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

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CSIRO

Australian Government
Australian Centre for International Agricultural Research

Numbers!

Rajan Mahadevan

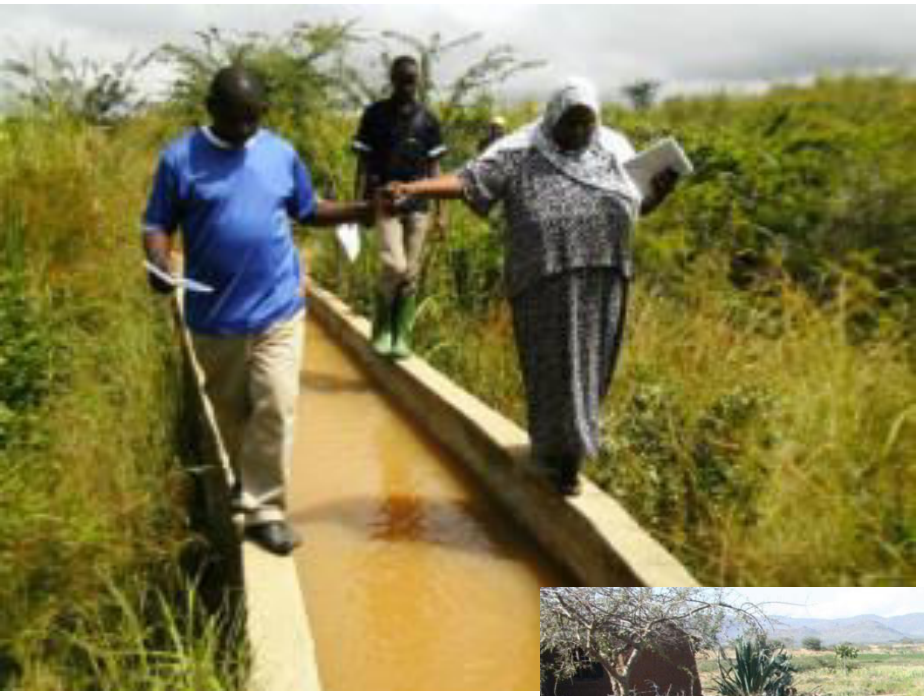

seedsmarket.co.z


djdayel.deviantart.com

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
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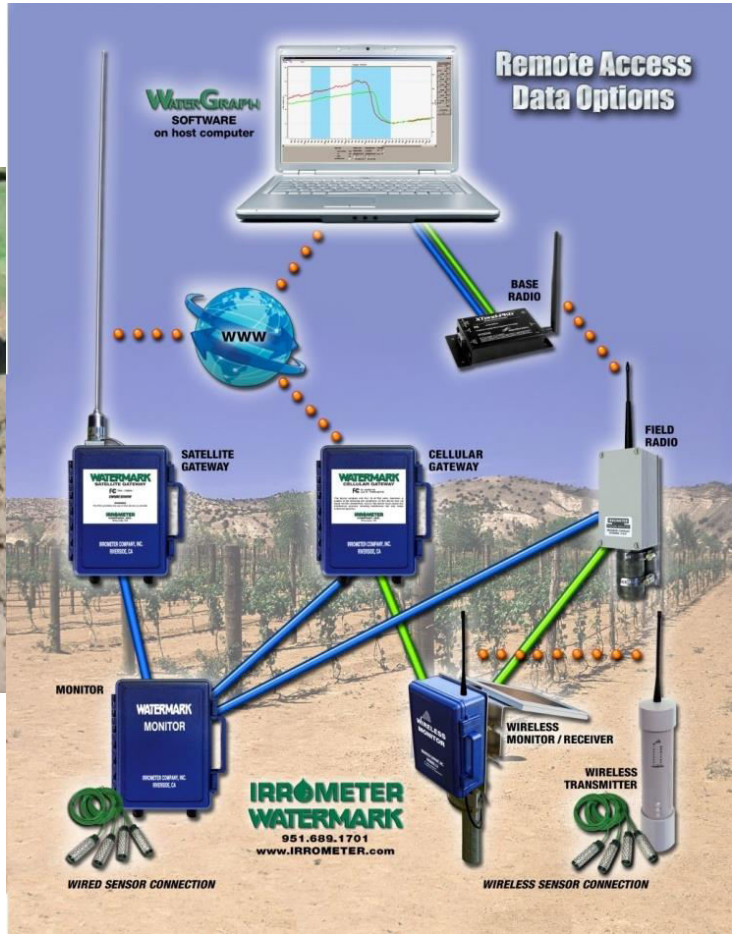
Soil water monitoring tools have become more sophisticated over the years… and more detailed



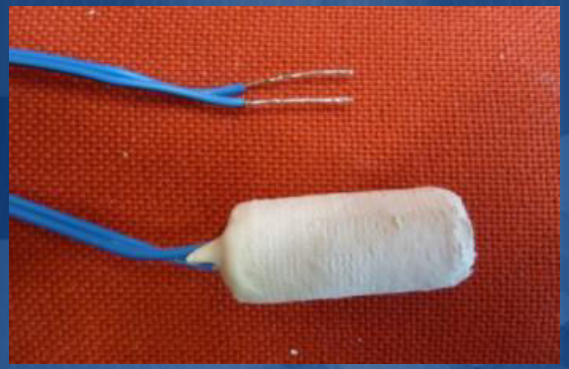
But how much detail is really useful in making decisions?

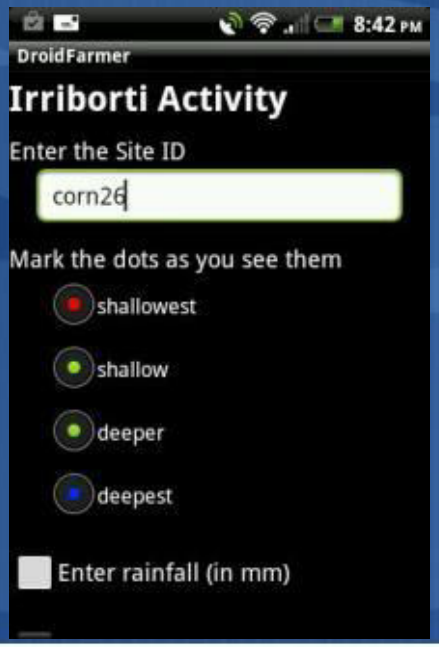
diabetesdad.org

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.



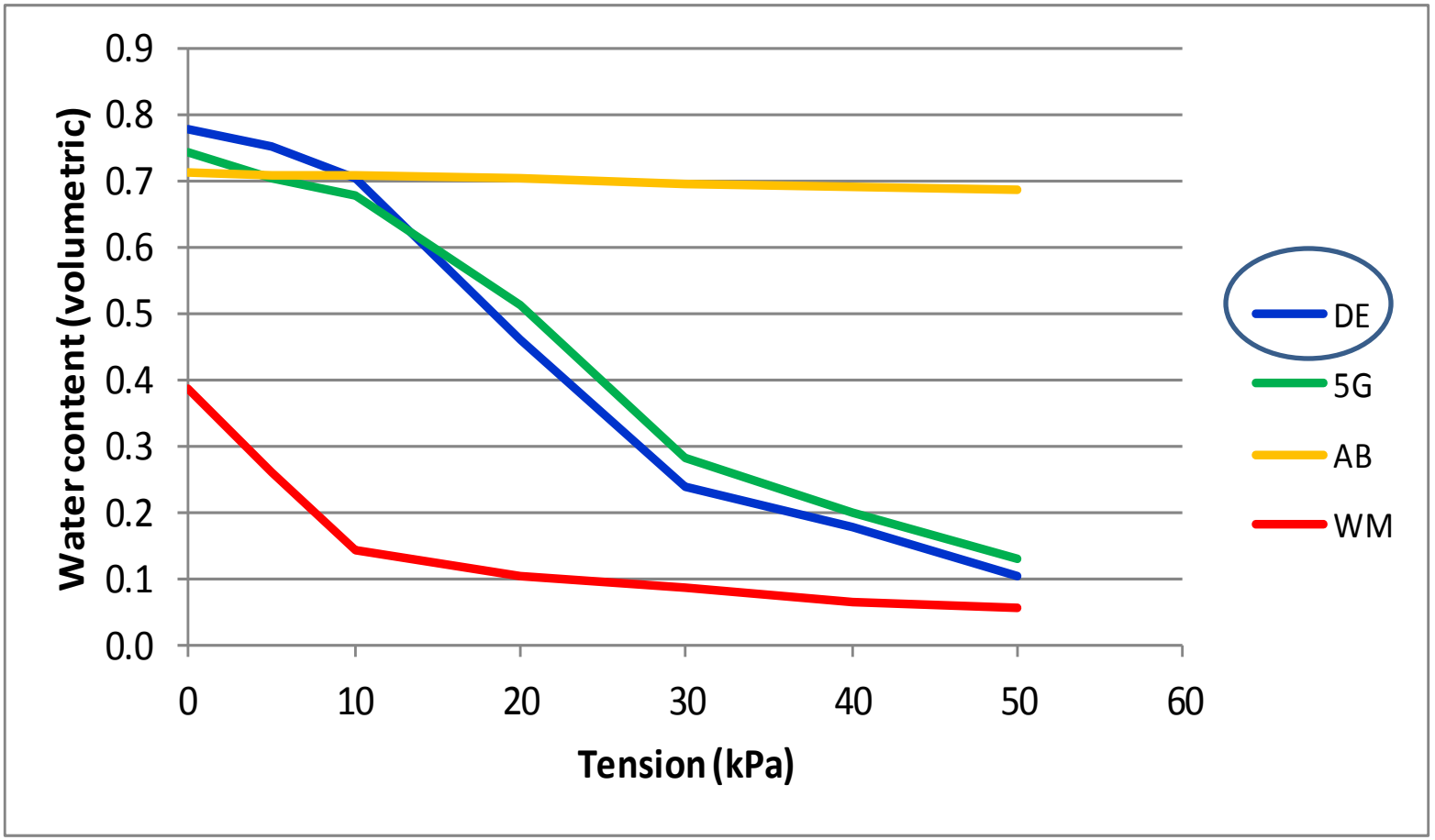


The Chameleon

Photo courtesy Mark Gush

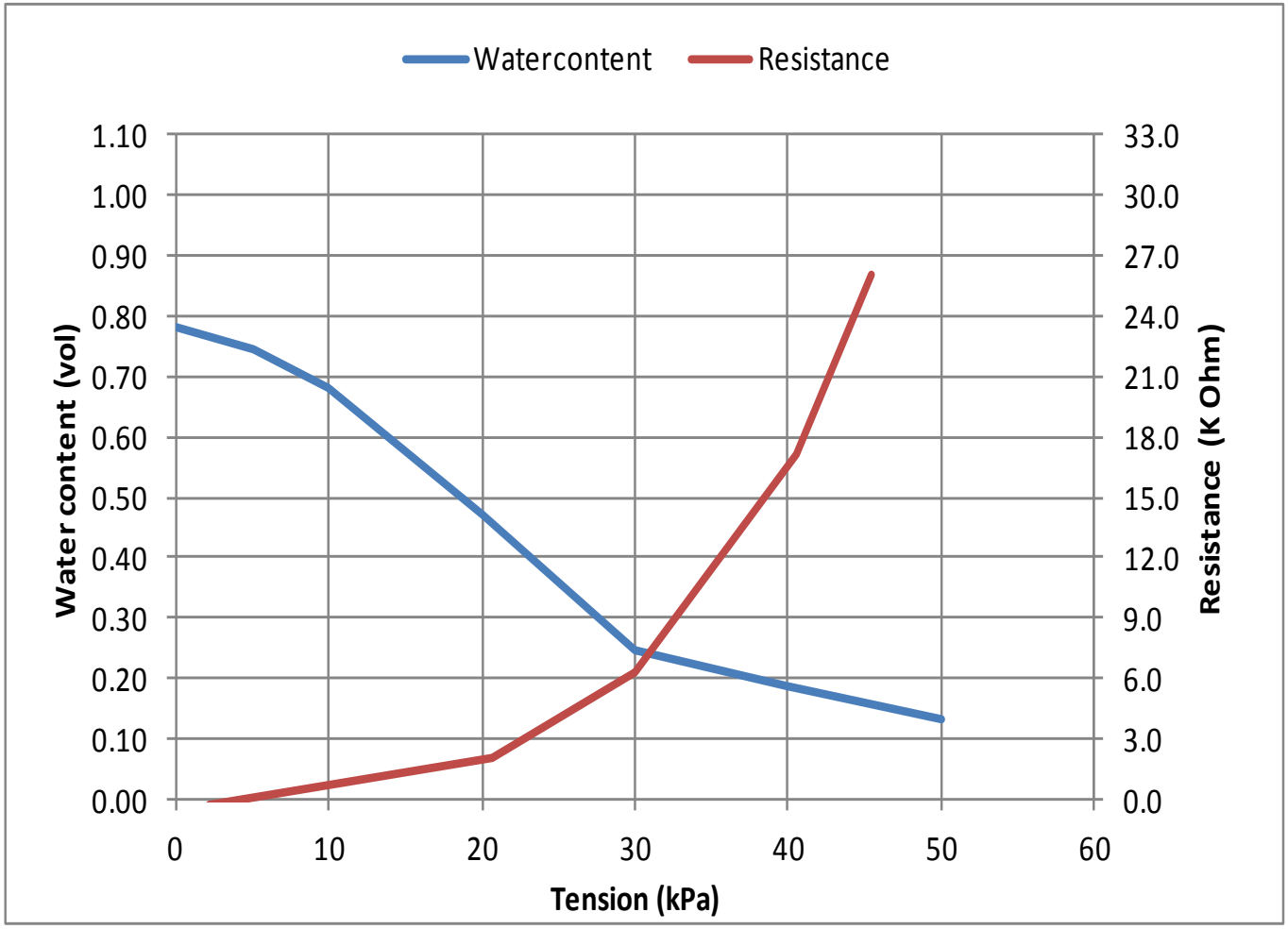
The switch points between blue, green and red lights are based on the extensive literature for avoiding crop water stress for most irrigated crops (Christen et al 2006)

Colour	Water level (Meaning)	Irrigate in this range (or before)	VEGETABLE CROP
Blue	Wet soil	20-30 kPa	Broccoli, Celery, Lettuce, Onion
Green	Moist soil	30-45 kPa	Beans, Cabbage, Carrot, Capsicum, Corn, Cucumber, Eggplant, Melons, Potato, Tomato,
Red	Dry soil	>60 kPa	Beet, Peas, Sweet potato, Pumpkin



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



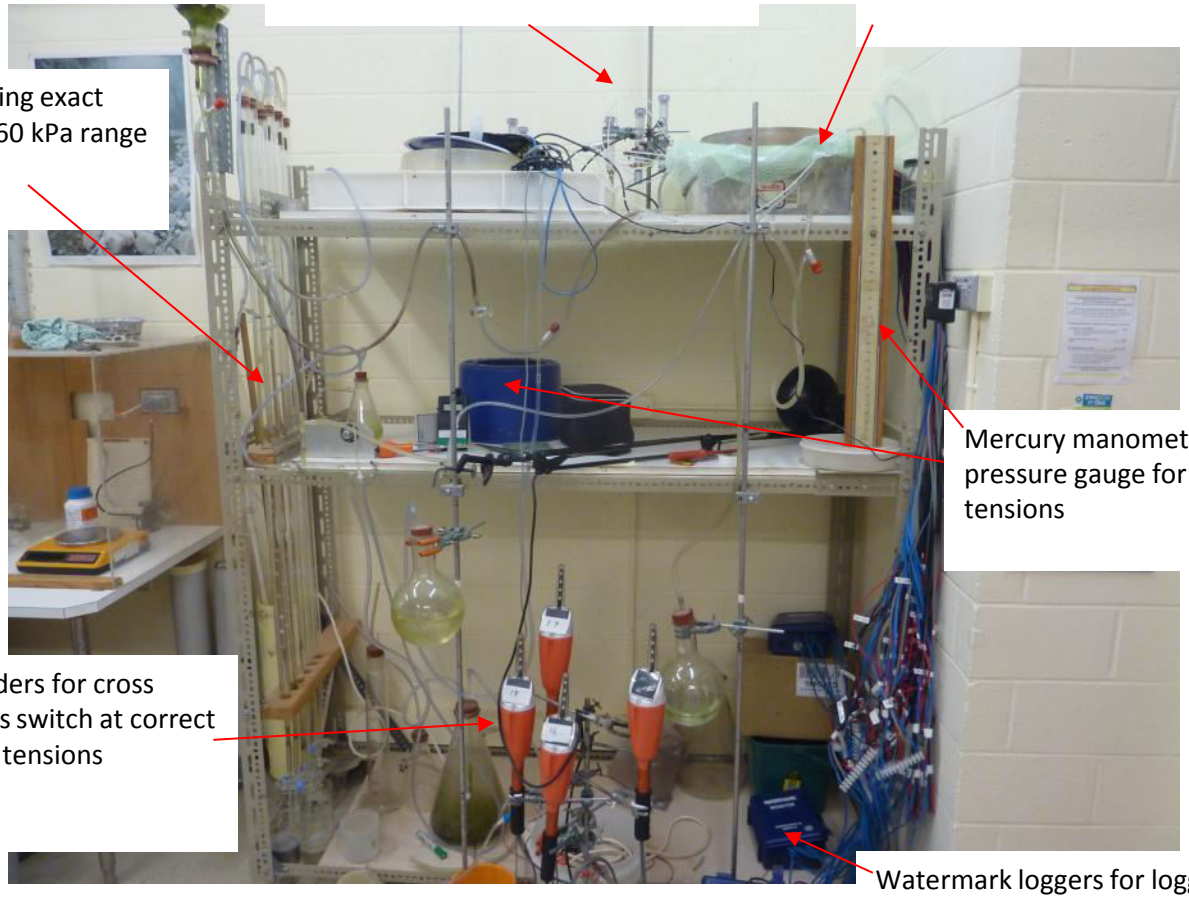
Sensors are handmade…

…and rigorously tested

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

Sensors buried in high conductivity bedding material on top of porous plate

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



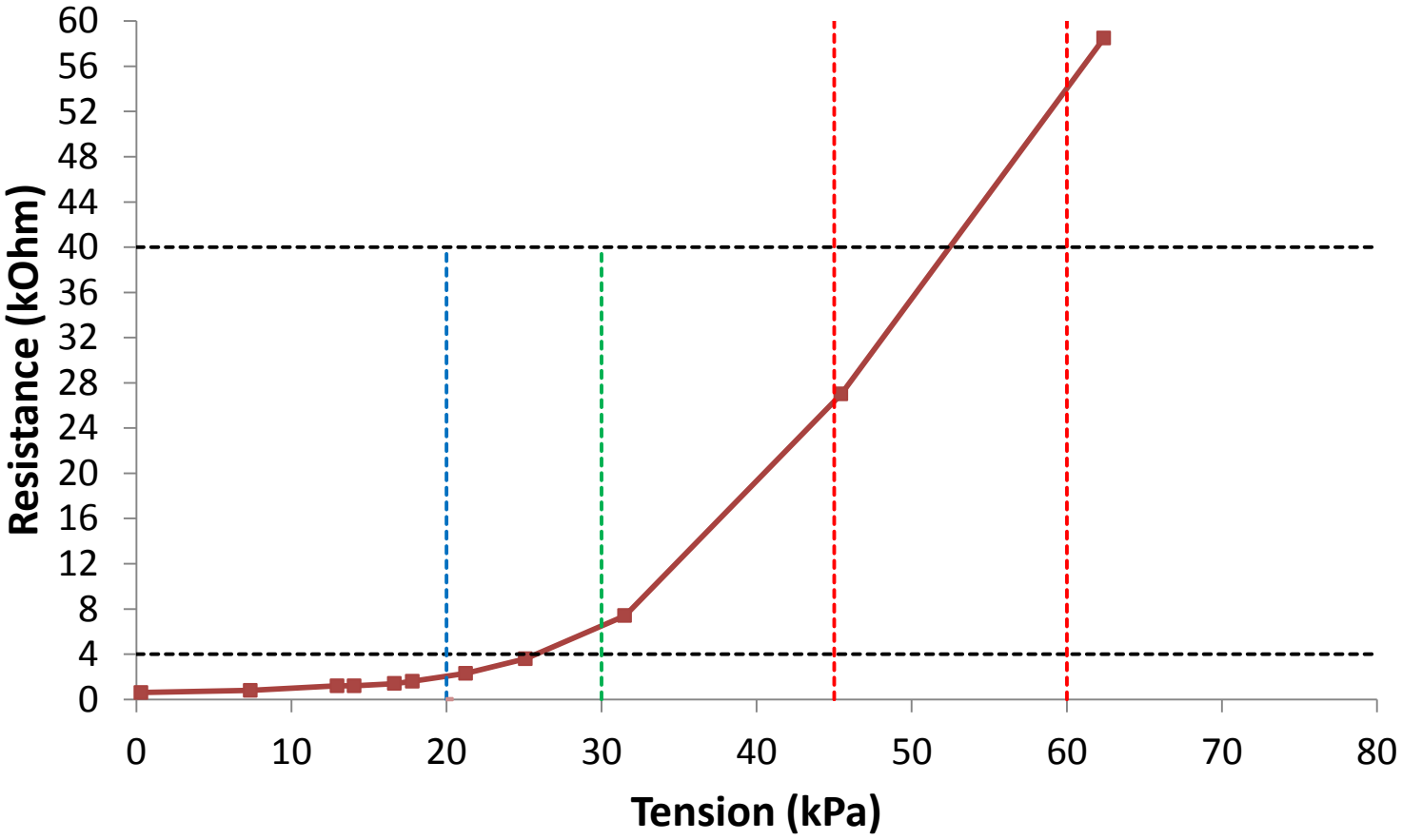
Mercury manometer and pressure gauge for checking tensions

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

Watermark loggers for logging resistance / tension

Set up for precision testing of sensors and readers

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

25 cm, kPa	10	14	18	18	26	28	34	40	34	24	30	32	46	59	25	21	10	12	12	16	14	14	17	18	12
50 cm, kPa	18	15	17	18	19	22	28	31	27	32	36	44	68	71	70	68	65	57	30	23	15	18	18	22	25
25 cm, Chameleon	B	B	B	B	B	B	G	G	G	G	G	G	G	G	G	G	B	B	B	B	B	B	B	B	B
50 cm, Chameleon	B	B	B	B	B	B	B	G	G	G	G	G	R	R	R	R	R	G	G	G	G	G	G	G	G

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"

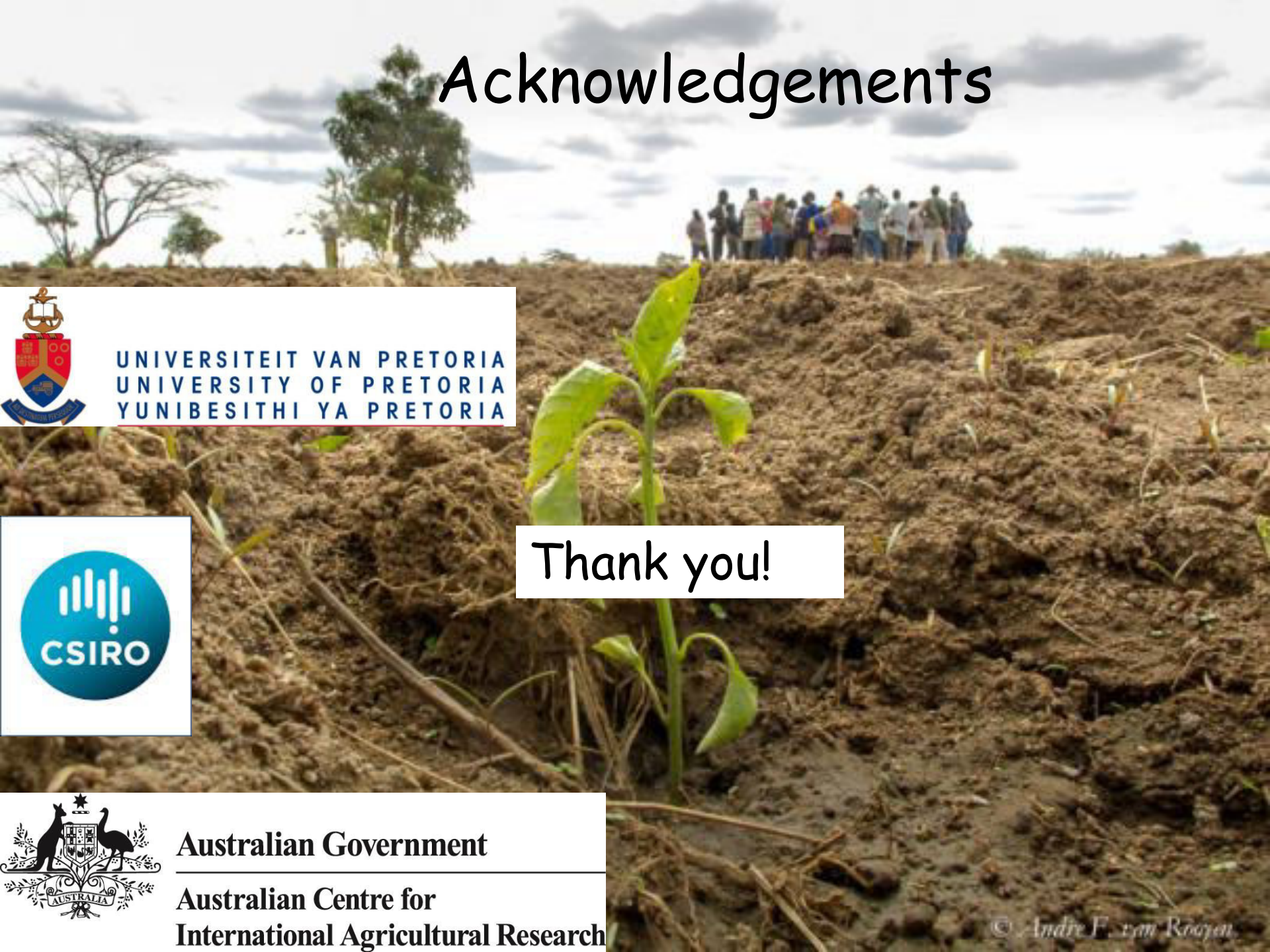
Farmer-based learning with the Chameleon

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



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Thank you!