



Tools for irrigation management: theory and practice of tensiometry

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HORTAU

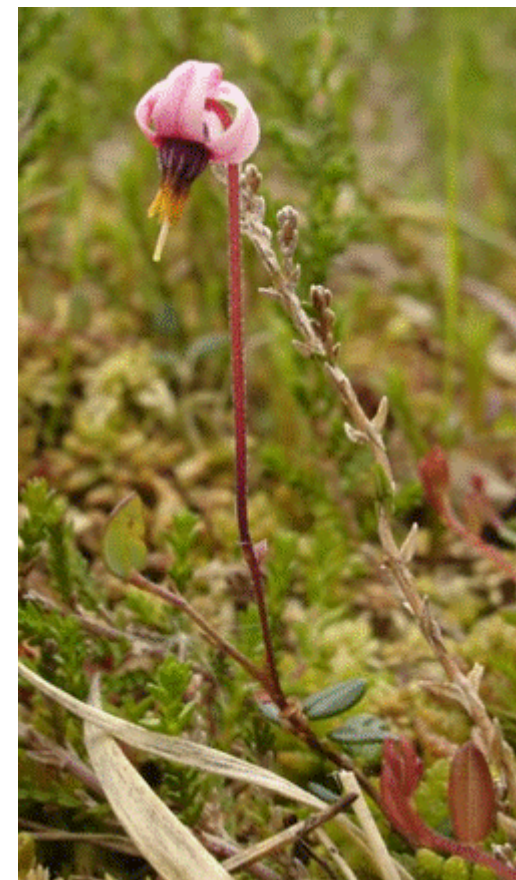
The basics of tensiometry: principles and advantages

The use of tensiometers in cranberry production



HORTAU

The basics of the technology



Categories of irrigation management tools

- **Blind: timers**
- **Based on plant uptake**

Level		Plant	Atmosphere	Soil
Measurement type	direct	Photosynthesis Transpiration Xylem potential		Tension
	indirect	Leaf temperature Fluorescence	Evapotranspirative demand	Water content

- **Research applications**
- **Limited field use**
- **Expansive**
- **Use to calibrate other approaches**

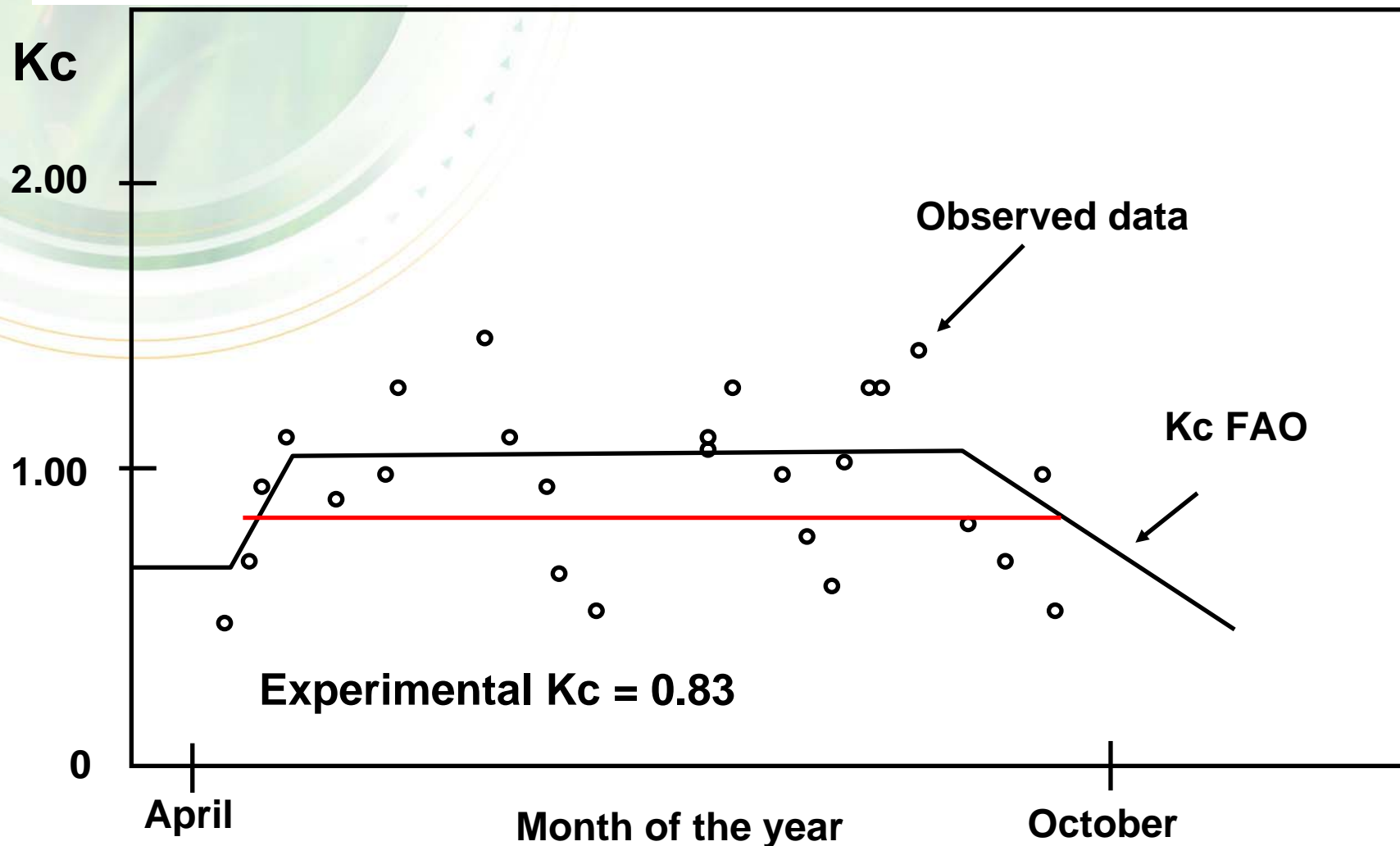
Evapotranspiration

- Based on meteorological (temperatures, net radiation, wind velocity, crop development)
- Largely used in North America
- Relatively simple
- Limited accuracy
- Calibrated with soil data (tension or water content) to prevent drift, waterlogging and excess leaching or drought stress

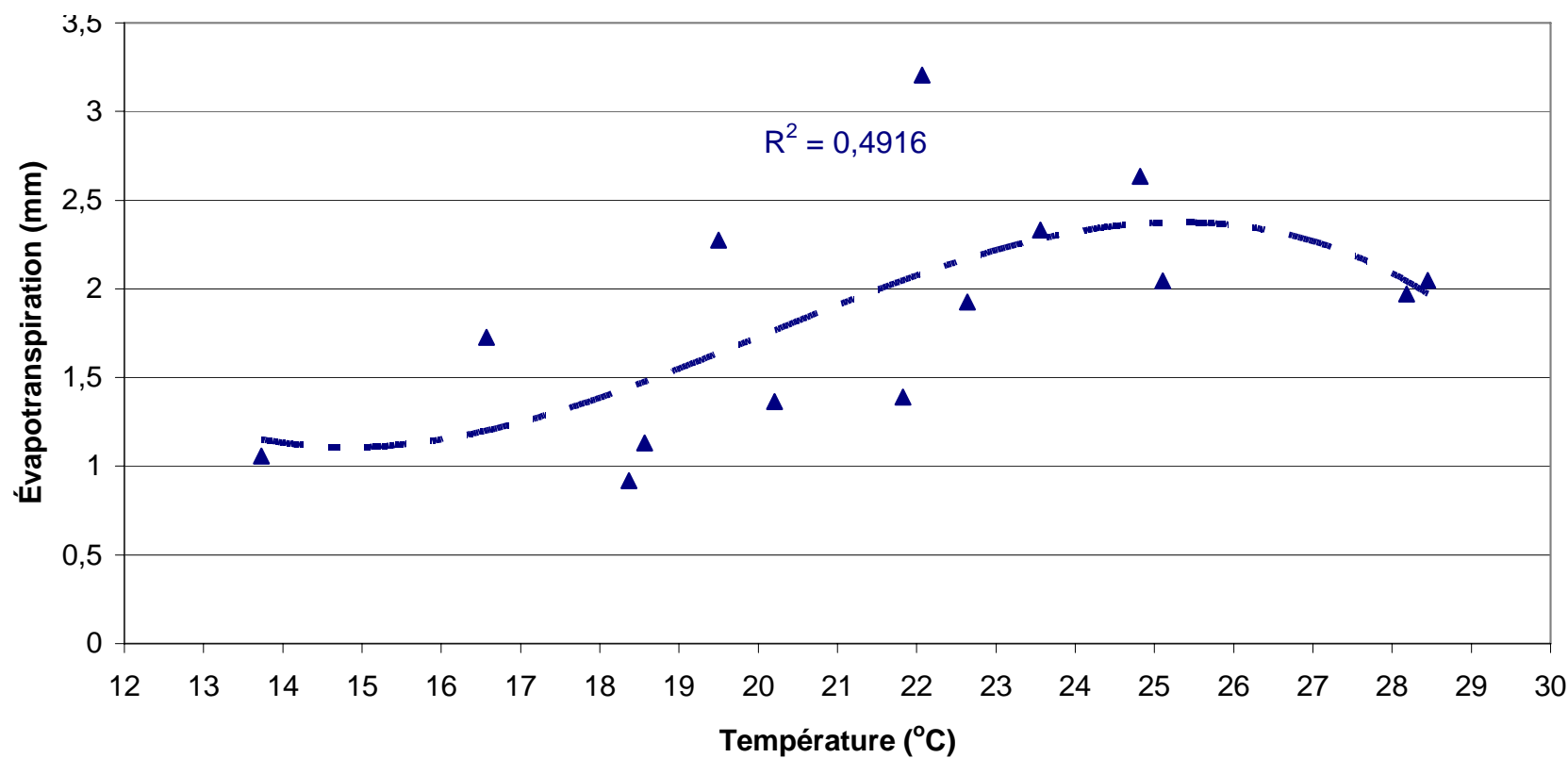


$$E_{tc} = E_{To} \times K_c$$

Evaluation of crop coefficient for sugarcane (Wiendenfeld et al, 2005)



Evapotranspiration of cranberry at different temperatures

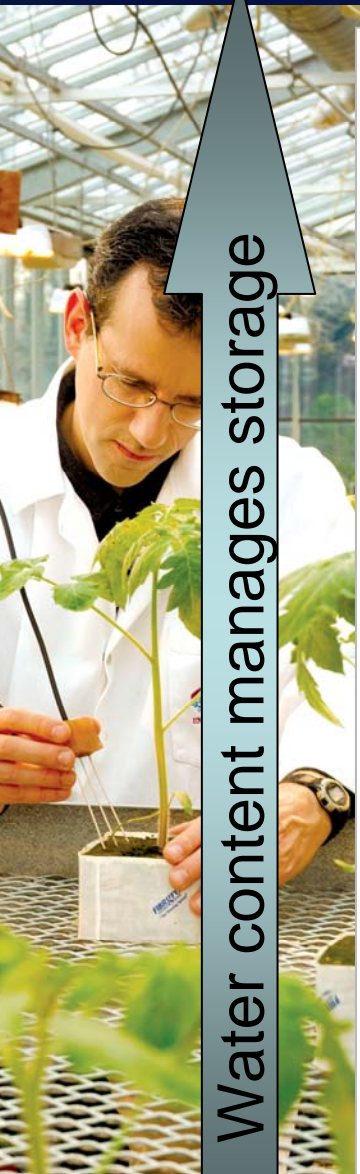


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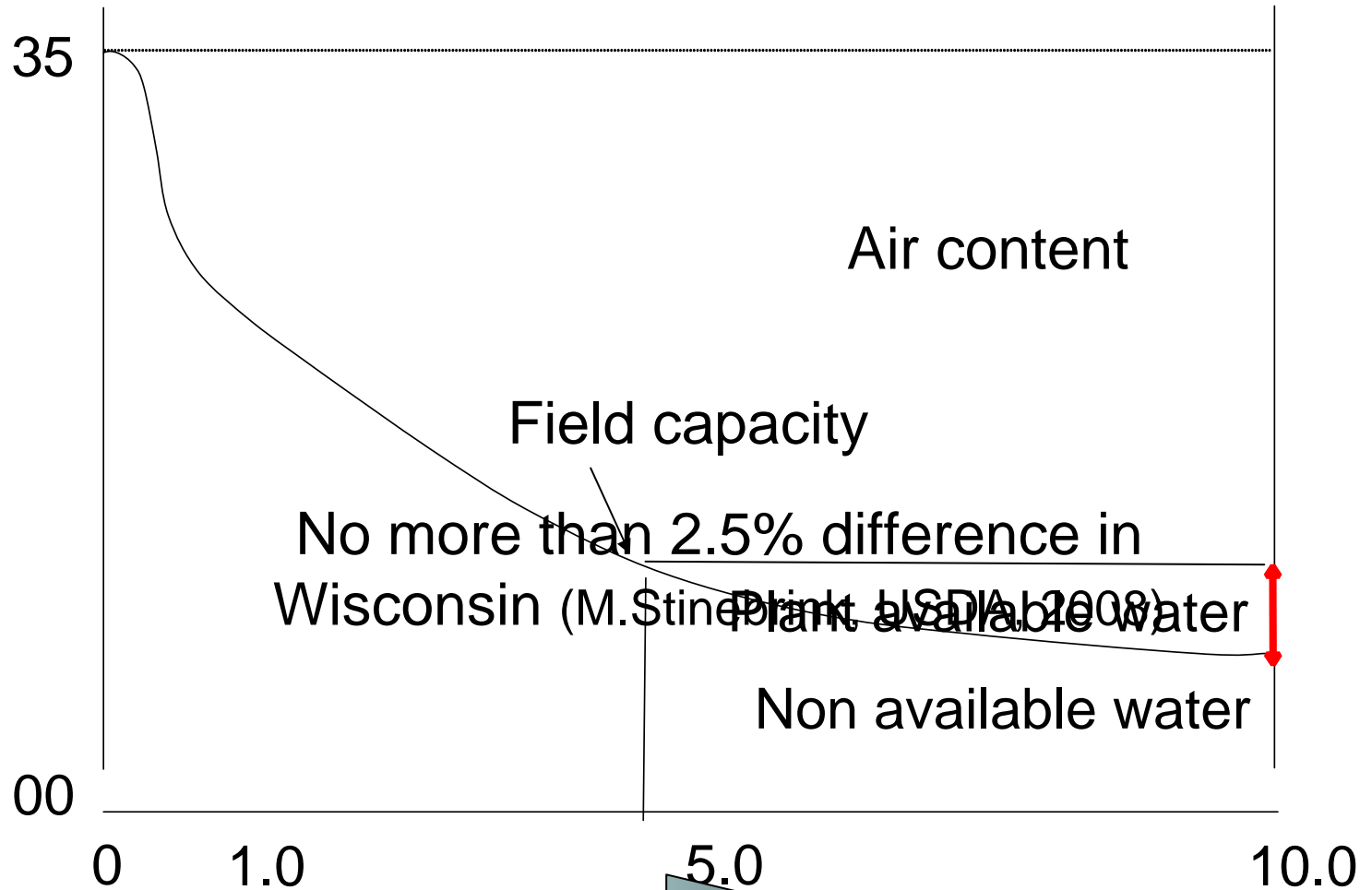
Transpiration=(tension difference air-soil)/resistance in the SPAC

Measuring tension or water content?



Water content manages storage

Soil water content (% volume)

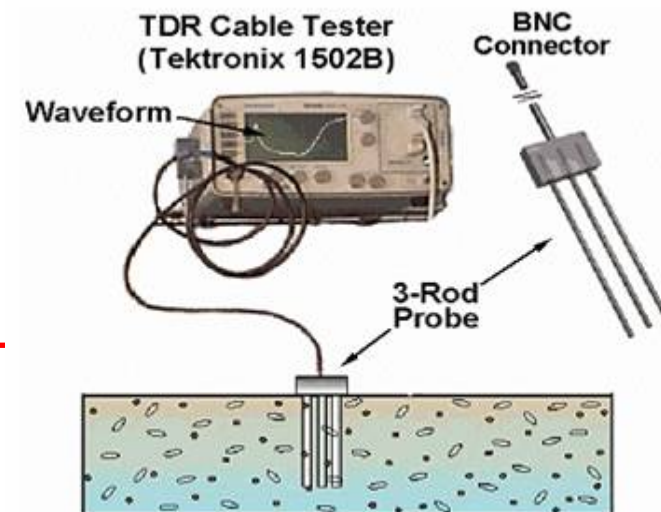


Tension manages plant stress

Water tension (cbar)

Water content determination (TDR, FDR, TDT, gravimetric)

- Easy to use
- Reliable
- No uniform reference to initiate and stop irrigation: field calibration by site compulsory
- Indirect relationship with plant stress
- Drift at high salinity ($>EC\ 2\ ms\ cm^{-1}$)
- High accuracy (1 %) needed in coarse soils
- Limited accuracy with drip irrigation



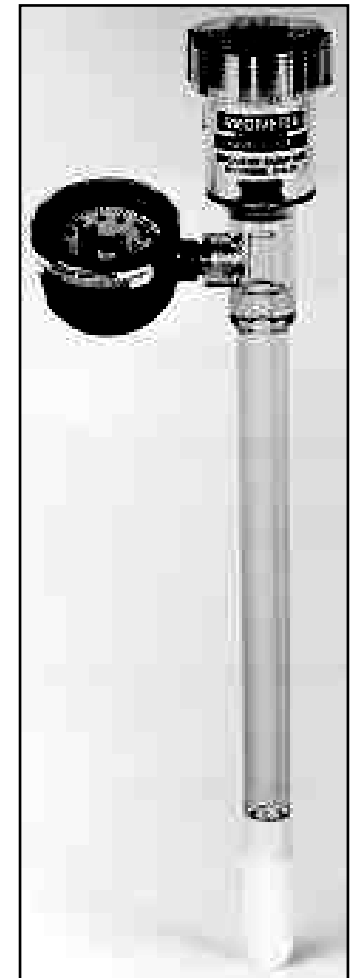
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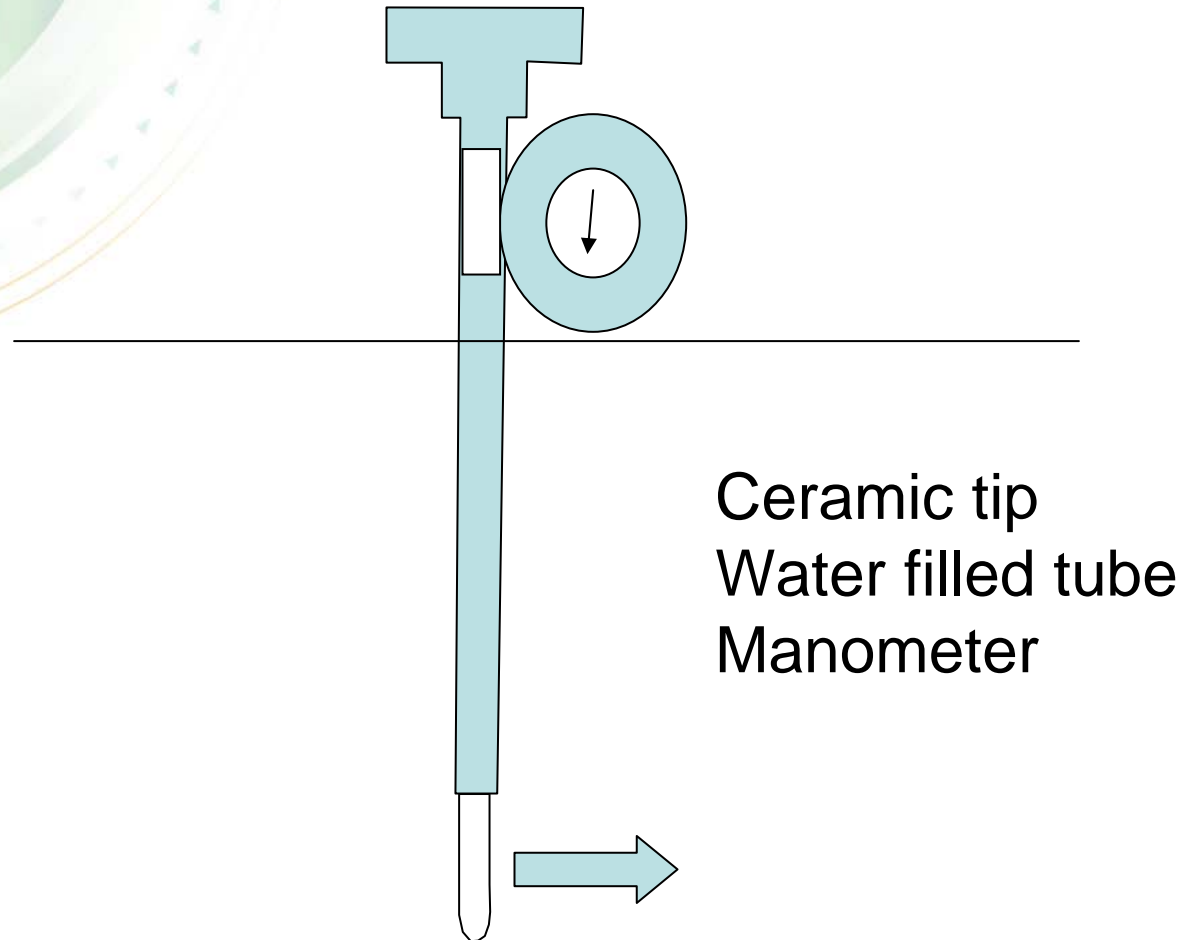
Measurements

- Tensiometer
 - Direct measurement of plant stress
 - Well accepted concept (1930)
 - A lot of well known threshold values to initiate irrigation

Crop	Soil Type	Tension
Vegetables/Fruit in open field	Sandy & Loamy Soil	-15 to -36 kPa
Vegetables/Fruit in open field	Clay Soil	-30 to -60 kPa
Greenhouse Vegetables	Rockwool (dry type)	-1.0 to 1.5 kPa (Day) ~ -2.5 kPa (Night)
Greenhouse Vegetables	Rockwool (wet type) Sawdust; Coarse Coir	-1.5 to 2.0 kPa (Day) ~ -3.0 kPa (Night)
Greenhouse Vegetables	Peat-Based Substrates Fine Coir	-2 to -3 kPa ~ -4 kPa (Night)
Nursery	Peat/Bark Mix	-3 to -10 kPa
Potted Plants	Peat-Lite Mix	-3 to -10 kPa



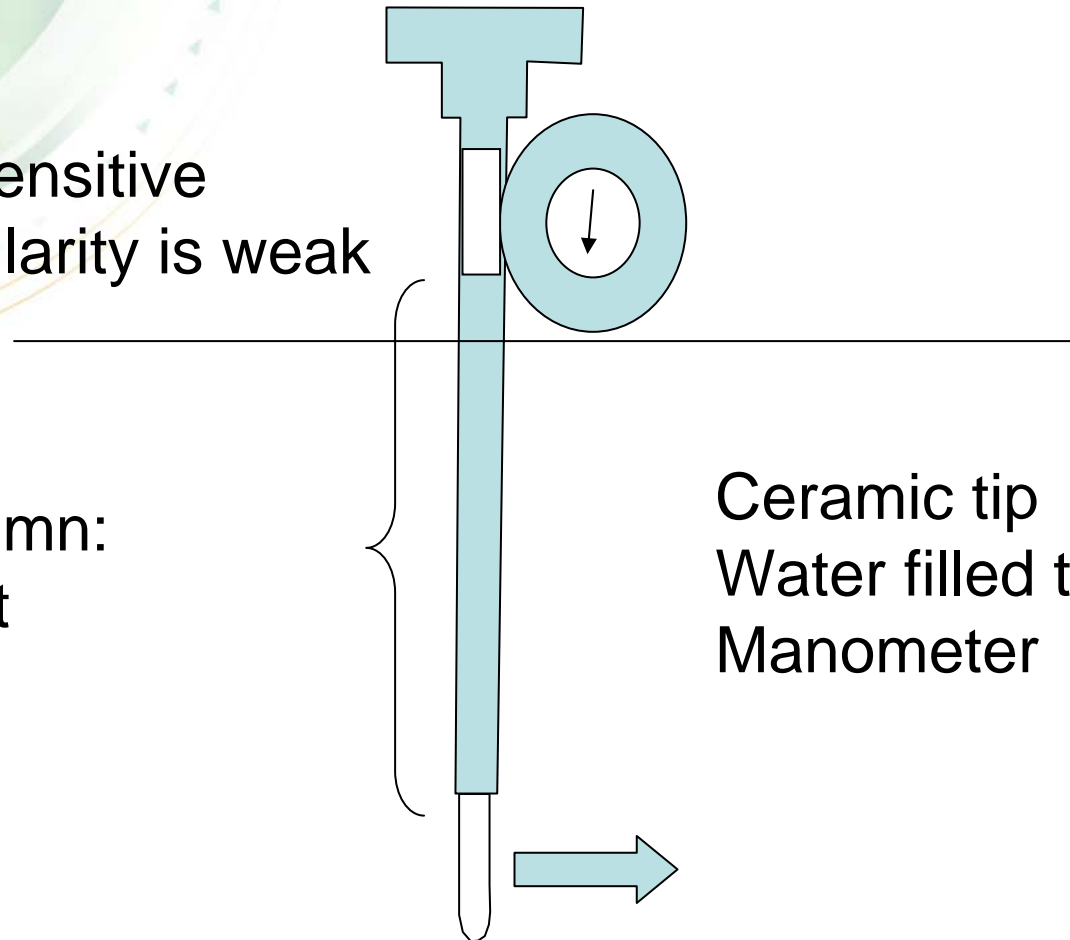
Measurements



Measurements

Water vapour:
Temperature sensitive
When soil capillarity is weak

Water column:
adjustment



Ceramic tip
Water filled tube
Manometer

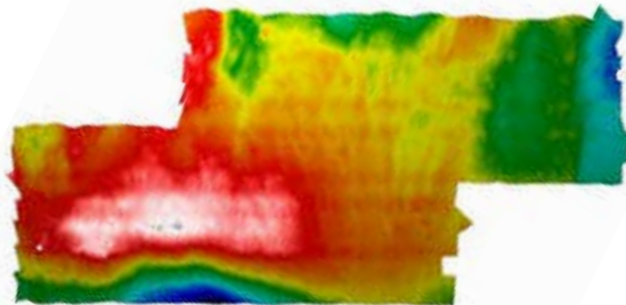
Measurements

- Tensiometer
 - Requires calibration
 - High maintenance
 - Temperature fluctuation sensitive in some situations
 - (Warrick et al, 1998)



Measurements

- All systems should ideally deal with spatial variability
 - Spatial variability issues
 - Need to collect information on many locations
 - Hydrozoning can generate easily 25% water savings



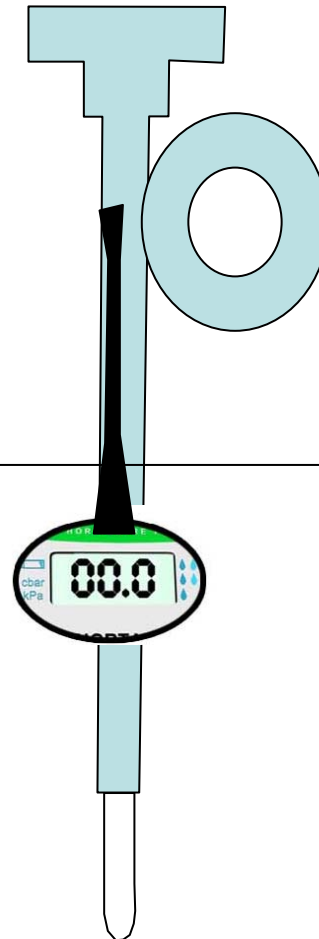
New tensiometer by Hortau



Water vapour effect
In low capillarity soil
largely reduced:
Buried

Water column:
No more water level check
Detection of water filling needs
Calibration by a chip at factory

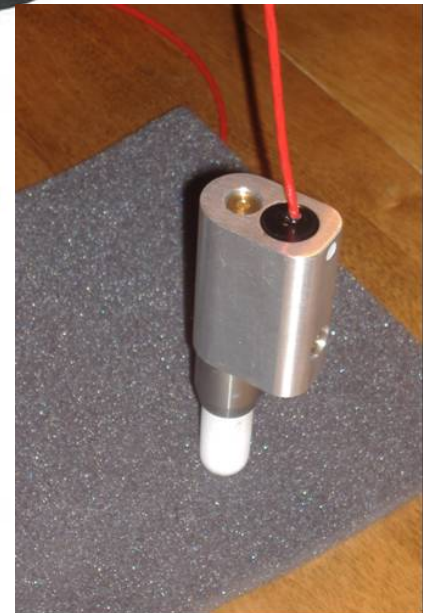
Wireless collection
of spatial information



Measurements

Irrolis Sense vs tensiometer

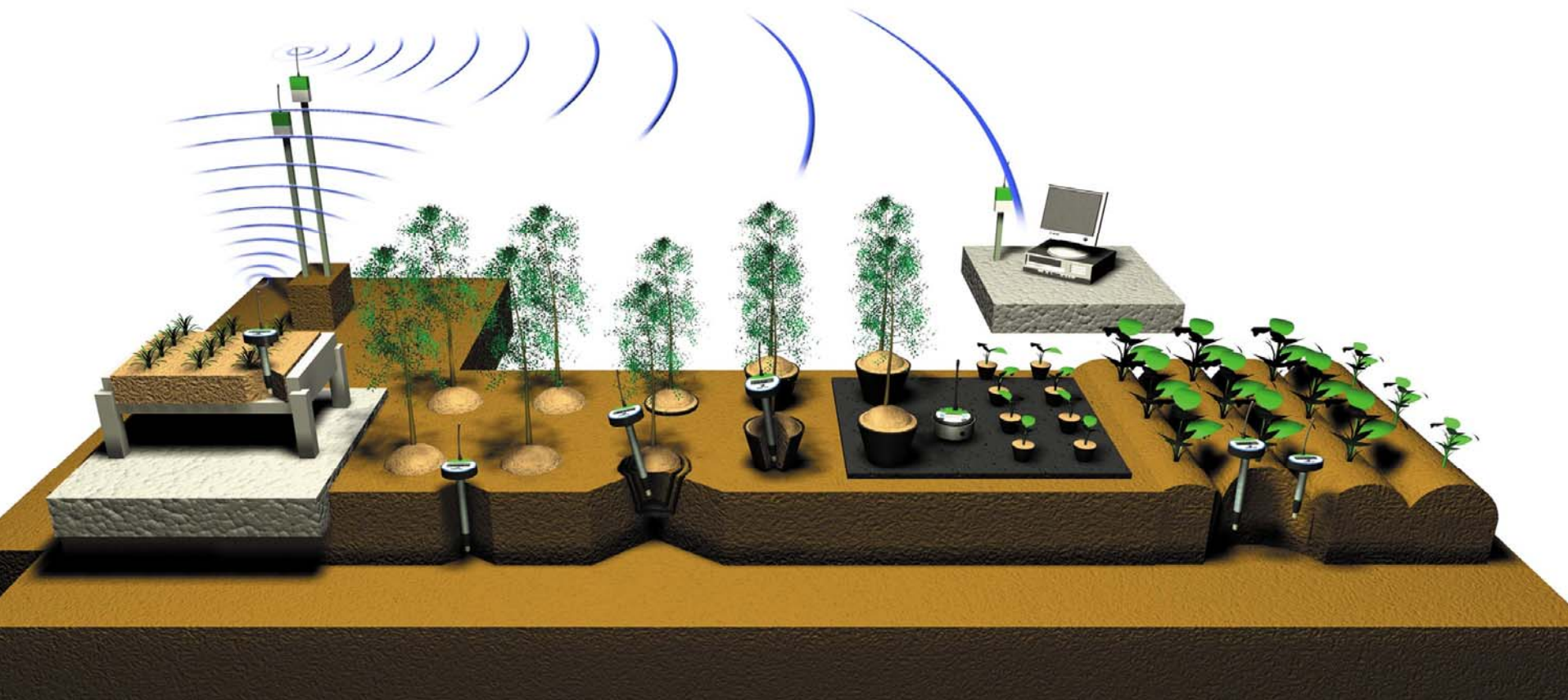
- Pressure transducer's location
- Low maintenance
- Self detecting
- Wireless
- Digital display
- Temperature sensitivity (low maintenance allows buried model (Tx model))
- Temperature sensor for frost detection



Hortau's solution



Integrated system

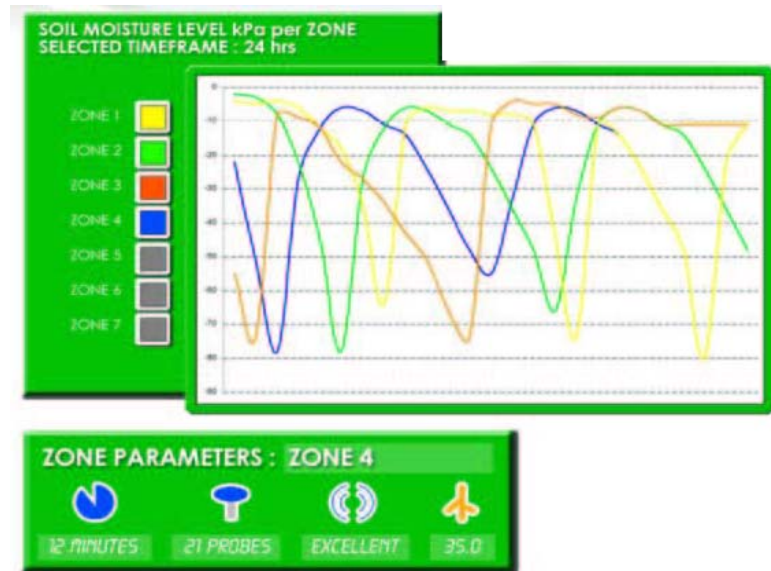


Hortau's solution



Irrolis Complete

- Information treatment and display
- Irrigation and frost-heat damage control



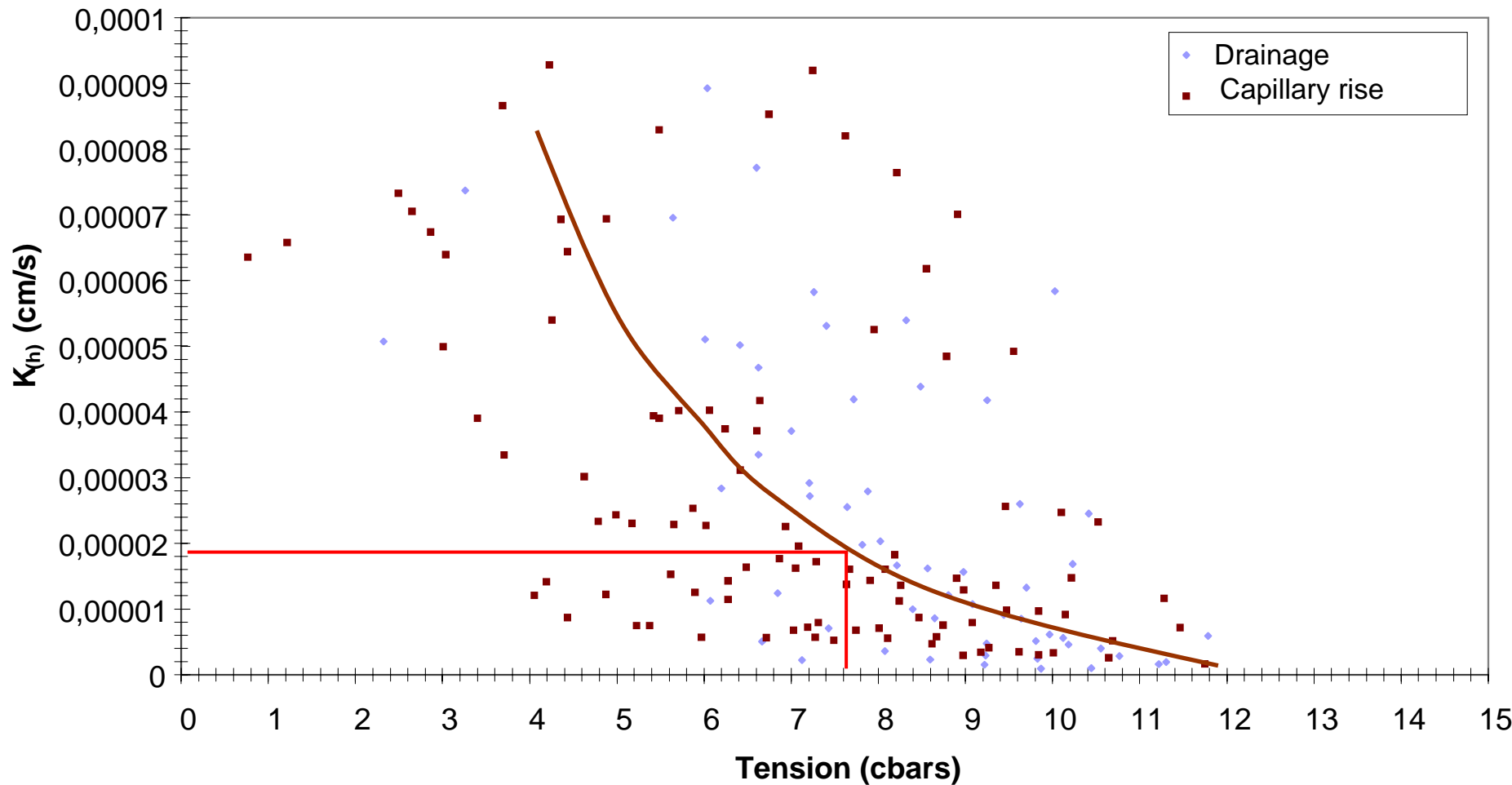


Use of tensiometers in cranberry production (Bonin¹, S., Caron^{1,2}, J. and S. Pépin¹), Laval University¹ and Hortau²

- **When to initiate irrigation**
 - Few references (2-4 cbars)
 - Determined from unsaturated hydraulic conductivity (speed of water movement in soils)
 - From model of water flow from the soil to the plant using the evapotranspirative demand
 - From transpiration, photosynthesis and yield measurements
- **When to stop irrigation**
 - Drop in tension deeper in the profile
 - Waterlogging

Capillarity measurements

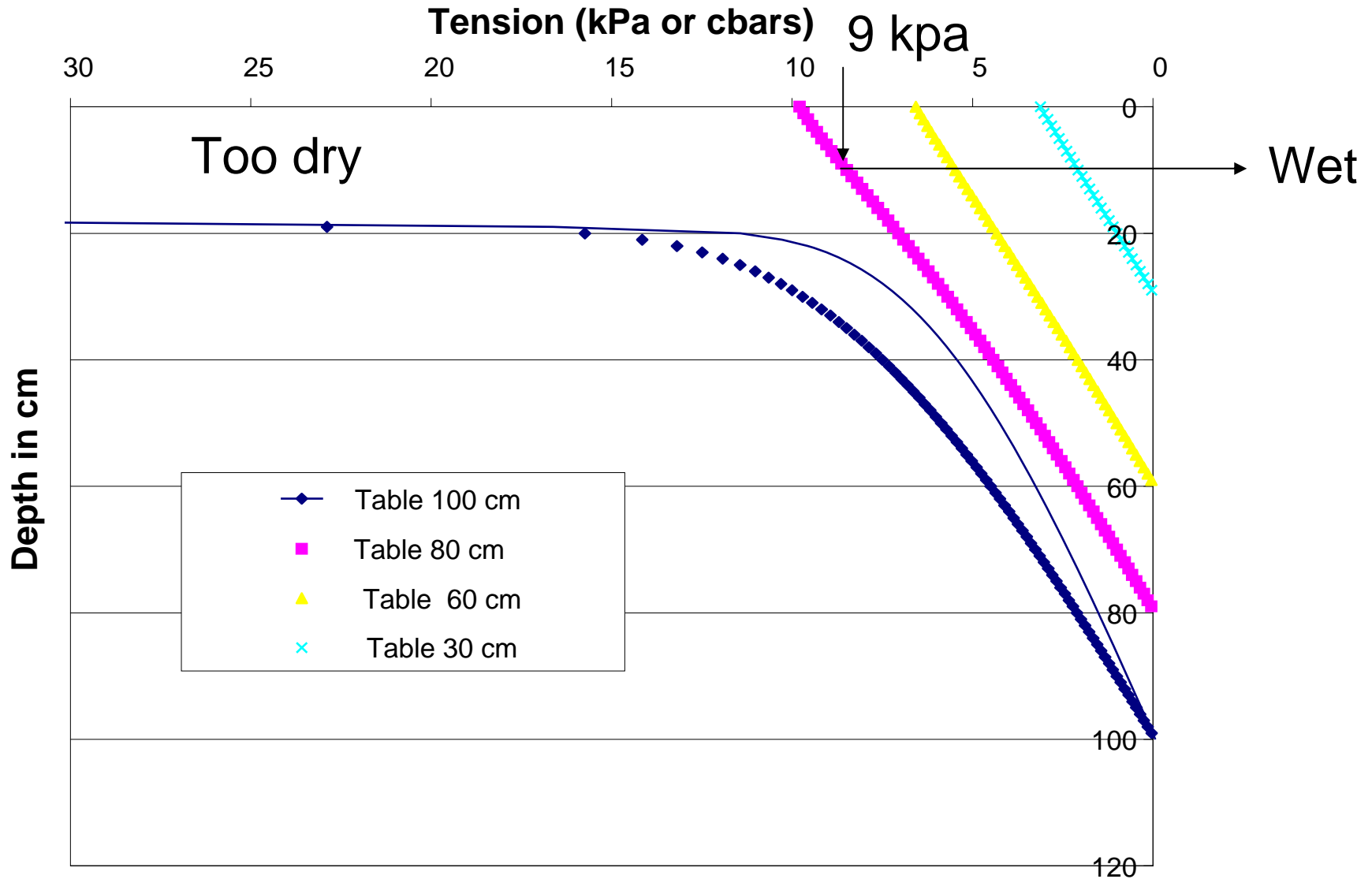
Unsaturated hydraulic conductivity of a coarse sandy soil (0-15 cm)



Tension distribution in a sandy soil for different water table depths



HORTAU



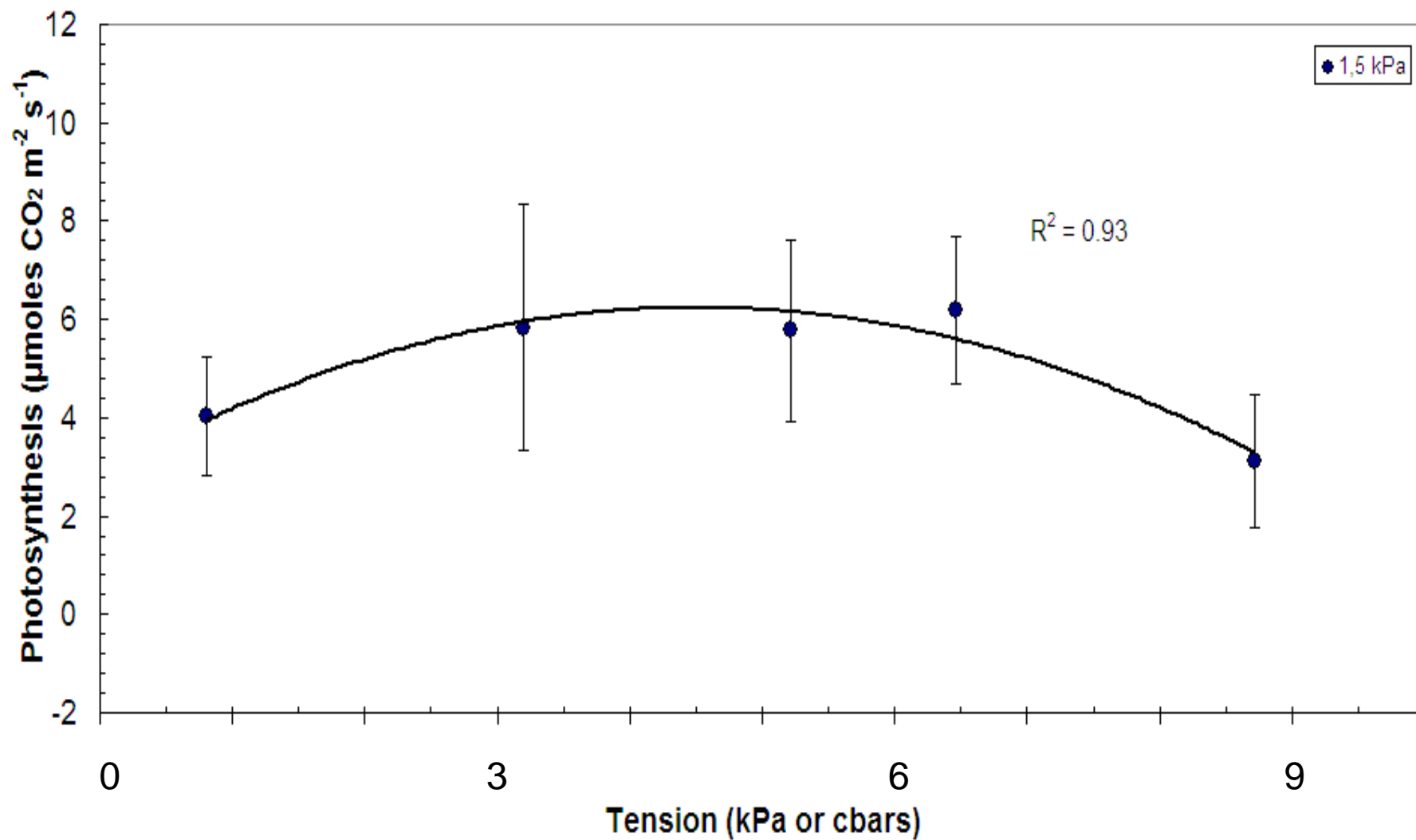


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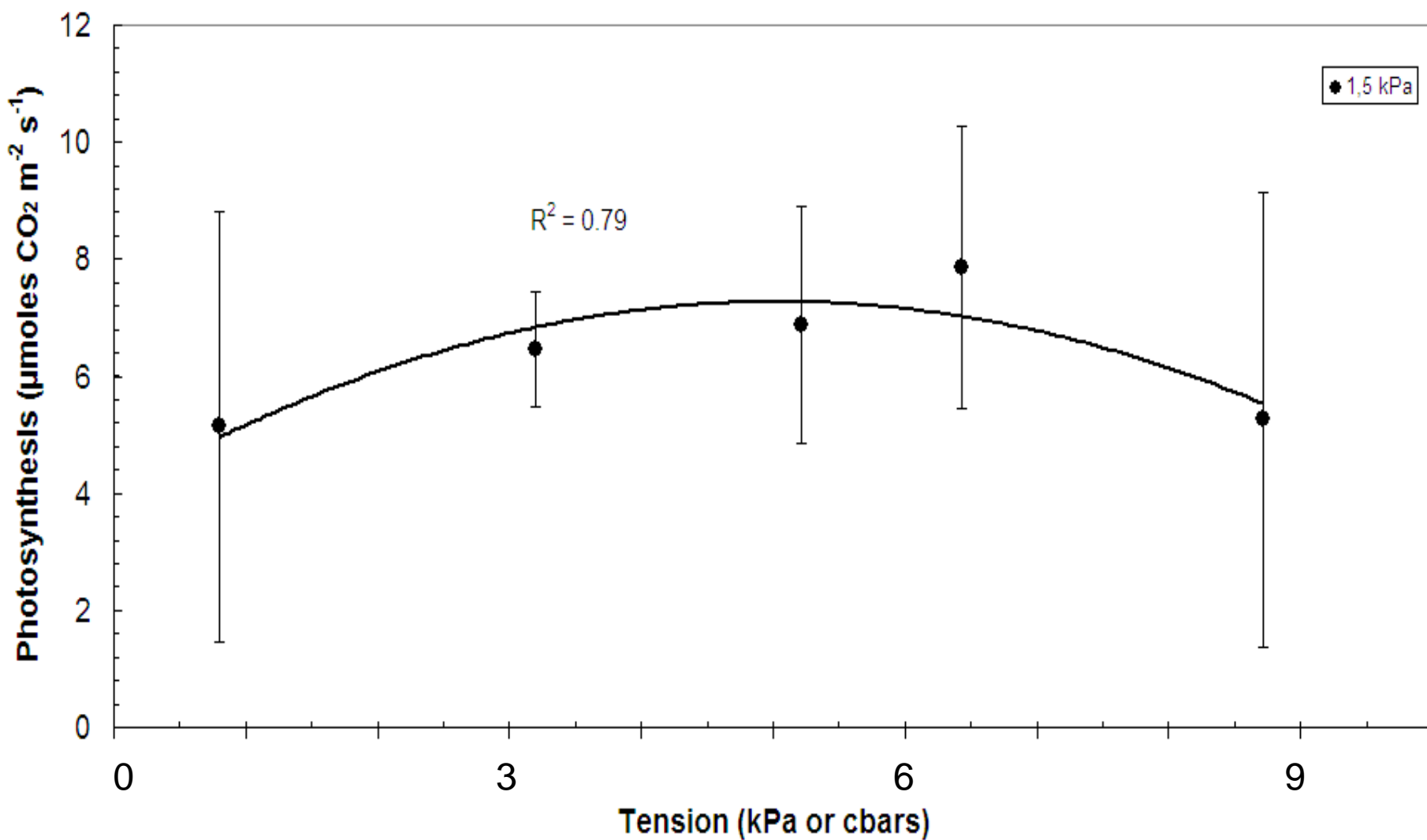
DANGER

Wurbrand 1/4-ID Car. Ho. ca.

Photosynthesis of vegetative shoots at different tension (A.M.)

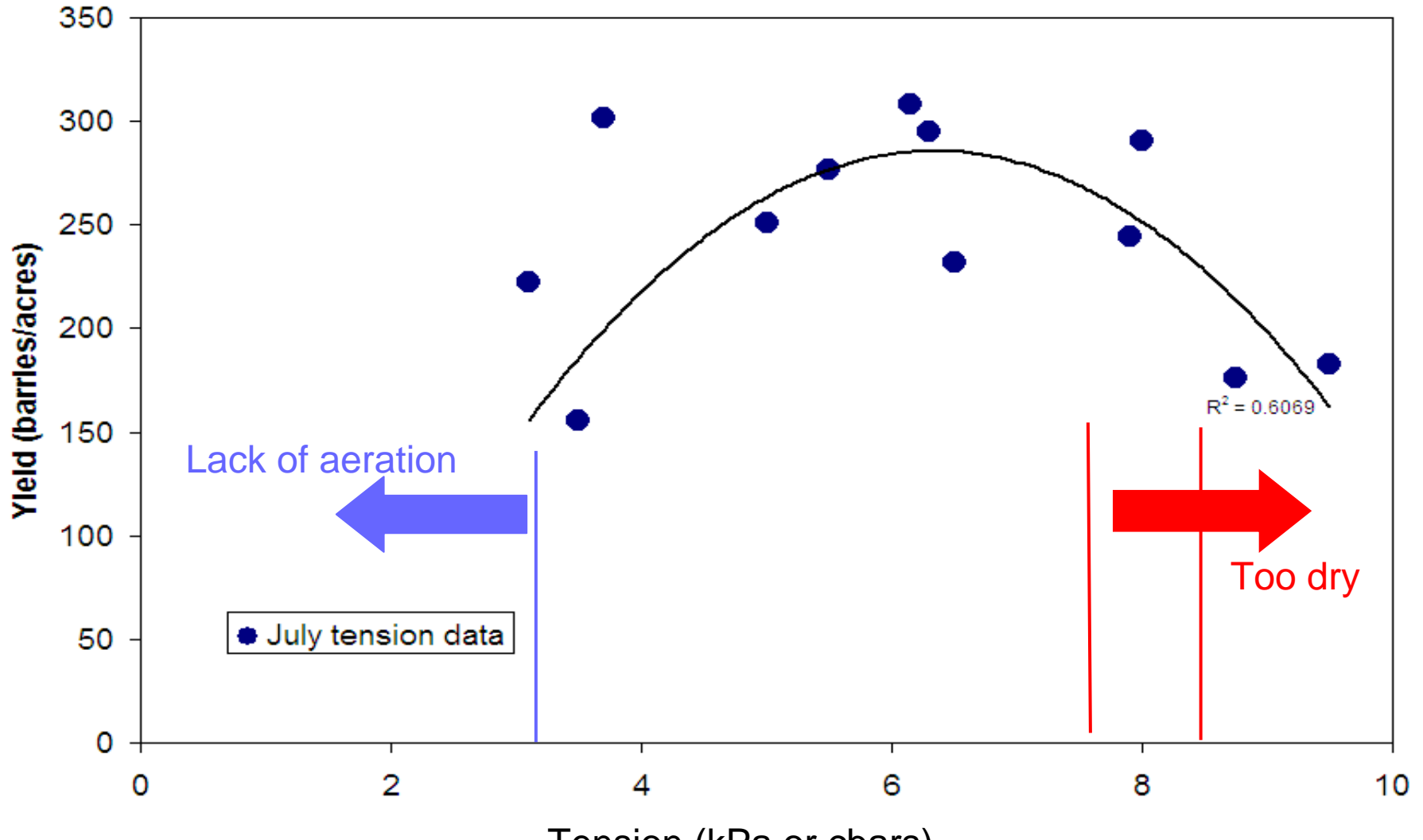


Photosynthesis of fruiting shoots at different tensions

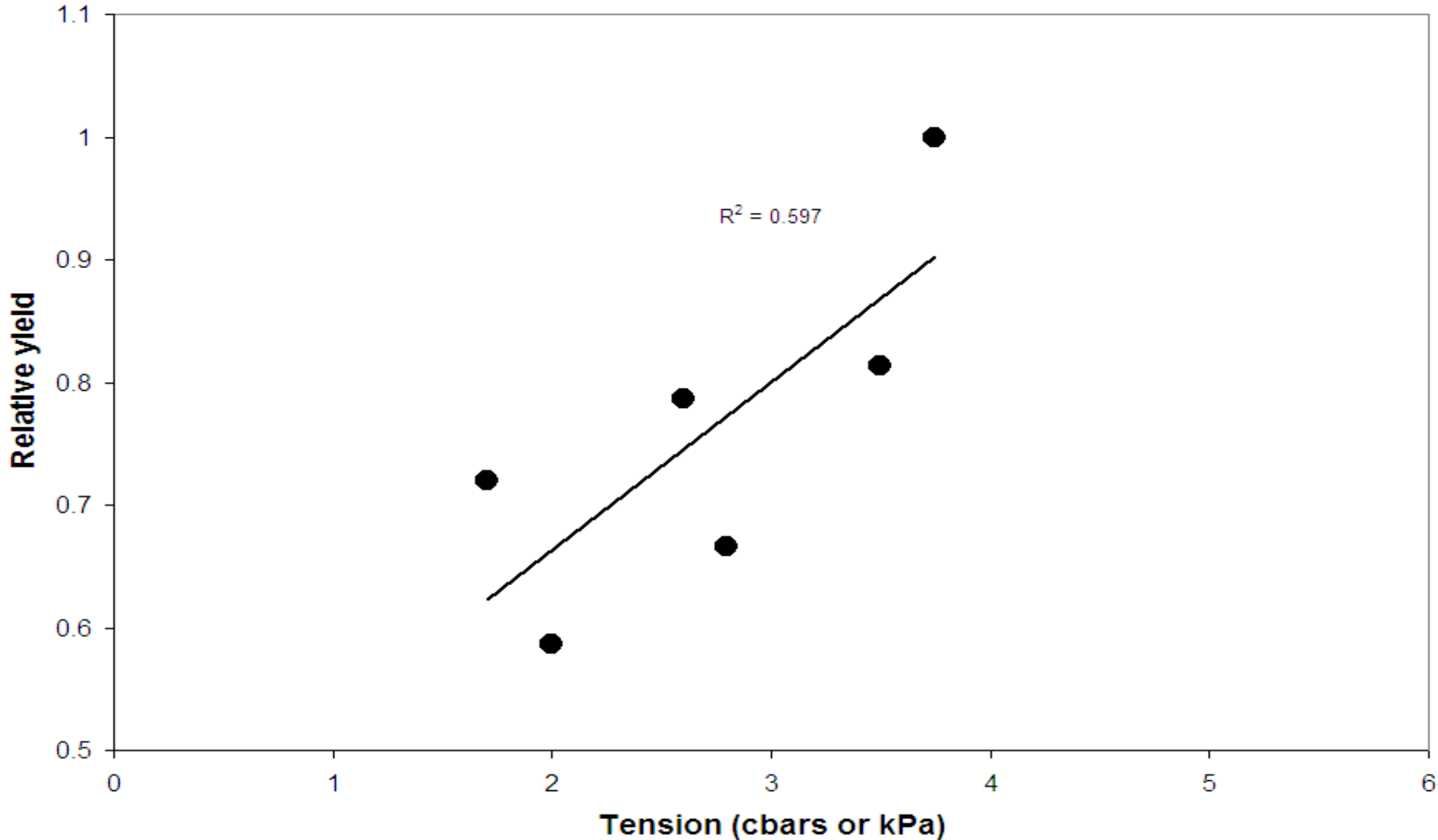


Yield measurements

Yield and tension in Wisconsin (Kummer, 2004)

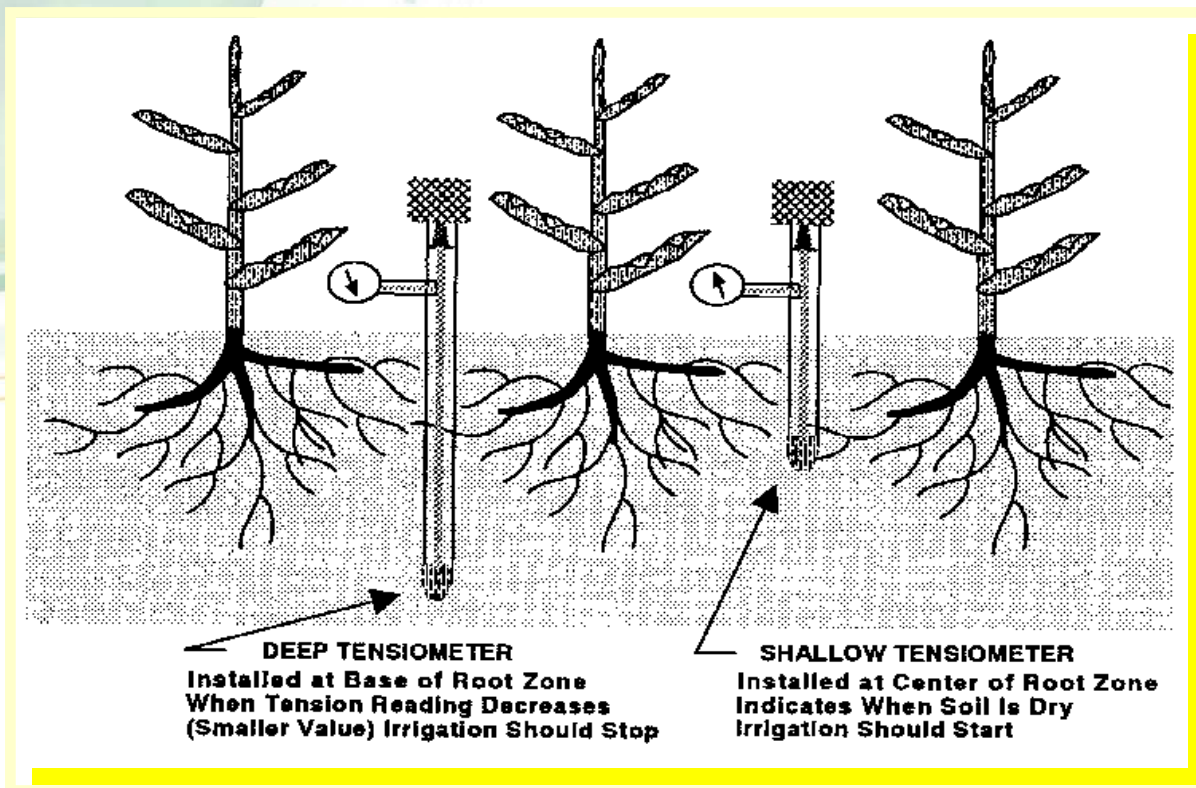


Relationship between relative yield and tension in Quebec (2006)



- **When to initiate irrigation**
 - Determined from unsaturated hydraulic conductivity (speed of water movement in soils)
 - From model of water flow from the soil to the plant using the evapotranspirative demand
 - From transpiration, photosynthesis and yield measurements
- **When to stop irrigation (if frost control not needed)**
 - Drop in tension deeper in the profile
 - Waterlogging

Starting and stopping irrigation





Irrolis

- Home
- History**
- Status
- Zoning
- Communication
- Alarm-Setpoints

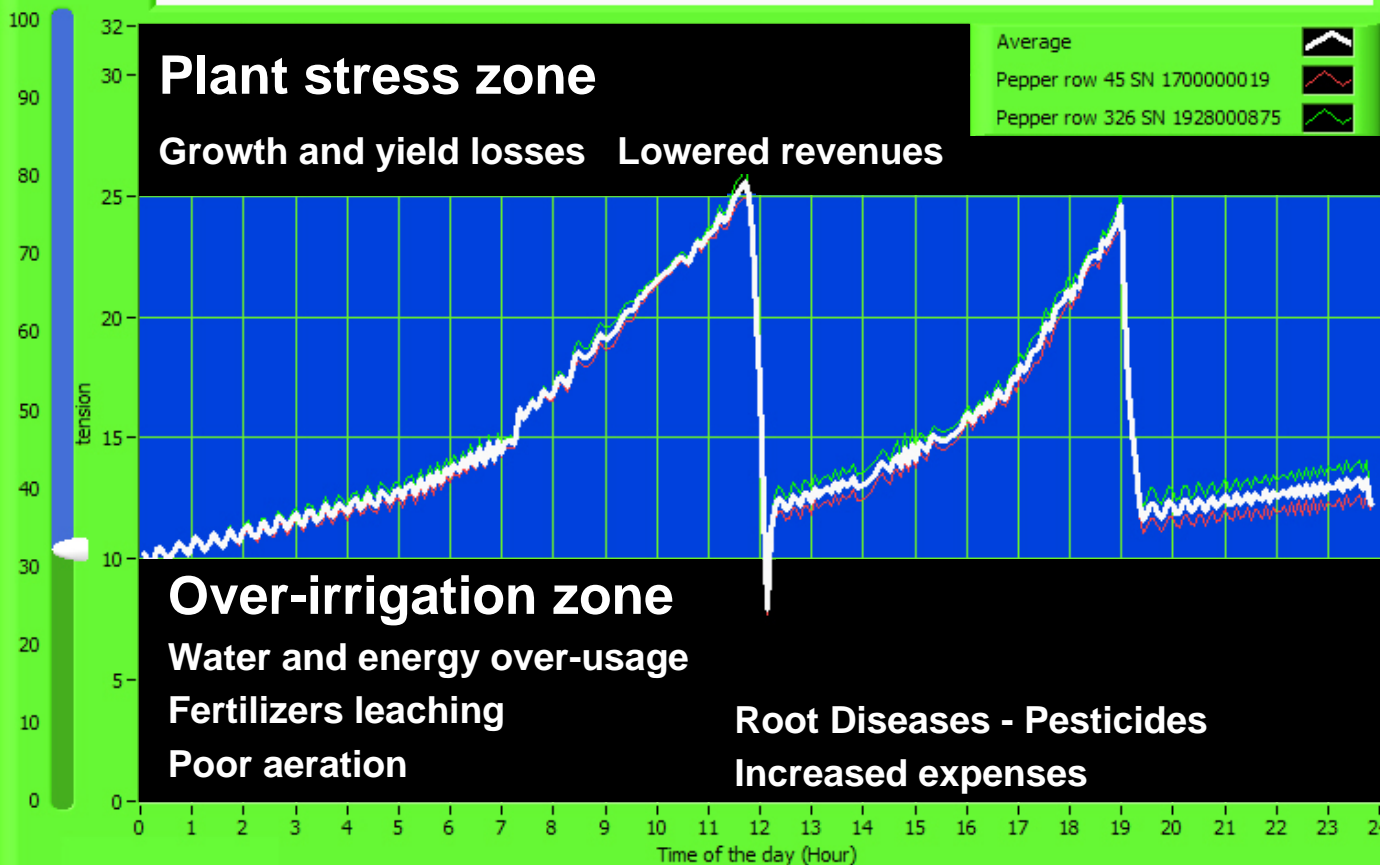
- Zone 1
- Zone 2**
- Zone 3
- Zone 4
- Zone 5
- Zone 6
- Zone 7
- Zone 8
- Zone 9
- Zone 10
- Zone 11
- Zone 12

Yesterday tension Peper field no 2476 (Zone 2) graph

Plant stress zone

Growth and yield losses Lowered revenues

- Average
- Pepper row 45 SN 1700000019
- Pepper row 326 SN 1928000875



Over-irrigation zone

Water and energy over-usage
Fertilizers leaching
Poor aeration

Root Diseases - Pesticides
Increased expenses

Legend

ON

Setpoint

ON

Today

Yesterday

7-Days

30-Days

365-Days

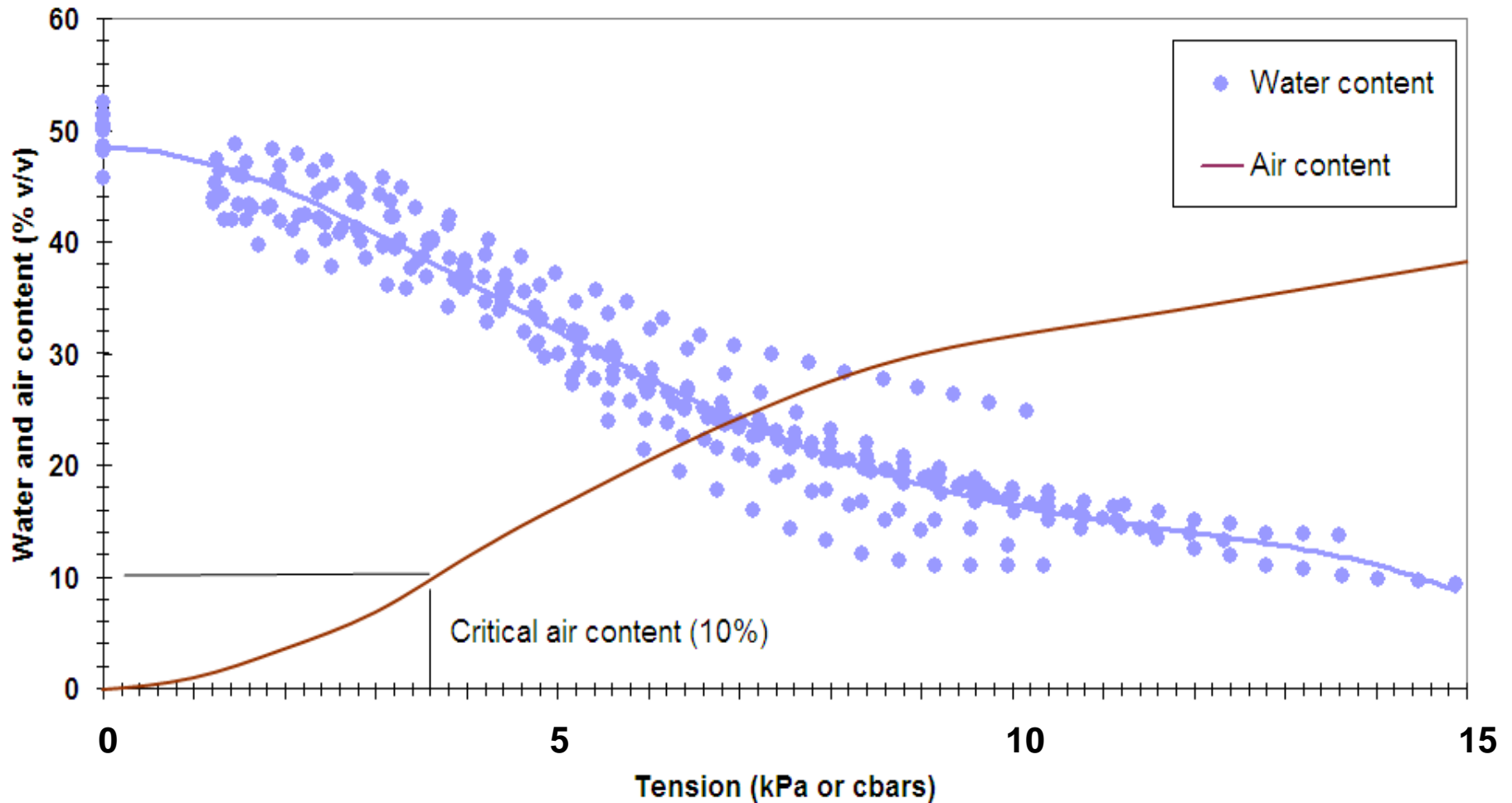
Tension/Temp.

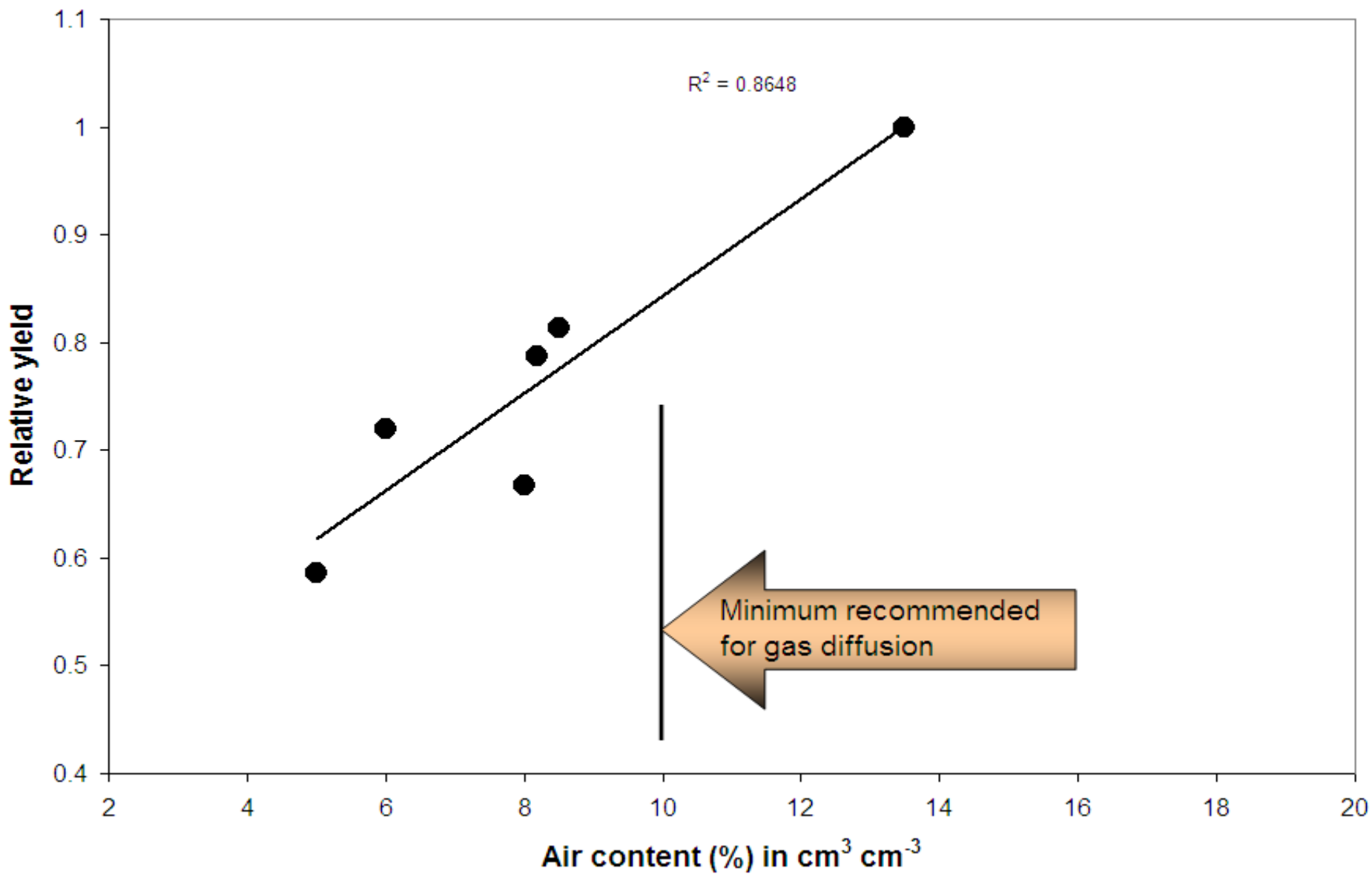
Tension

Temperature

Print Graph

Water and air content in a fine sandy soil





Conclusions

- Hortau's has developed specific wireless tensiometers with reduced maintenance and an overall integrated irrigation management approach
- Irrigation set points seem to oscillate between 3 and 8 cbars during the production period for cranberry in coarse soils. Prior literature was suggesting 2 to 4, which seems too wet.

Acknowledgments

- Thank you for inviting us
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- Thank you for attending

