

# Soil-based sensors and irrigation scheduling

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- Water content measurement
- Relationship between water content and matric potential
- Water-filled tensiometers
- Porous matric sensors
- Field measurements of matric potential
- Example of a sensor controlled irrigation in Turkey
- Conclusions

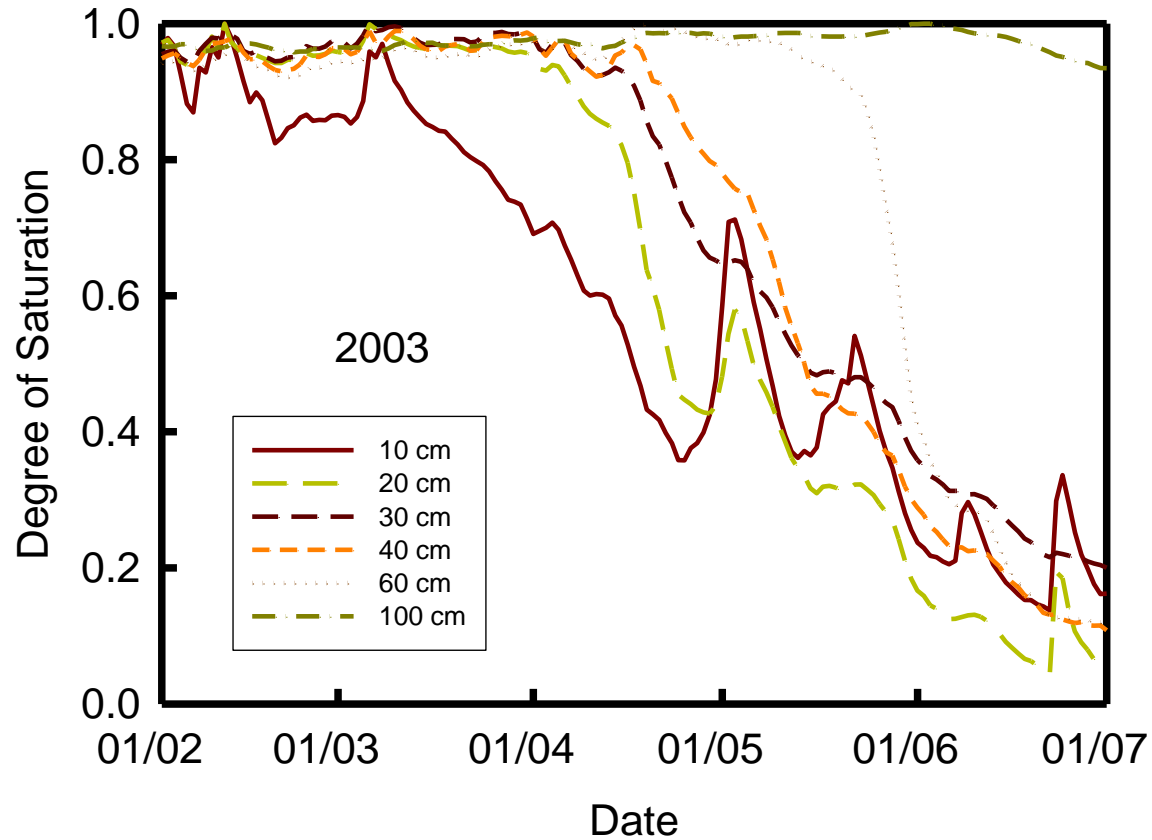
# Water content



# Using a profile probe

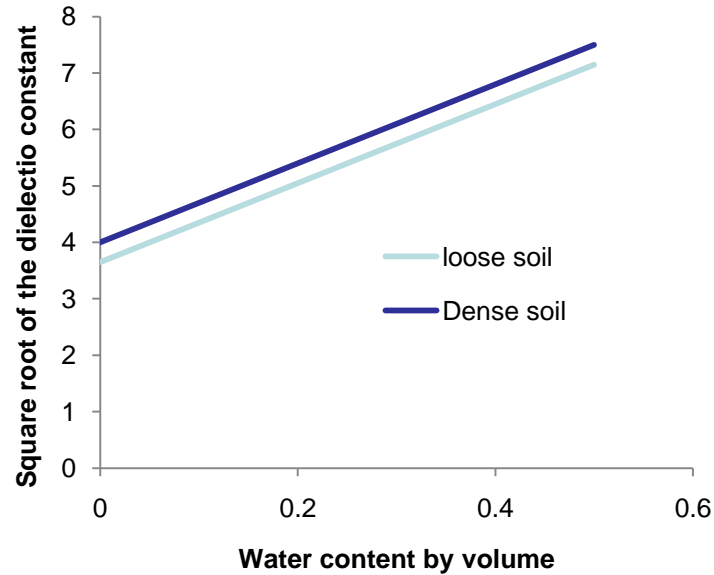


# Example of soil drying data

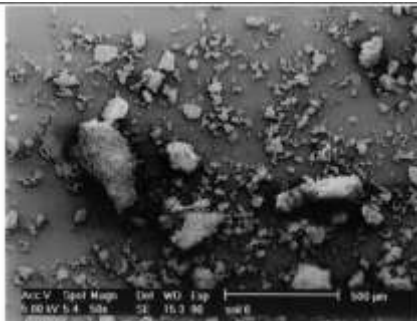


# Generic problems with soil water content sensors

## 1. Soil density



## 2. Soil type:

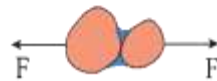
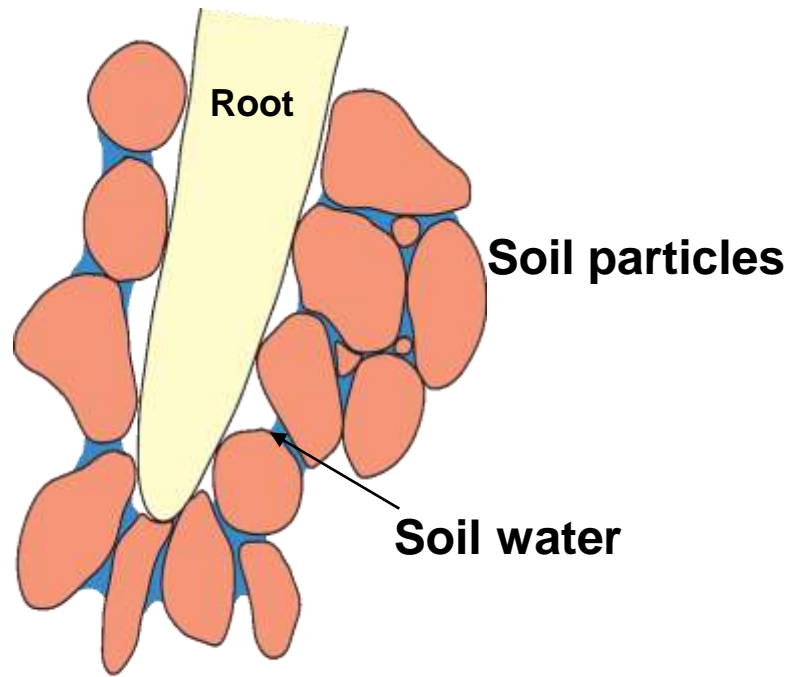


## 3. Temperature effects

Table 1. Dielectric constant of water.

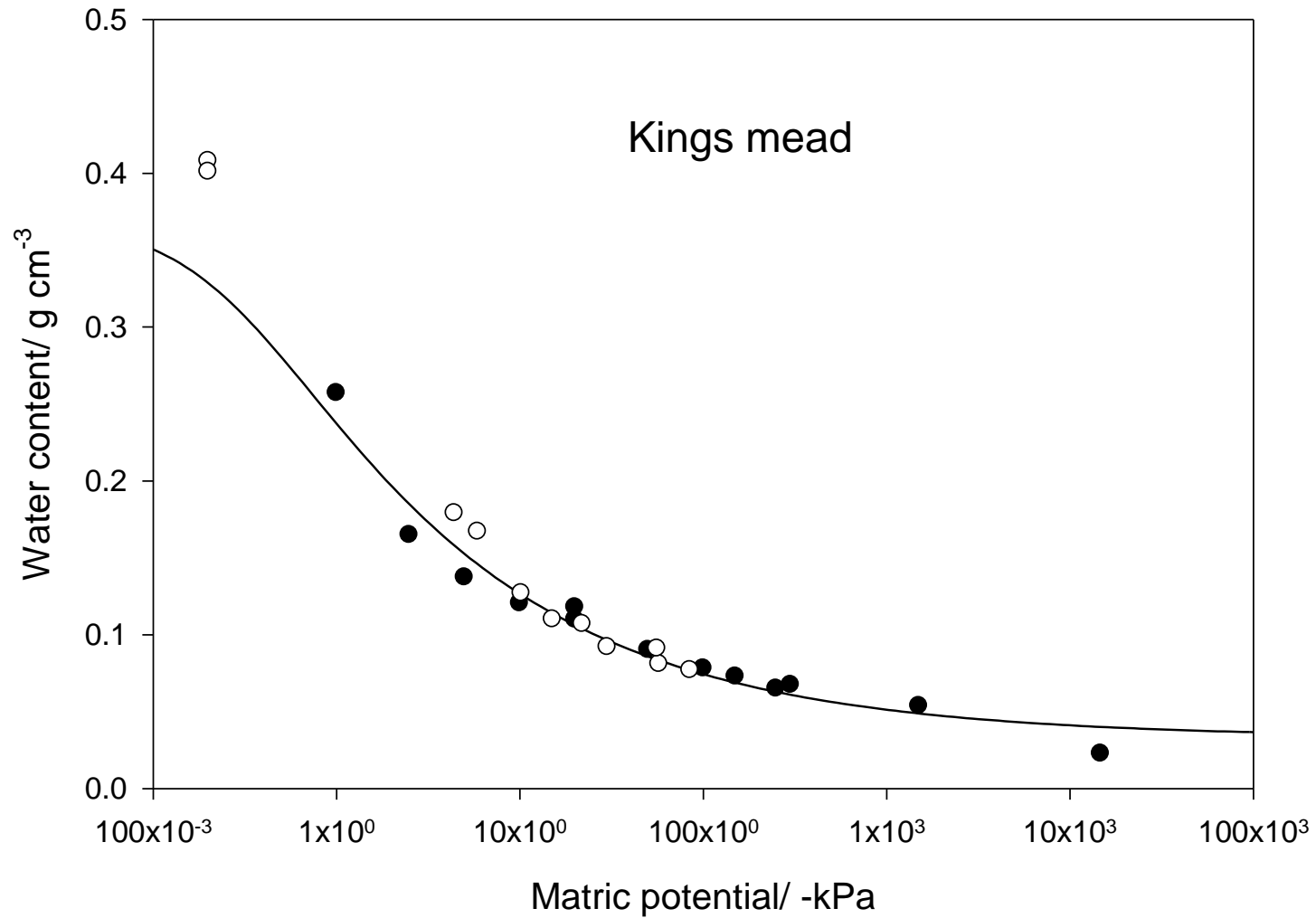
T (°C)	K	T (°C)	K
0	88.00	40	73.28
5	86.40	45	71.59
10	84.11	50	69.94
15	82.22	60	66.74
20	80.36	70	63.68
25	78.54	80	60.78
30	76.75	90	57.98
35	75.00	100	55.33

# Water release characteristic

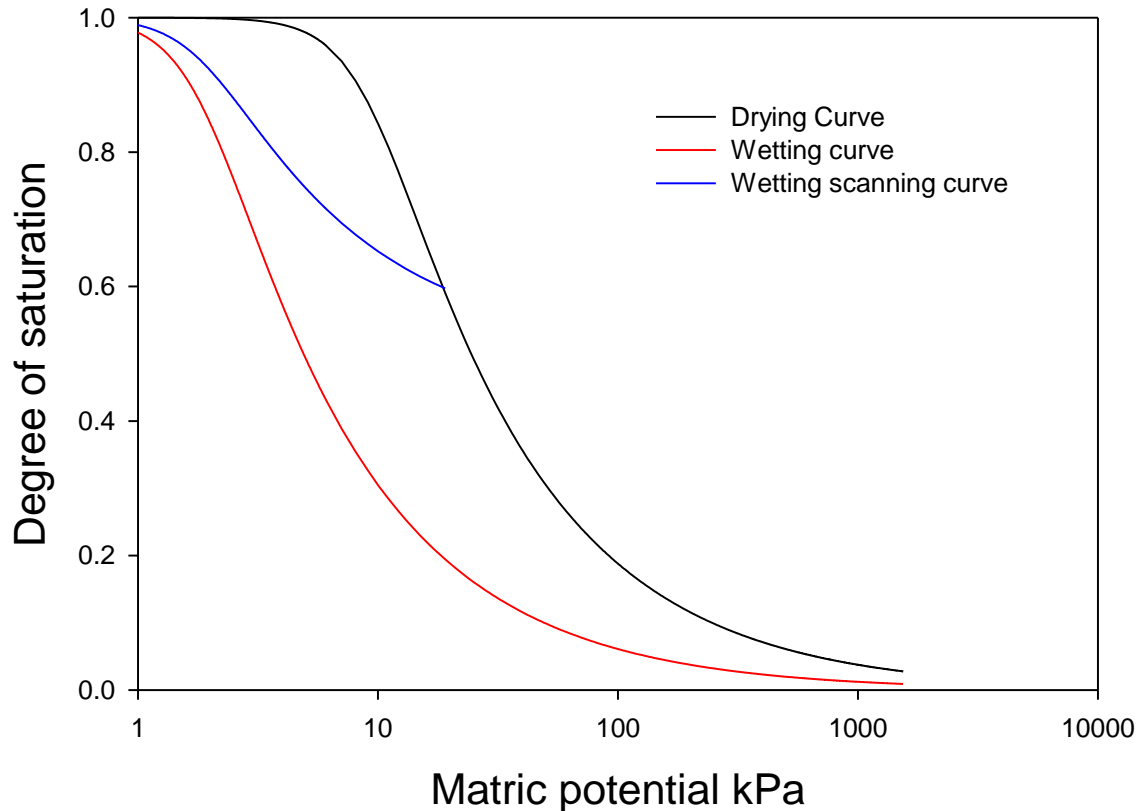


**Capillary pressure**

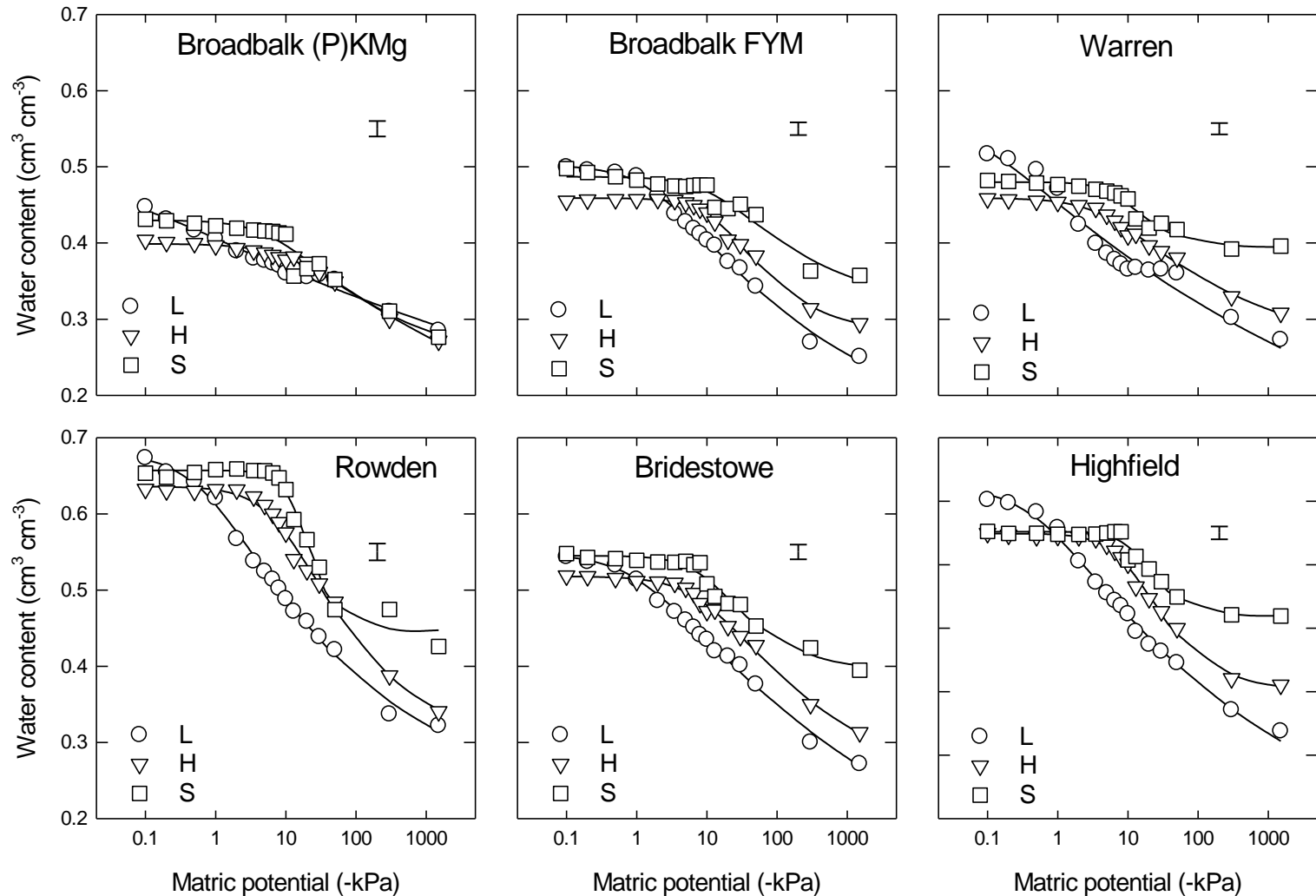
# Water release curve for a sandy soil



# Non unique nature of the water release curves



# Effects of soil deformation on the water release characteristic

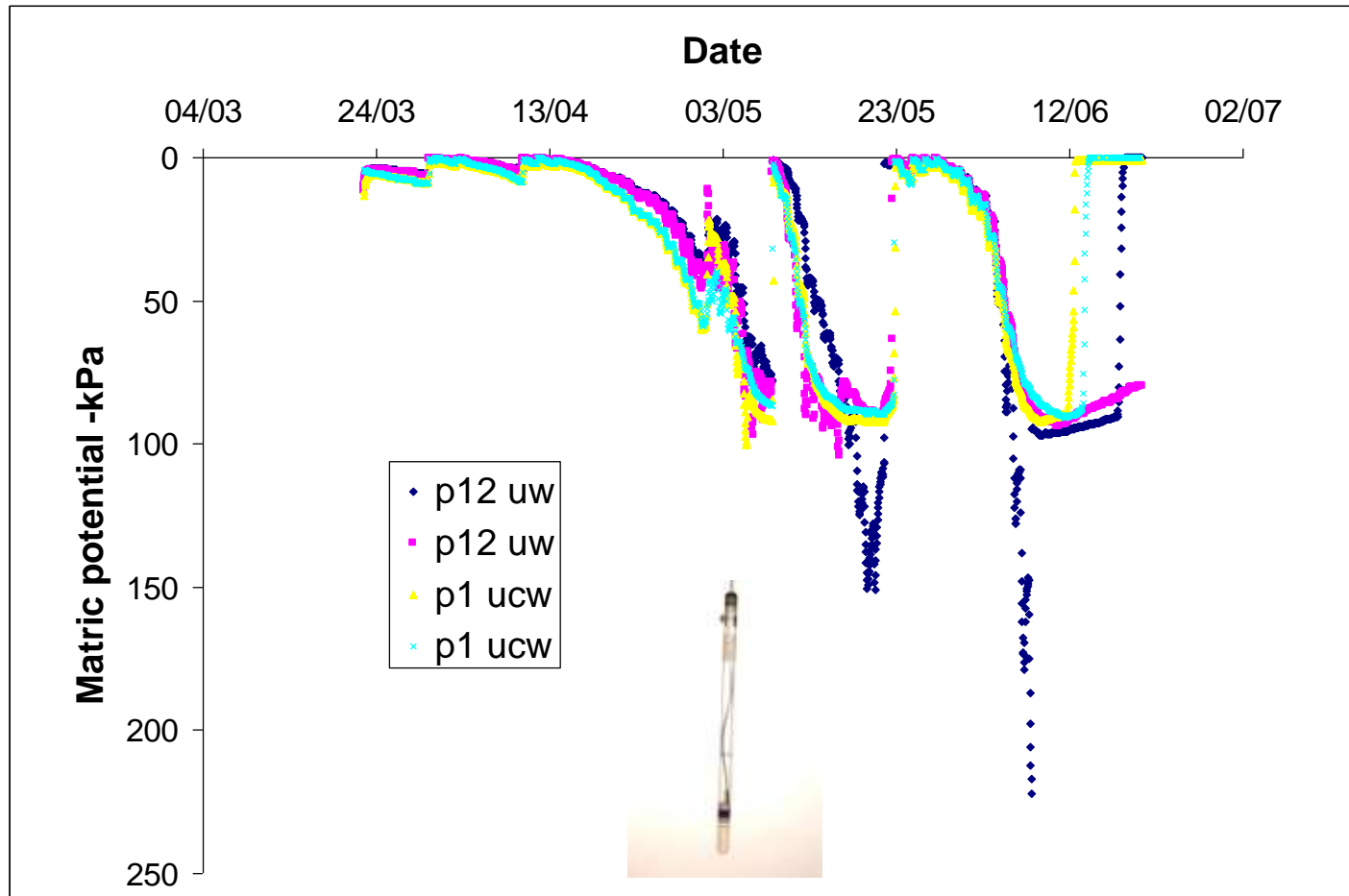


# The water-filled tensiometer

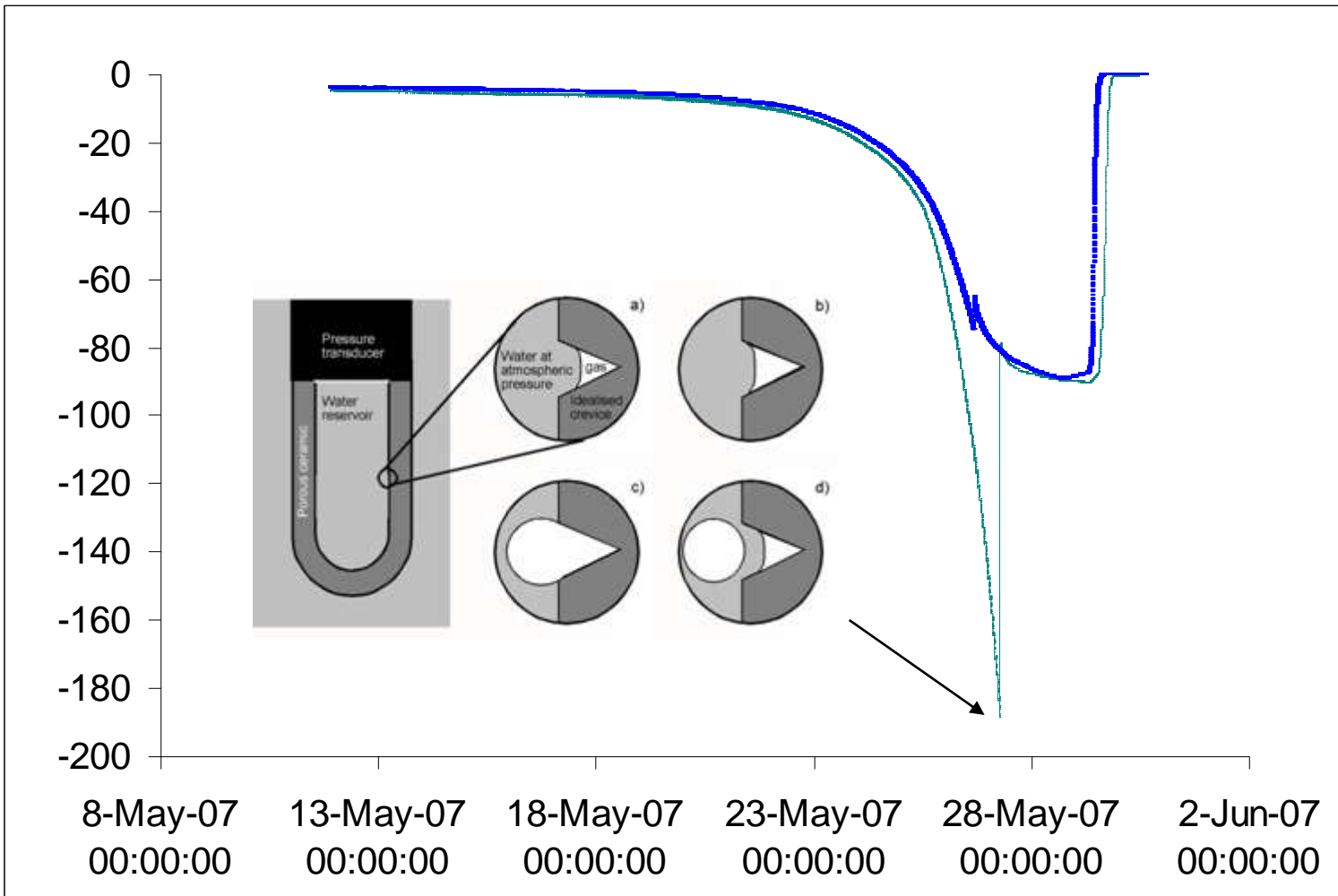


Typically used between  
0 and -90 kPa

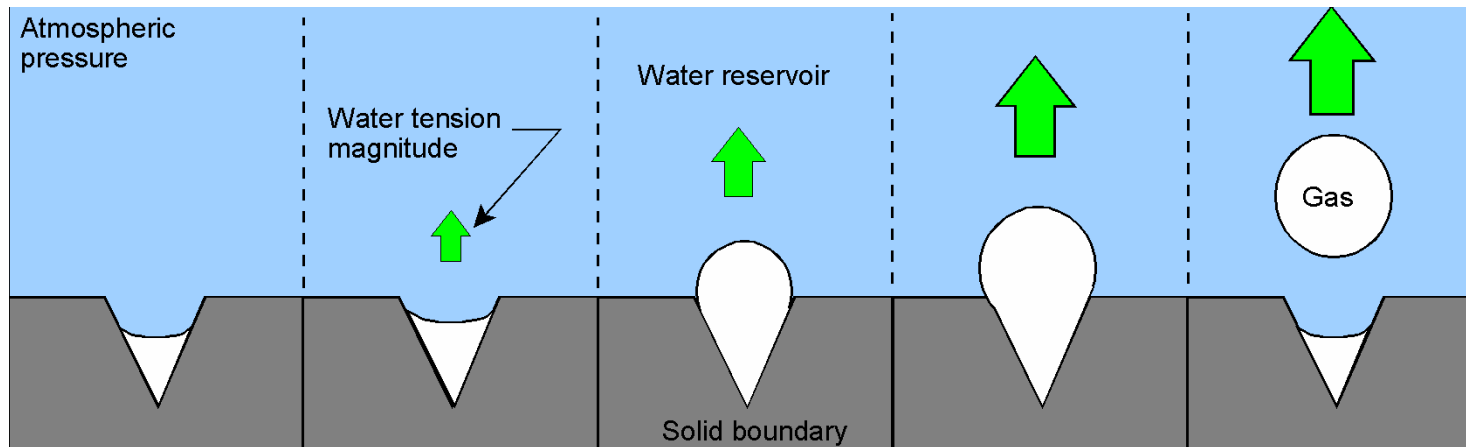
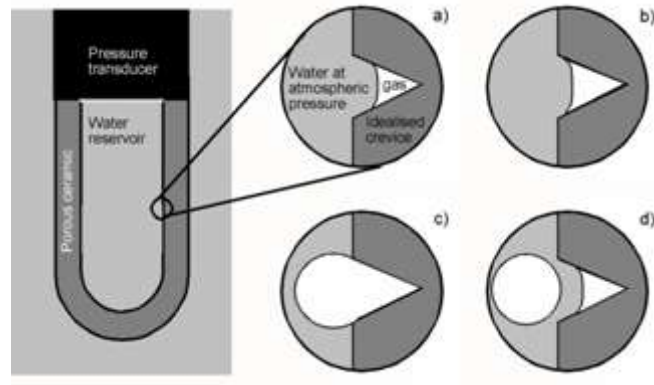
# Measure range of water filled tensiometers?



# Behaviour of two commercial water-filled tensiometers



# Why do water-filled tensiometers fail?

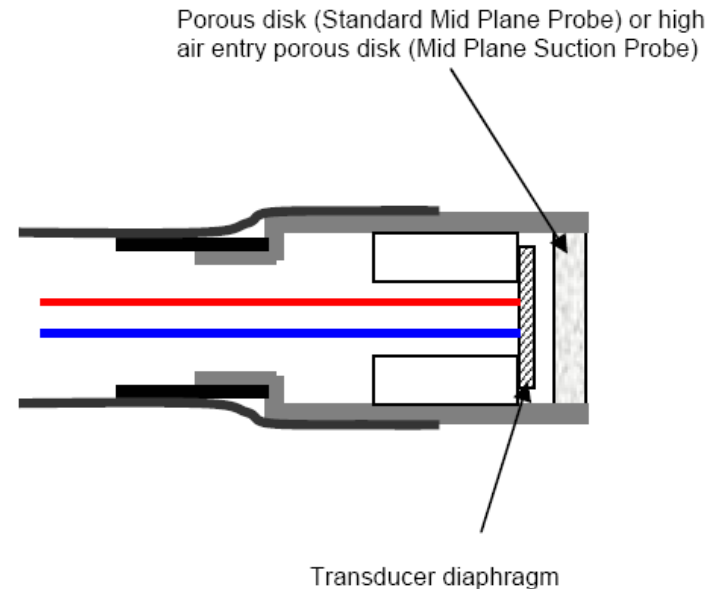


# Solutions

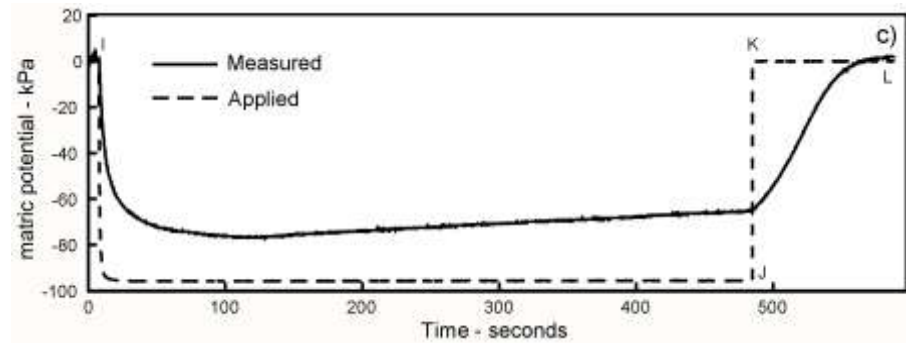
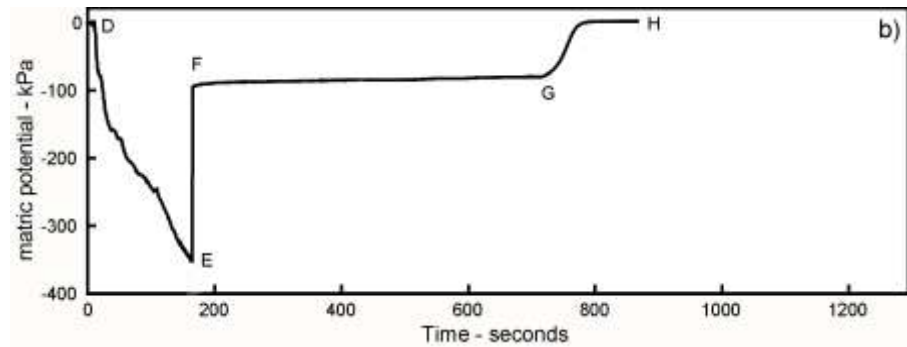
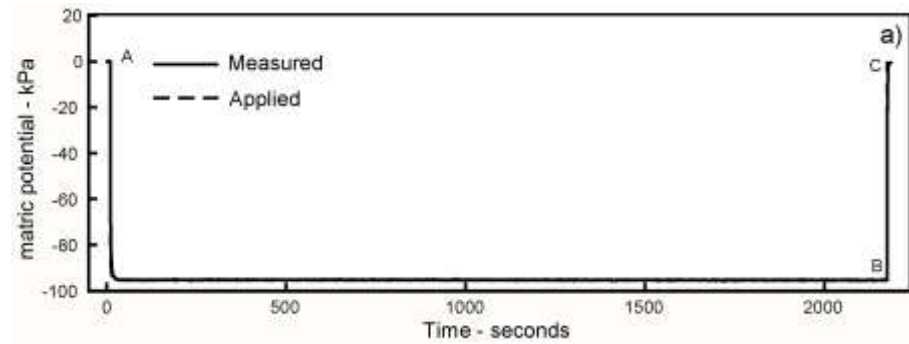
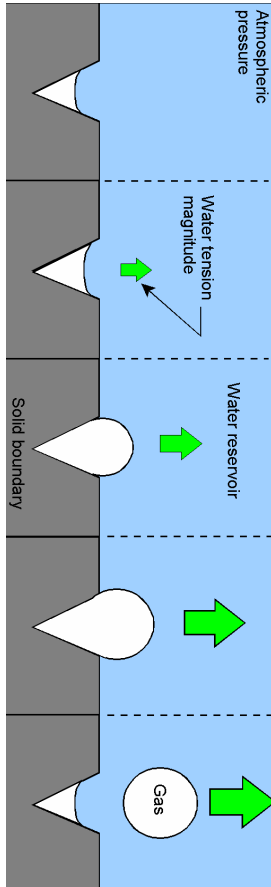
## *High capacity tensiometers*

Advantage:  
Direct reading  
Very accurate  
Wide measurement range

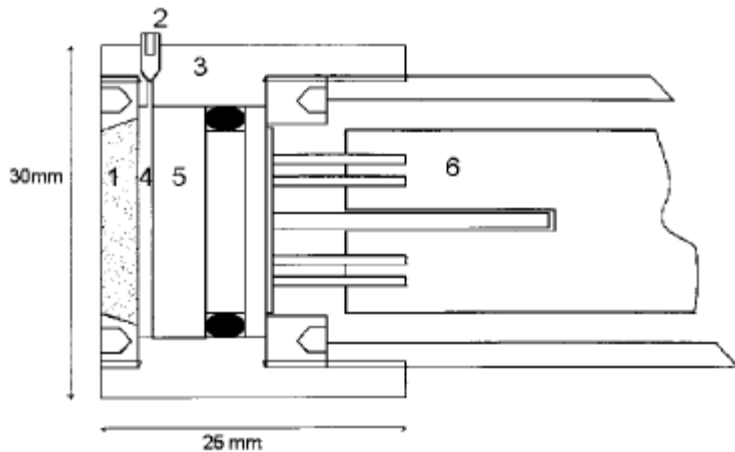
Disadvantage:  
Need specialist knowledge to use  
High cost



# Use of a high capacity tensiometer



# Osmotic tensiometer

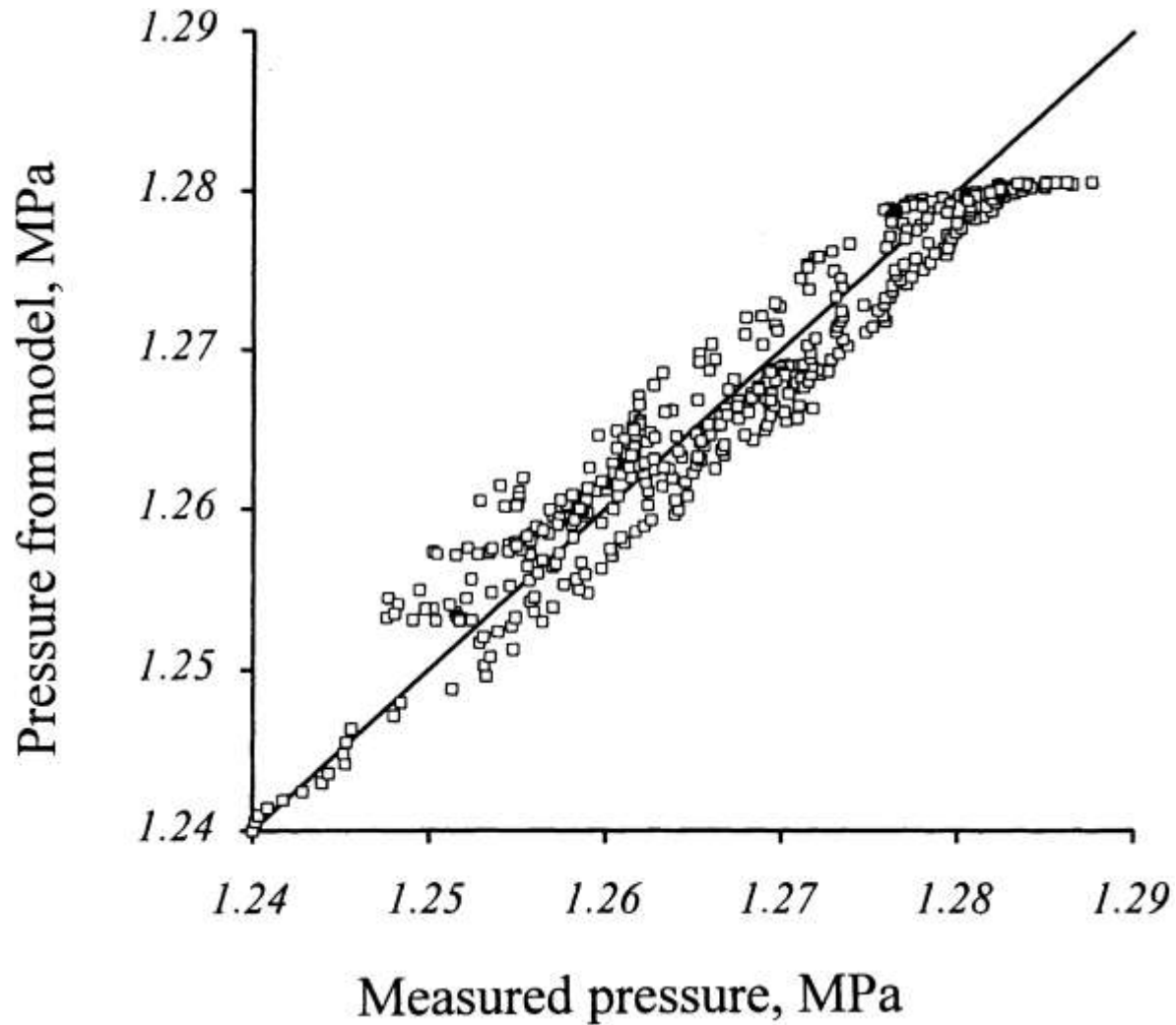


**Fig. 1. Construction of osmotic tensiometer: 1, ceramic filter; 2, injection point; 3, brass housing; 4, cell filled with polymer-water solution; 5 pressure transducer; 6, data transfer.**

When the soil is saturated it reads a high positive pressure

When the soil is dry it reads a low but positive pressure

From Maarten Biesheuvel et al. SSSAJ 1999



# Porous matrix sensors



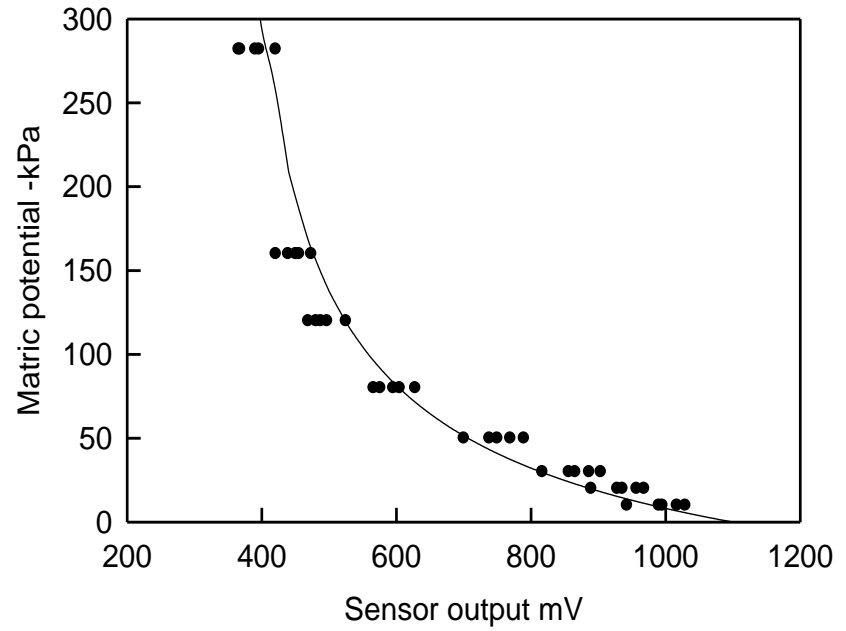
Spaans, E.J.A. & Baker, J.M. 1992.  
Calibration of Watermark soil-moisture sensors for soil matric potential and temperature.  
*Plant and Soil*, 143, 213–217.

“calibration varies when the same sensor is repeatedly calibrated in the same soil”

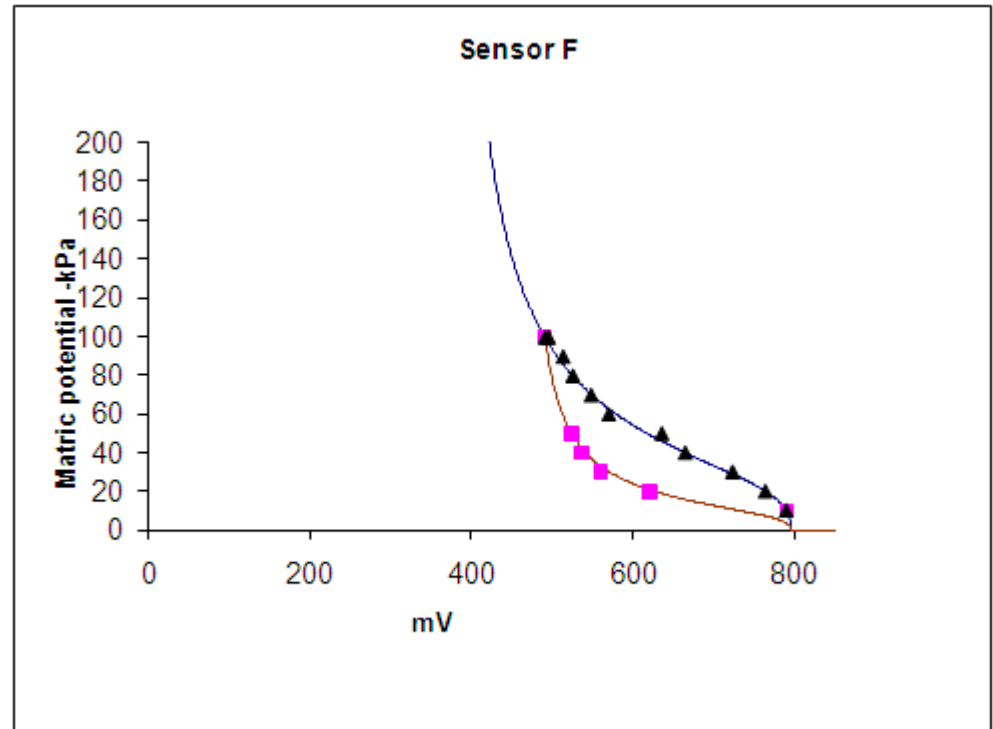
# A porous matrix sensor



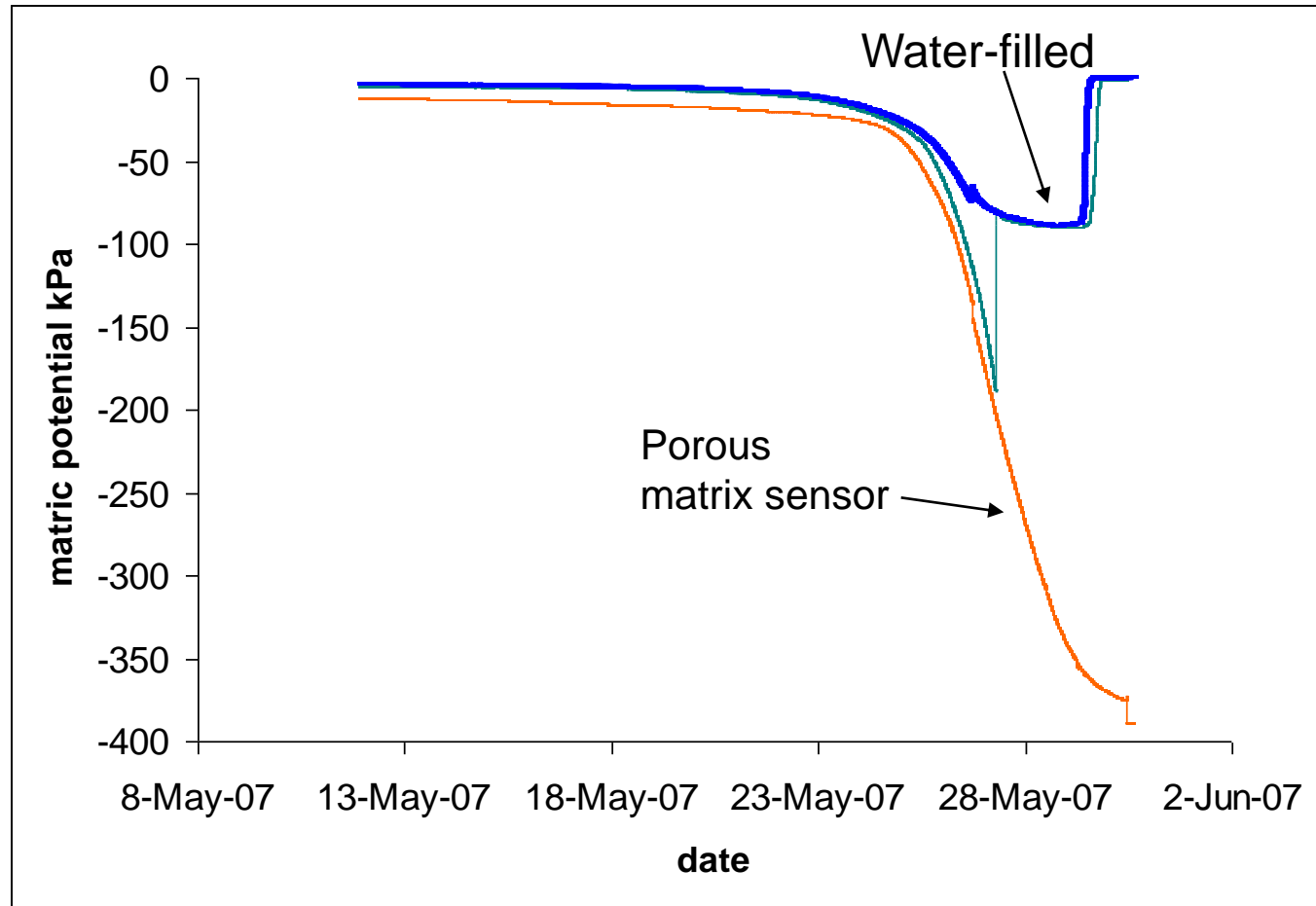
Water release  
characteristic of  
the porous matrix



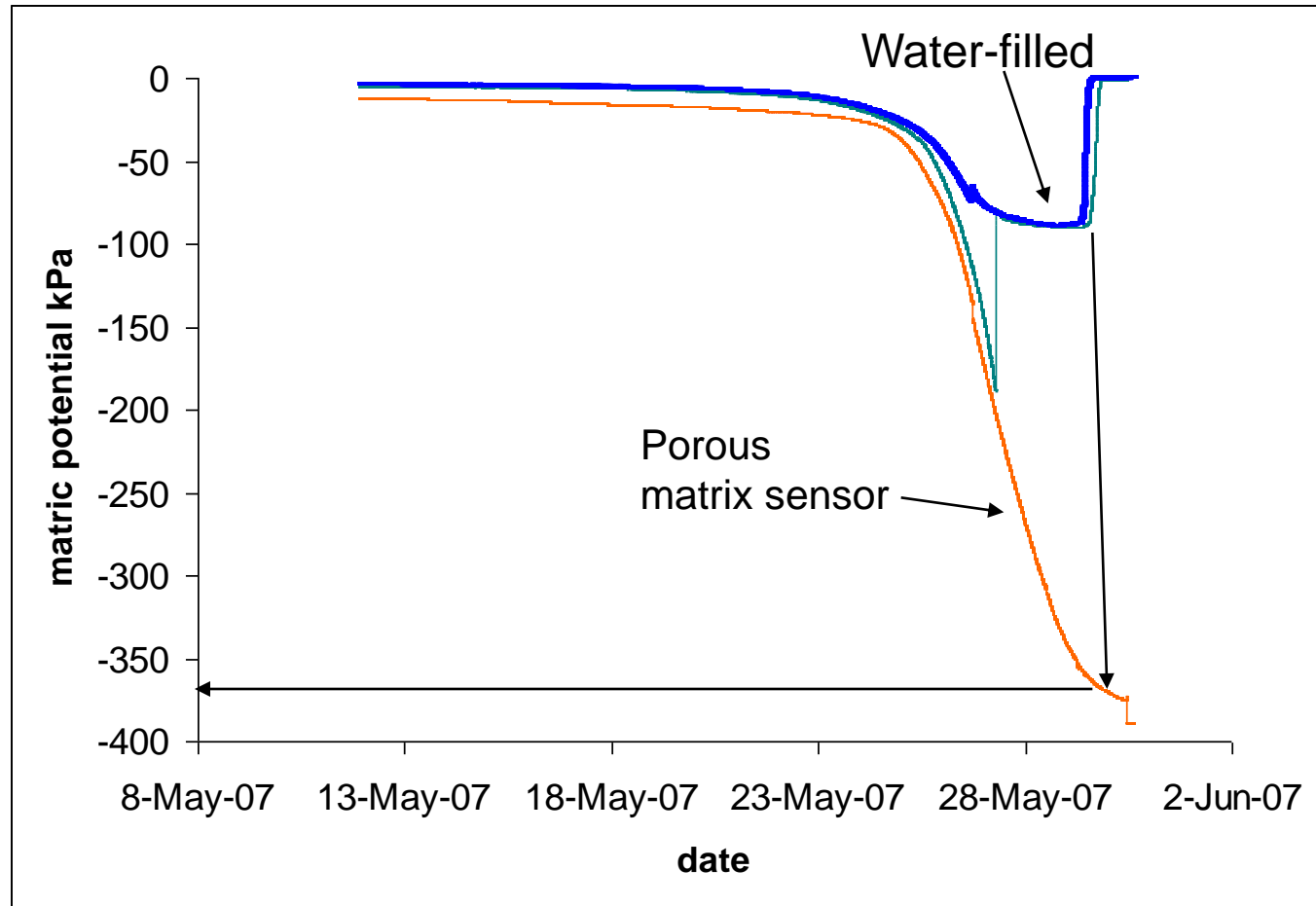
# Hysteresis?



# Porous matrix and water-filled tensiometers in drying soil



# Porous matrix and water-filled tensiometers in drying soil



# Cucumber farm in Turkey





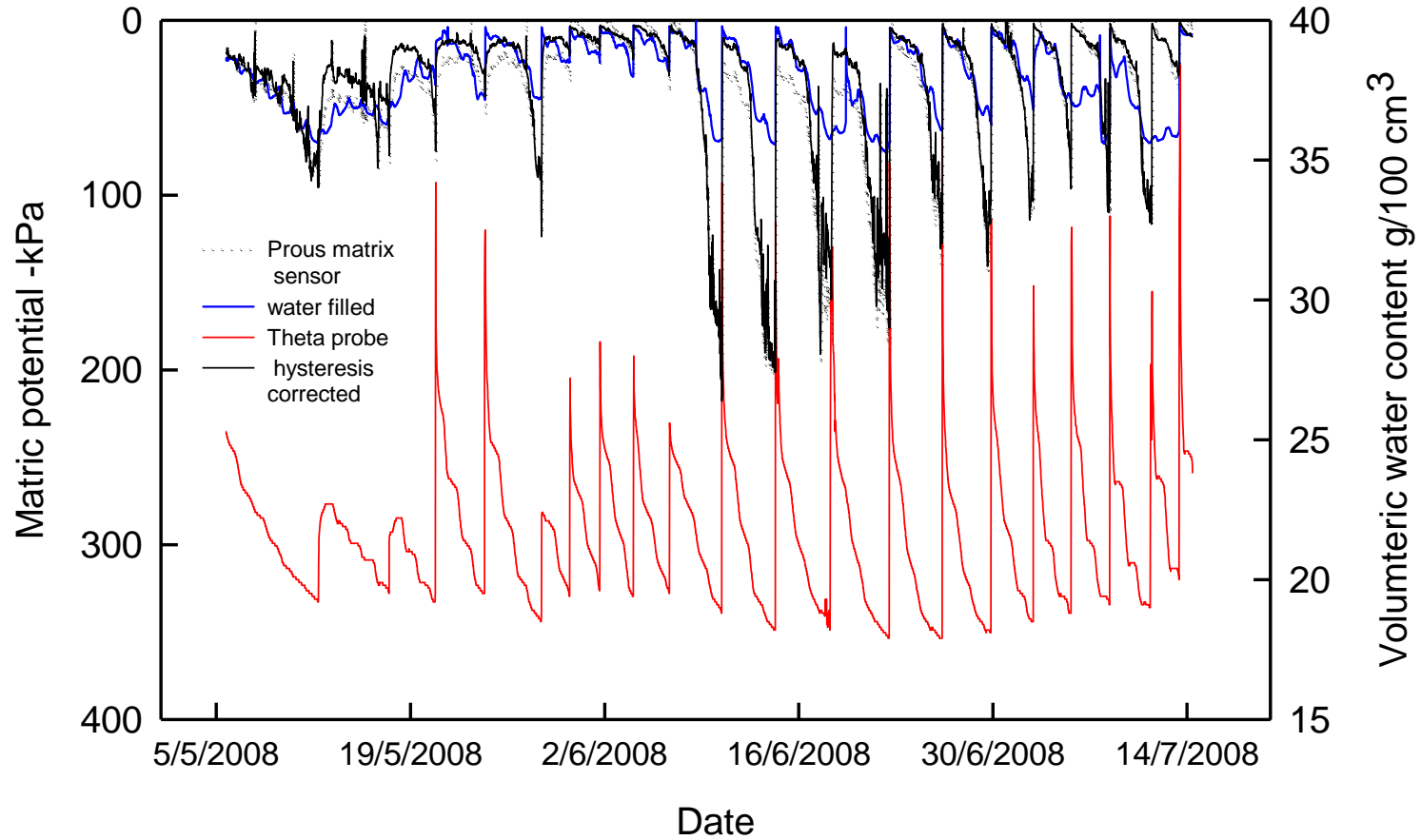
# Field experiment



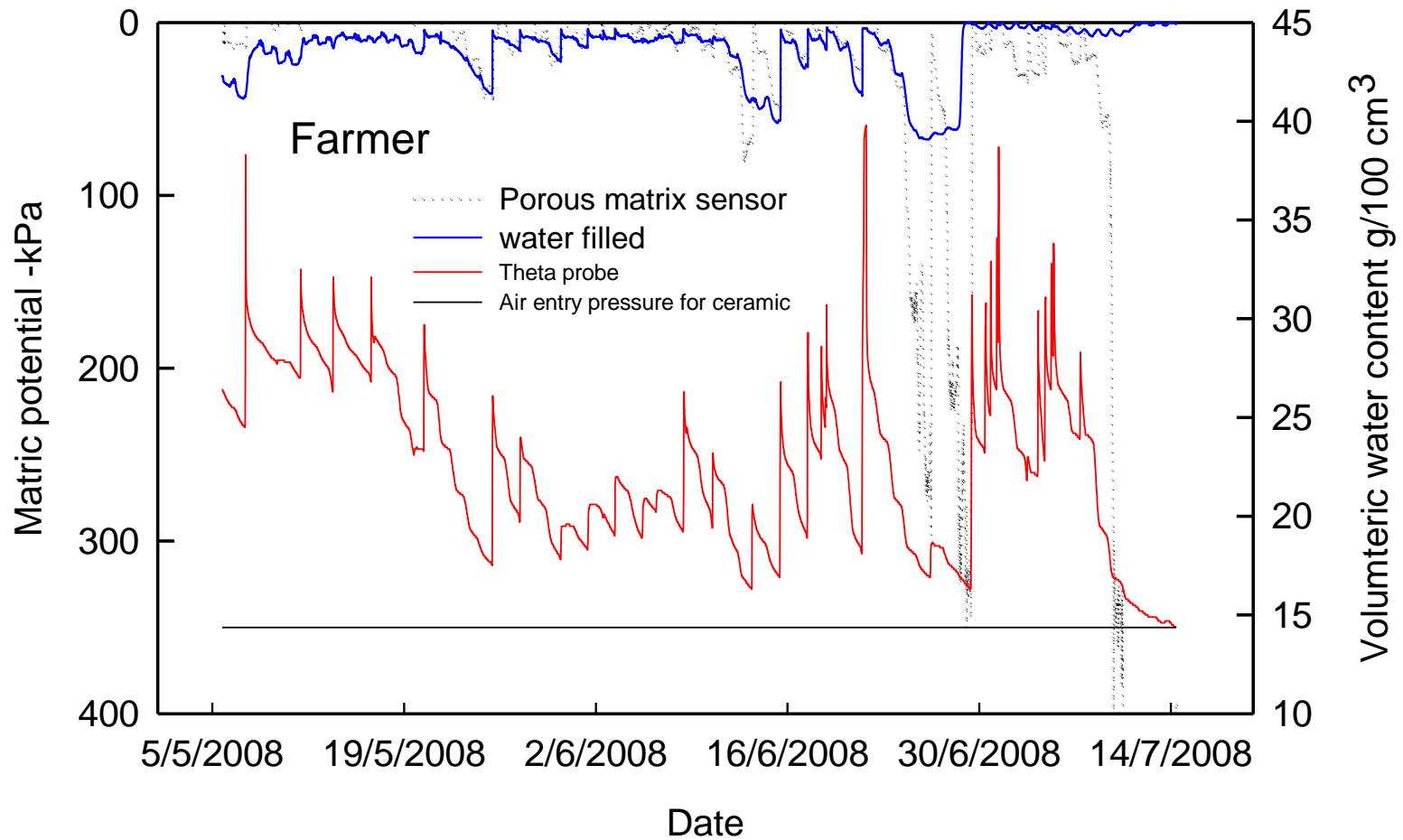
# Installing sensors in the field



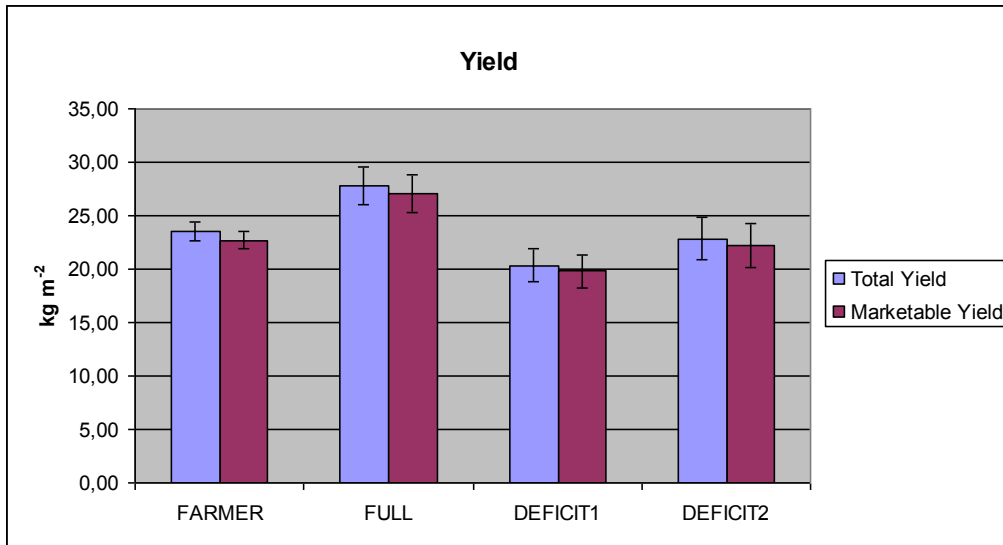
# Field data



# Field data

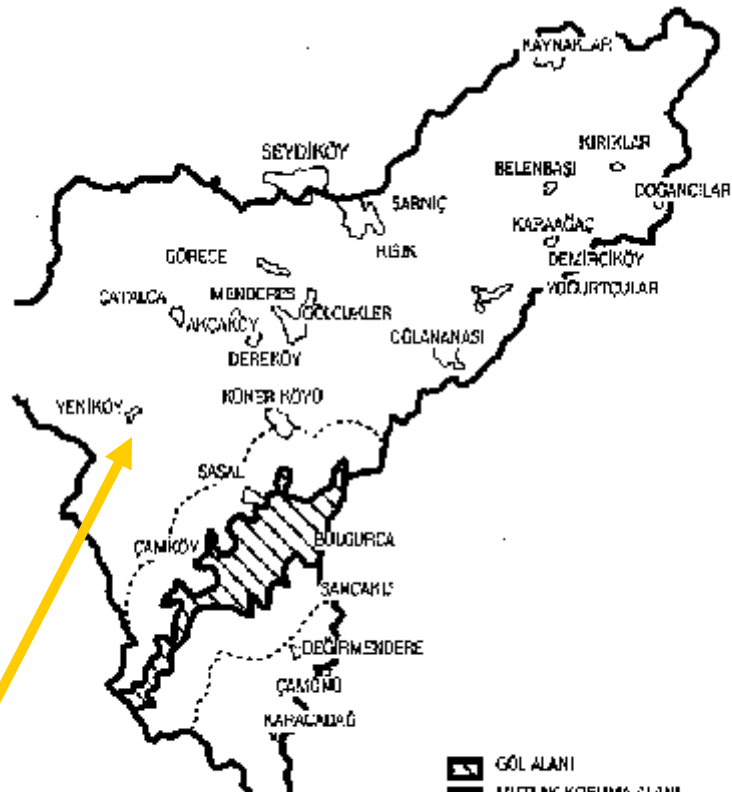


# Yield data



	Water consumption mm	Water use efficiency kg/m <sup>3</sup>
Full irrigation	591	39.5
Deficit 1	387	50.7
Deficit 2	436	50.1
Farmer	534	35.7

# Reducing water use in Izmir, Turkey



**Total protection zone :**

**51 808 ha**



# Concluding comments

- Water-filled tensiometers can measure low matric potentials, but even the best of these sensors will cavitate in drying soil
- We have shown how and why water filled tensiometers can give false readings of matric potential for extended periods of time
- We have shown that it is not wise to re-fill tensiometers in drying soil
- Porous matrix sensors are more reliable in dry soils
- While intuitively one thinks water-filled tensiometer are better because they give a direct reading. We have shown examples of when a porous matrix sensor is more accurate.

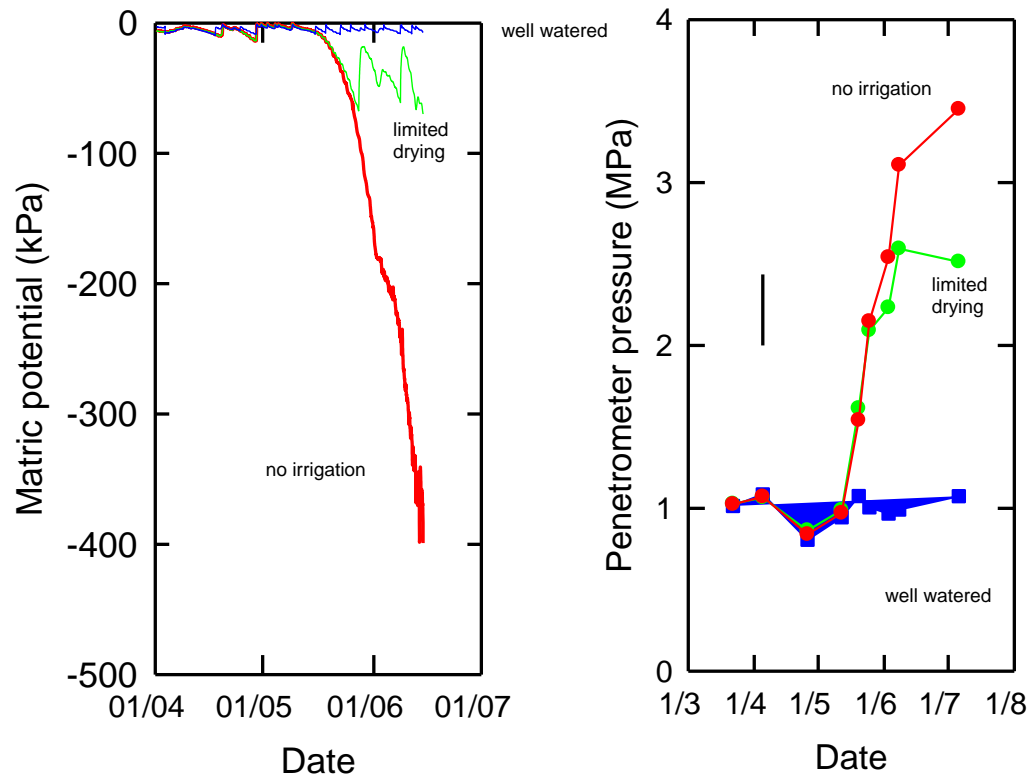
# Future developments

Improved logging systems

Internet access to logging systems

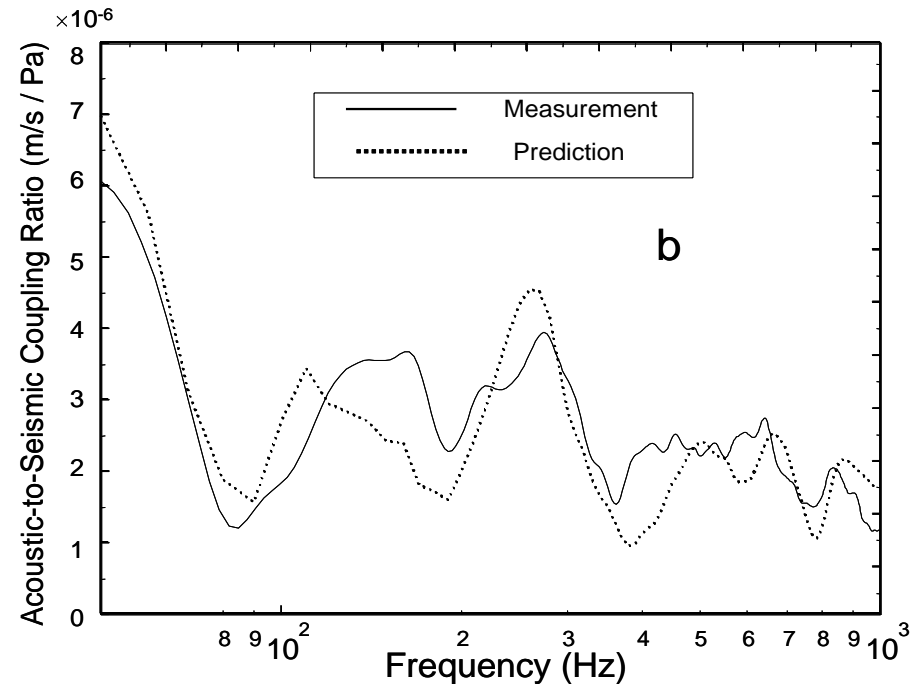
Exploitation of data on multiple stress

## Dealing with multiple stresses



The matric potential and penetrometer strength of soil under different irrigation regimes in a field of wheat. Note the greatly increased strength of soil after only limited drying, and the low matric potential of non-irrigated soil. The colours correspond to the same irrigation treatments.

# Non-invasive sensing of soil



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1 May 2010 to April 2013.