Development of the Chameleon soil moisture sensor: substituting numbers for colour patterns

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Abdallah a farmer in Kiwere, Tanzania
Abdallah’s onion farm in Kiwere irrigation scheme, Tanzania
Irrigation infrastructure in Kiwere. Each farmer pays a water fee to the irrigation association and applies for water whenever he needs water for irrigation.
But that’s the question! How does Abdallah know when his crops need water?
Knowing how much water is in the soil is vital for irrigation management, so farmers avoid plant stress on the one hand and over-irrigation, loss of nutrients and waterlogging on the other.
Soil water monitoring tools have become more sophisticated over the years... and more detailed.

www.hydrosense.com

www.irrometer.com
But how much detail is really useful in making decisions?
For simplicity:

- Minimize the problems of interpretation, installation, complicated units, loggers and graphical representation of data

- Give farmers the ability to “see” what the crop is experiencing
We have developed a low cost soil water monitoring package that consists of a resistivity sensor that is buried in the soil, a reader which is connected to the buried sensors and gives an output via colour diode as blue (wet), green (intermediate) and red (dry) and a phone app where the visual output from the reader is entered and subsequently time-stamped, geo-referenced and displayed for the user. African workers named it the Chameleon.
The Chameleon
Photo courtesy Mark Gush
The switch points between blue, green and red lights are based on the extensive literature for avoiding crop water stress for most irrigated crops (Christen et al 2006)

<table>
<thead>
<tr>
<th>Colour</th>
<th>Water level (Meaning)</th>
<th>Irrigate in this range (or before)</th>
<th>VEGETABLE CROP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>Wet soil</td>
<td>20-30 kPa</td>
<td>Broccoli, Celery, Lettuce, Onion</td>
</tr>
<tr>
<td>Green</td>
<td>Moist soil</td>
<td>30-45 kPa</td>
<td>Beans, Cabbage, Carrot, Capsicum, Corn, Cucumber, Eggplant, Melons, Potato, Tomato,</td>
</tr>
<tr>
<td>Red</td>
<td>Dry soil</td>
<td>&gt;60 kPa</td>
<td>Beet, Peas, Sweet potato, Pumpkin</td>
</tr>
</tbody>
</table>
The water release curves of different materials tested for the sensor.
The rise in resistance (red line) as a consequence of falling water content (blue line) in Diatomaceous earth.
Sensors are handmade...
Sensors buried in high conductivity bedding material on top of porous plate

Bubble tower for setting exact suction levels over 0-60 kPa range

Accurate mini-tensiometers to independently log tension at multiple locations in sensor bedding material

Watermark loggers for logging resistance / tension

Chameleon readers for cross checking colours switch at correct resistances and tensions

Mercury manometer and pressure gauge for checking tensions

Set up for precision testing of sensors and readers...and rigorously tested
Sensors are evaluated based on readings of resistance Vs tension.
Sensors are further tested in the field alongside tensiometers.
Some tensiometer and Chameleon readings at 2 depths in a Swiss Chard plot
The Chameleon simplifies soil water information. This Chameleon reader shows readings from 15, 30, 45 and 60 cm depth. The soil is: wet at 15 cm, moist at 30 and 45 cm, getting dry at 60 cm. This profile contains sufficient water for the crop (blue/green) without causing leaching (dry subsoil).
Early roll out (ACIAR-funded project): “Increasing irrigation water productivity in Mozambique, Tanzania and Zimbabwe through on-farm monitoring, adaptive management and Agricultural Innovation Platforms”
Farmer-based learning with the Chameleon
Abdallah showing other farmers how to install the Chameleon
"... before this Chameleon, I used to over-irrigate my plot. That is why my onions did not grow well in some parts of the plot because of too much water. Since I have been using this tool my crops are growing very well".
Future work include developing a quick diagnostic test for sensors and evaluating sensor performance under various soil conditions.
Acknowledgements

Thank you!