting substrate moisture measurements: aligning substrate moisture responses with environmental drivers in polytunnel-grown strawberry plants

Martin Goodchild, Stuart Janes, Malcolm Jenkins, Chris Nicholl, and Karl Kühn
United Kingdom (martin.goodchild@delta-t.co.uk)

The aim of this work is to assess the use of temperature corrected substrate moisture data to improve the relationship between environmental drivers and the measurement of substrate moisture content in high porosity soil-free growing environments such as coir. Substrate moisture sensor data collected from strawberry plants grown in coir bags installed in a table-top system under a polytunnel illustrates the impact of temperature on capacitance-based moisture measurements. Substrate moisture measurements made in our coir arrangement possess the negative temperature coefficient of the permittivity of water where diurnal changes in moisture content oppose those of substrate temperature. The diurnal substrate temperature variation was seen to range from 7˚C to 25˚C resulting in a clearly observable temperature effect in substrate moisture content measurements during the 23 day test period. In the laboratory we measured the ML3 soil moisture sensor (ThetaProbe) response to temperature in Air, dry glass beads and water saturated glass beads and used a three-phase alpha (α) mixing model, also known as the Complex Refractive Index Model (CRIM), to derive the permittivity temperature coefficients for glass and water. We derived the α value and estimated the temperature coefficient for water - for sensors operating at 100MHz. Both results are good agreement with published data. By applying the CRIM equation with the temperature coefficients of glass and water the moisture temperature coefficient of saturated glass beads has been reduced by more than an order of magnitude to a moisture temperature coefficient of $<$-0.00011m3.m-3.˚C-1. This laboratory method was then further developed with the aim of addressing the diurnal substrate temperature variations seen in the substrate moisture measurements for the strawberry plants grown in coir. This was performed by deriving and calibrating a simplified (CRIM equation based) temperature correction algorithm that uses only substrate temperature and permittivity data. The resulting diurnal variations seen with the temperature compensated substrate moisture data now align very well with the expected diurnal water demands of the strawberry plants. To further evaluate the relationship between environmental drivers of solar radiation and vapour pressure deficit with substrate moisture the temperature correction algorithm was programmed within a GP2 data logger. The GP2 was also arranged to collect solar radiation, air temperature and relative humidity data. The resulting comparison of substrate moisture responses to environmental drivers in a follow-up strawberry growing trial illustrated a significantly improved correlation using the temperature correction algorithm. We conclude that this new temperature correction algorithm addresses the effect of temperature on the permittivity of water which will affect all capacitance based sensor measurements in high porosity soil-free growing substrates such as coir.