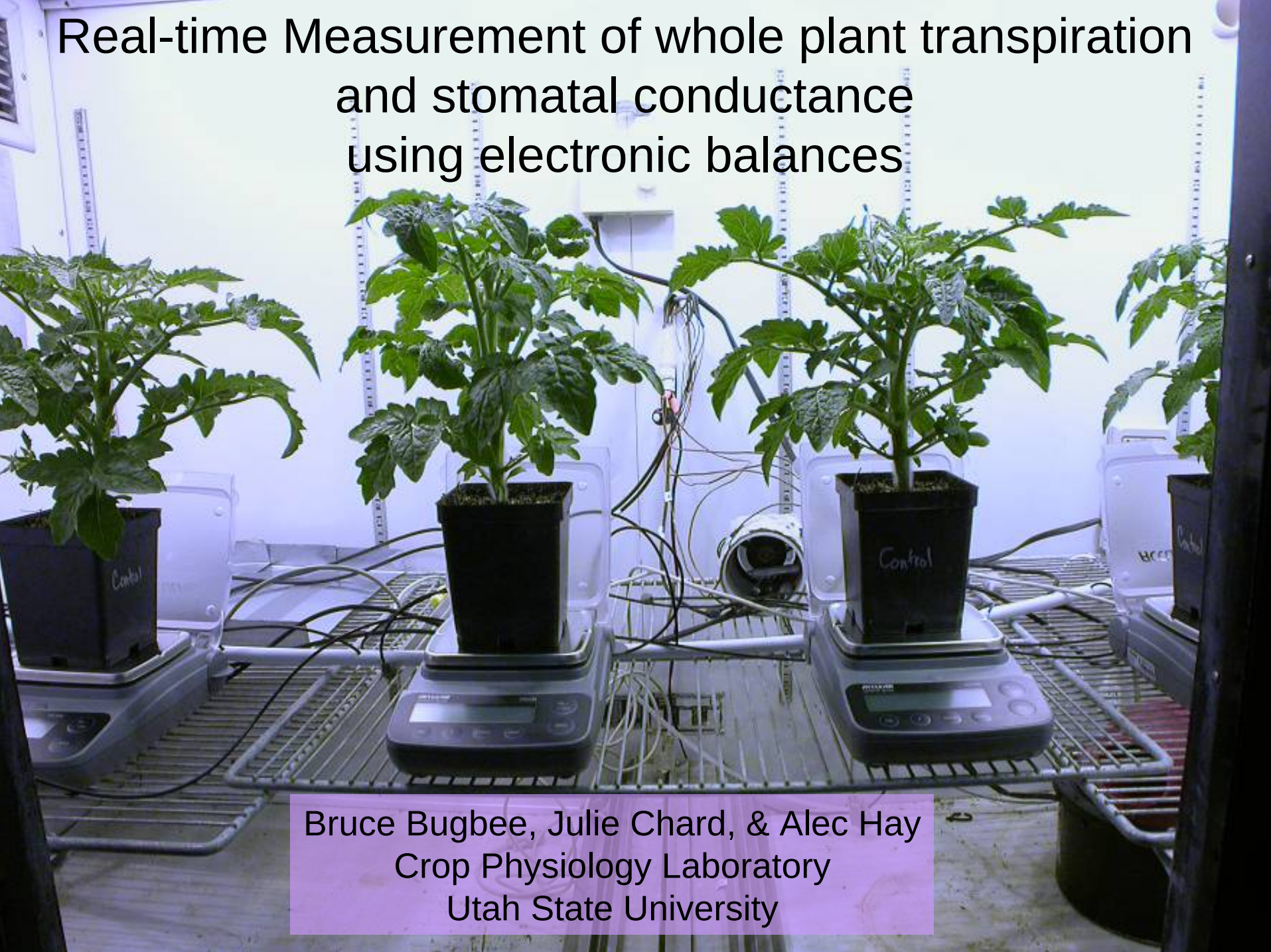
Real-time Measurement of whole plant transpiration and stomatal conductance using electronic balances



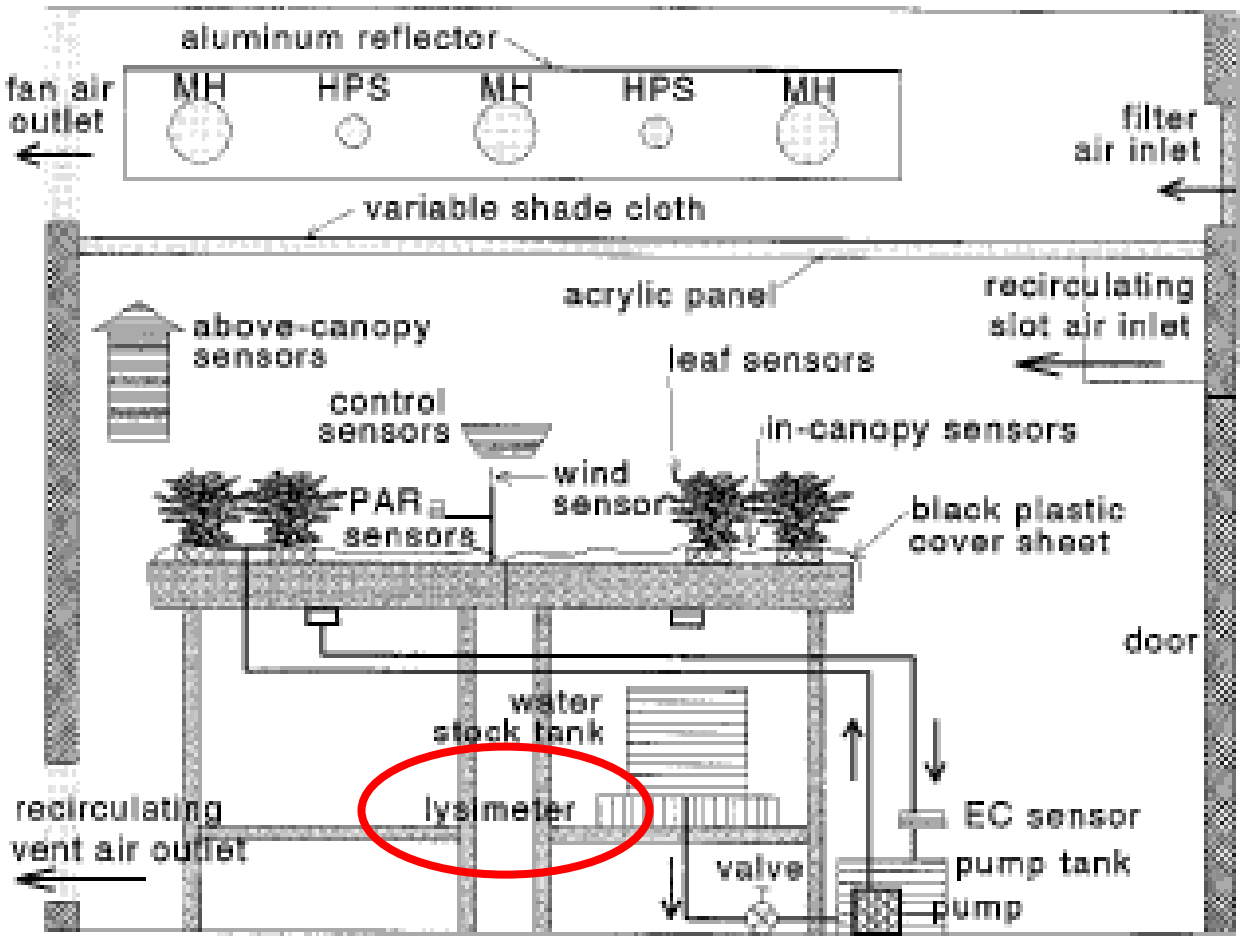
Bruce Bugbee, Julie Chard, & Alec Hay
Crop Physiology Laboratory
Utah State University

Literature review

WATER UPTAKE AND TRANSPIRATION CHARACTERIZATION OF NEW GUINEA IMPATIENS

K. R. Mankin, R. P. Fynn, T. H. Short

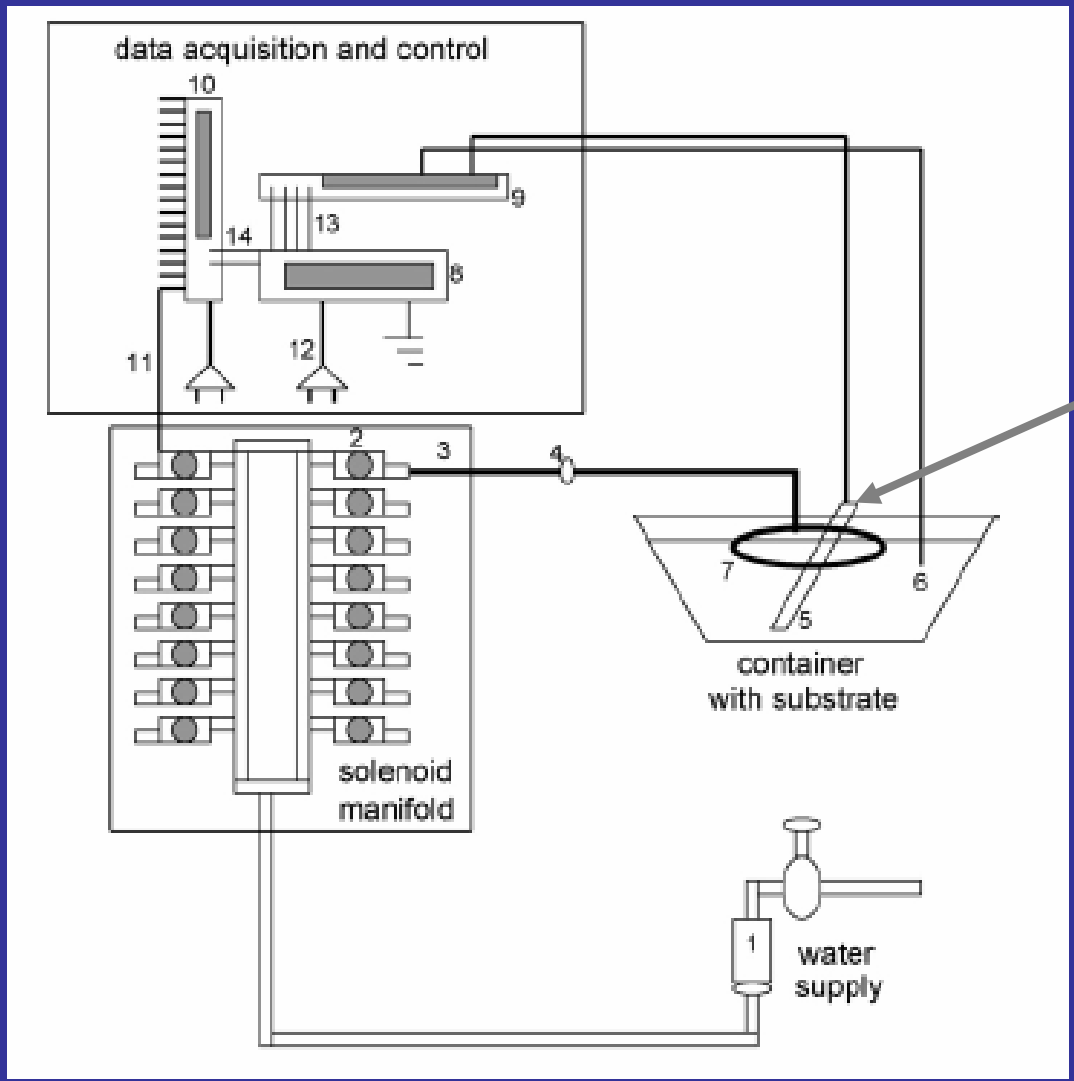
1996



An automated system for controlling drought stress and irrigation in potted plants

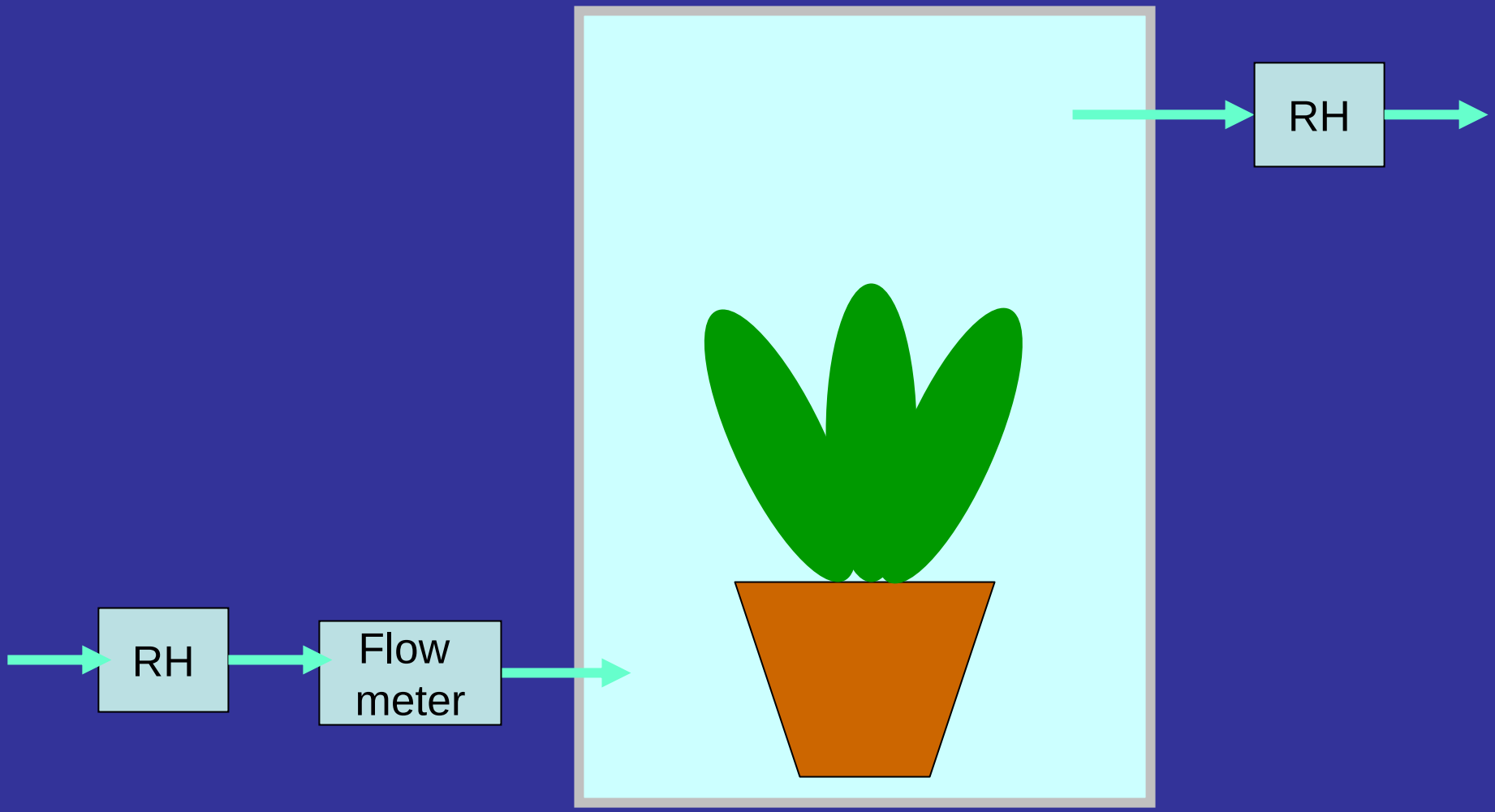
Krishna S. Nemali, Marc W. van Iersel *

2006



ECH_2O
Soil moisture sensor

Open-chamber technique

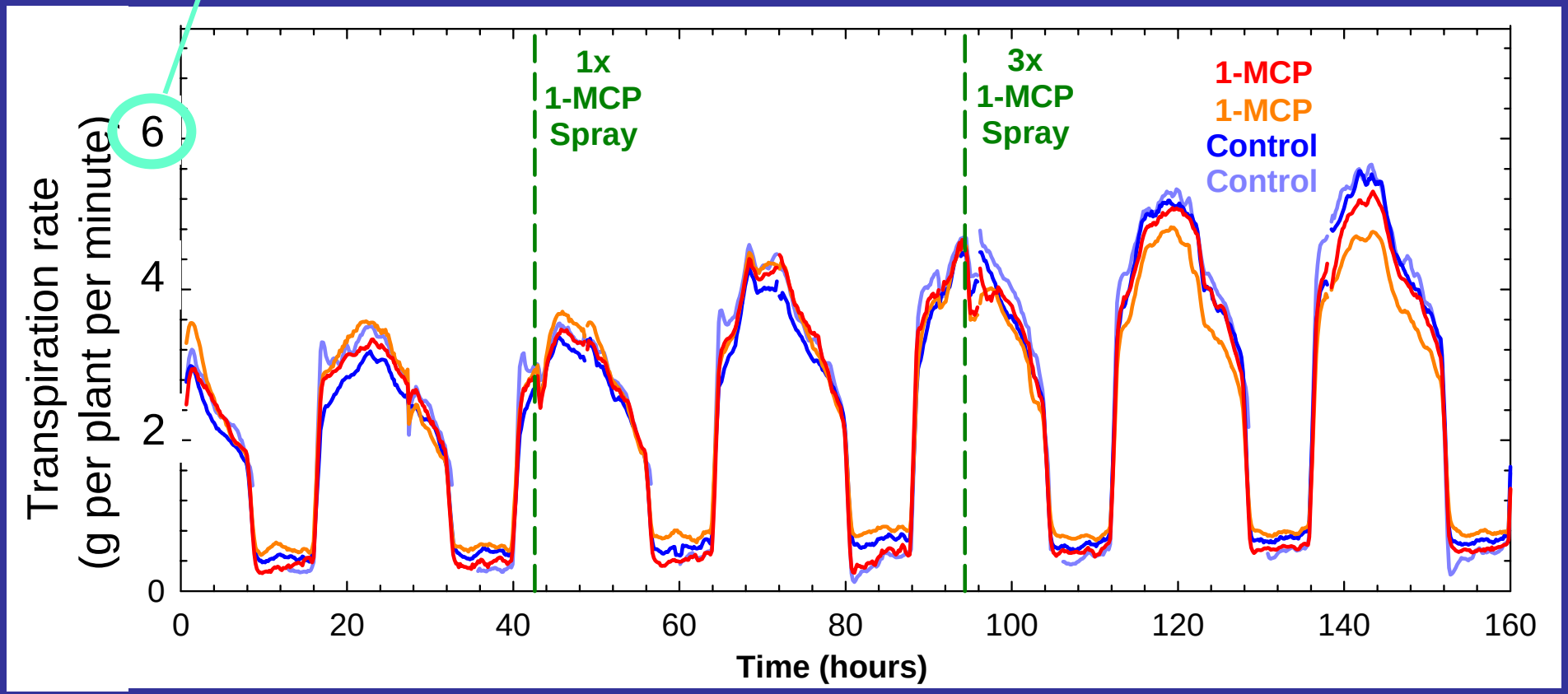


Direct measurement

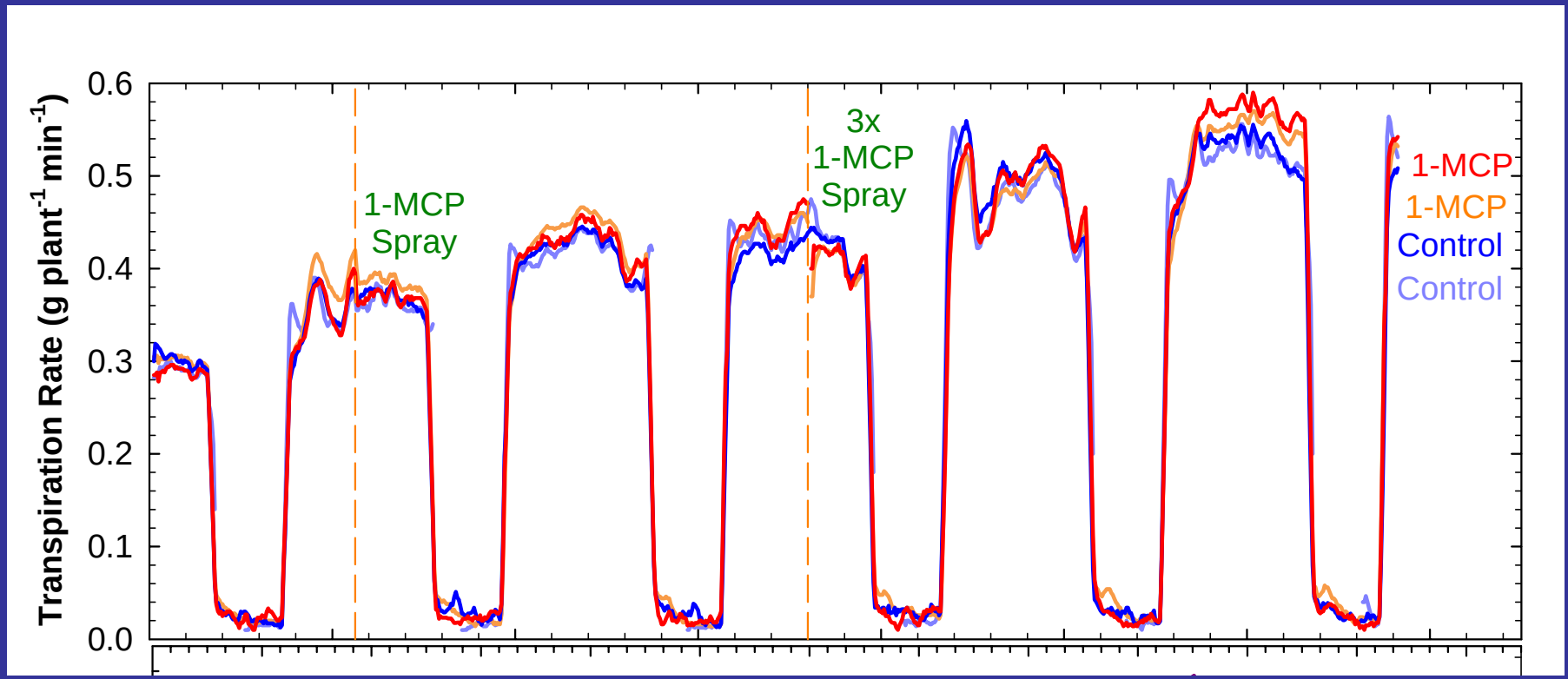
- Campbell Scientific CR-1000 datalogger
- RS-232 interface
- 0.1 g resolution (5 to 15 second interval)

Cotton

5.5 mmol s^{-1}

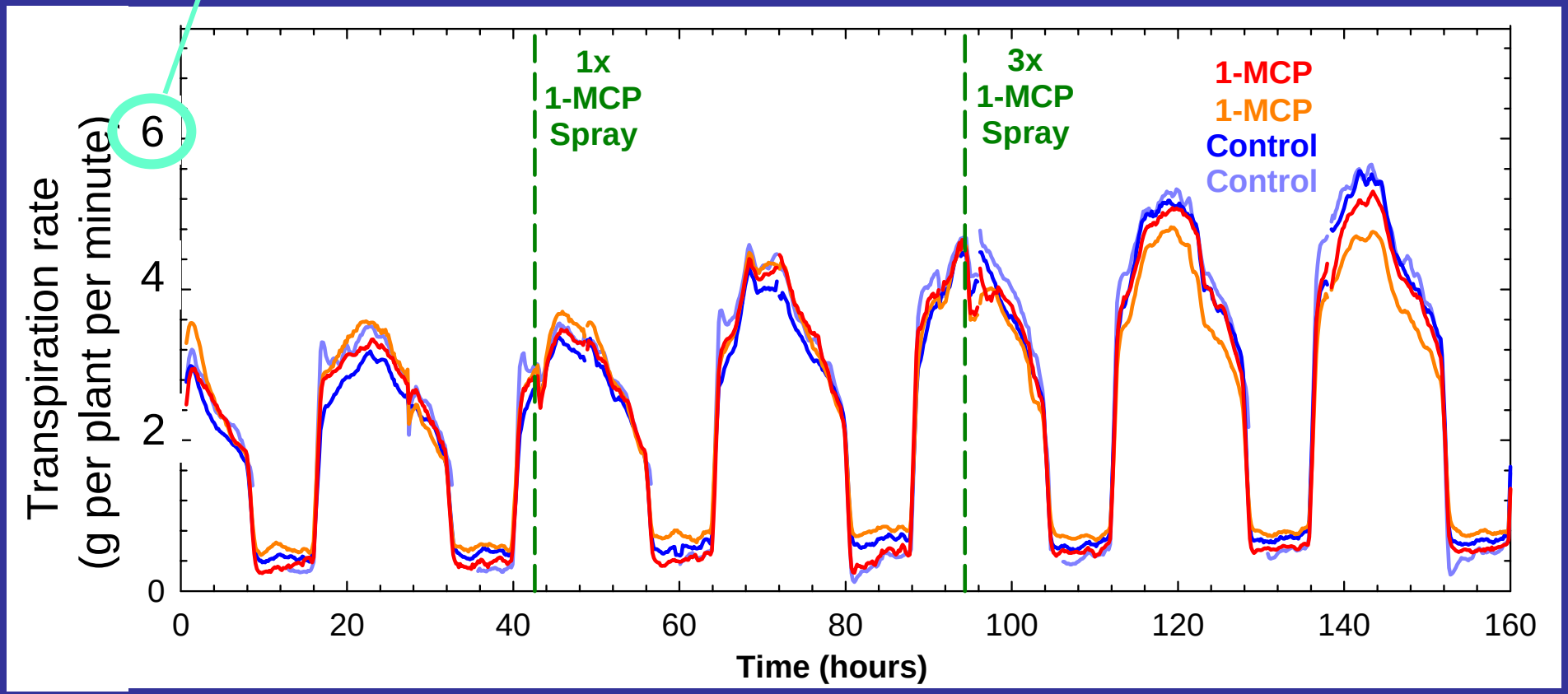


corn

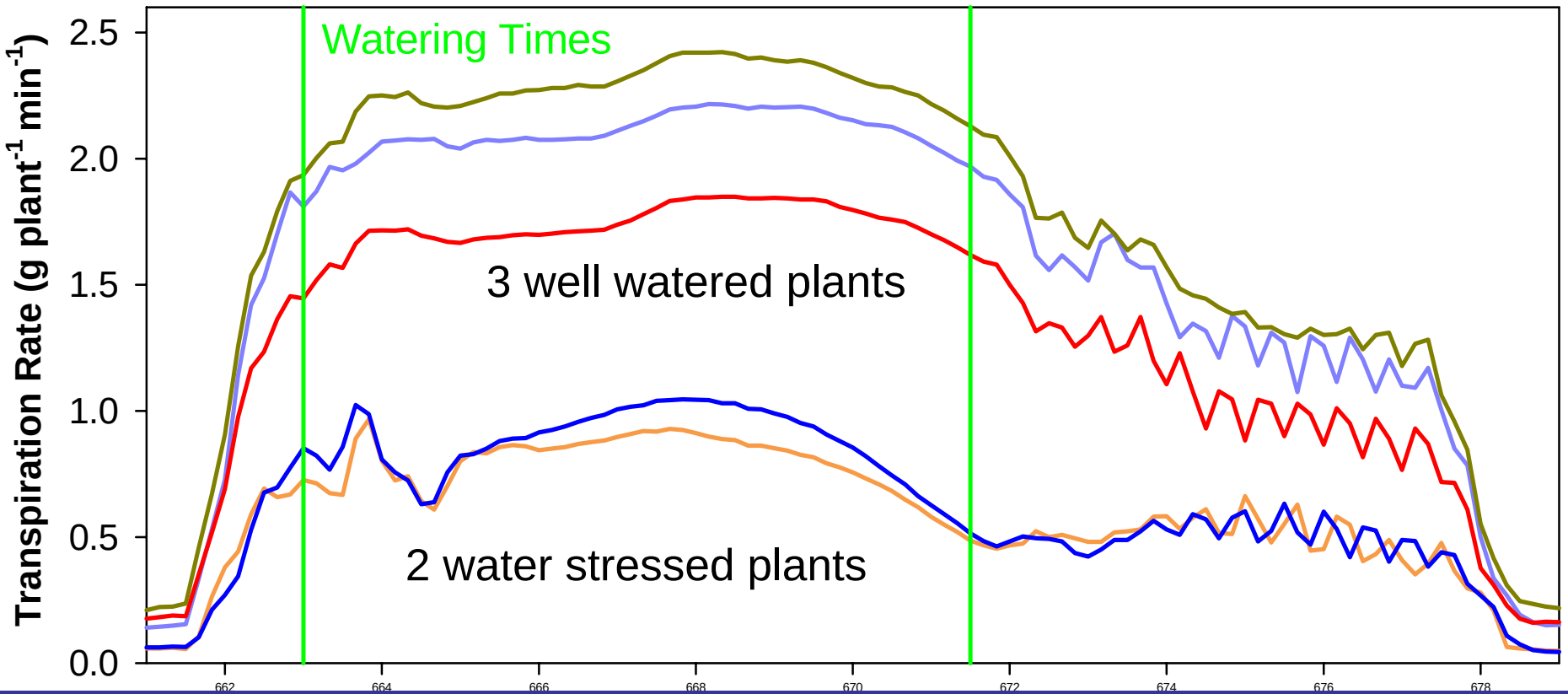

Transpiration Rate (g plant-1 min-1)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1-MCP
Spray
3x
1-MCP
Spray
1-MCP
1-MCP
Control
Control

Cotton

5.5 mmol s^{-1}



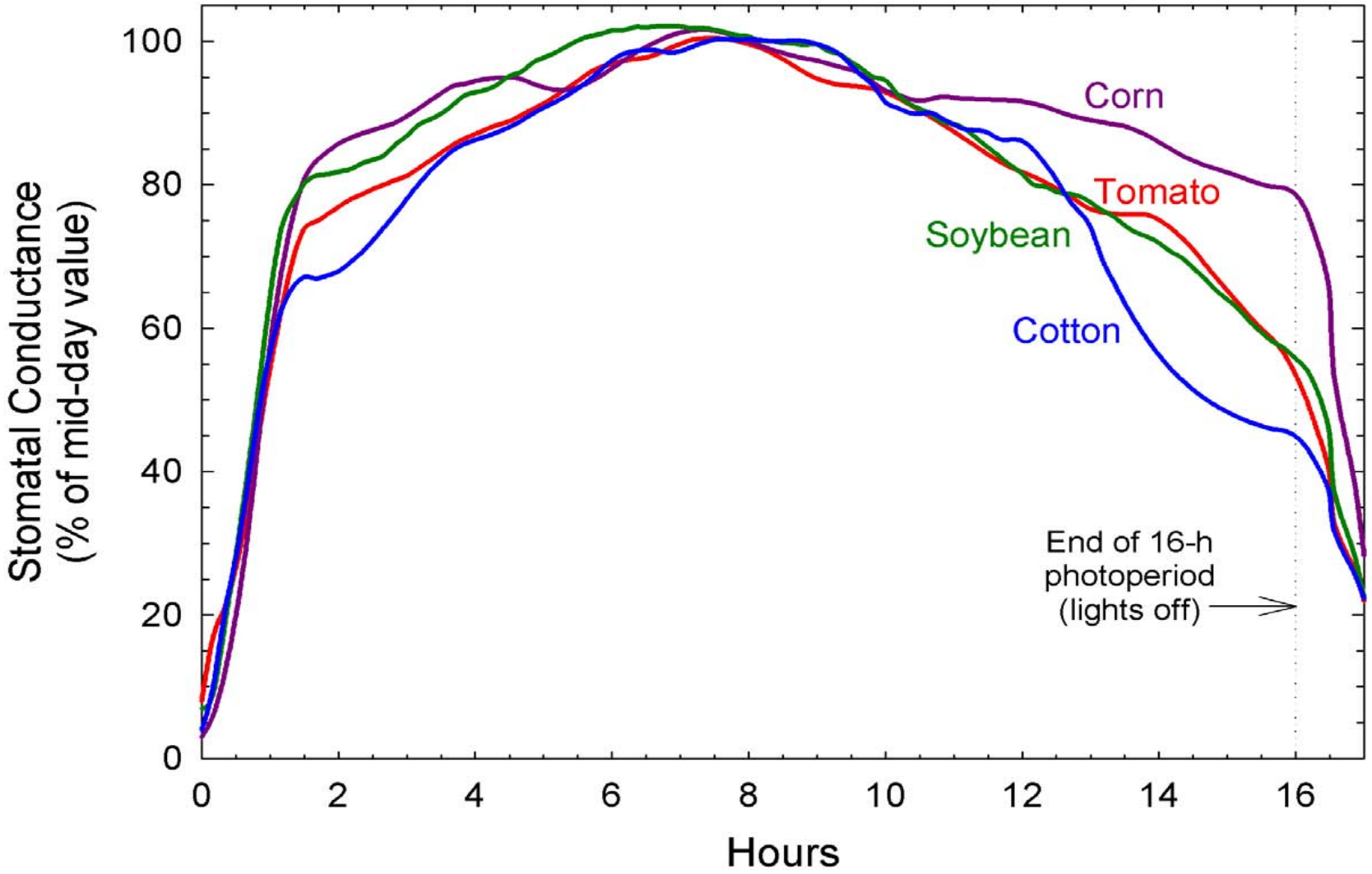
Diurnal and hourly stomatal cycling in cotton



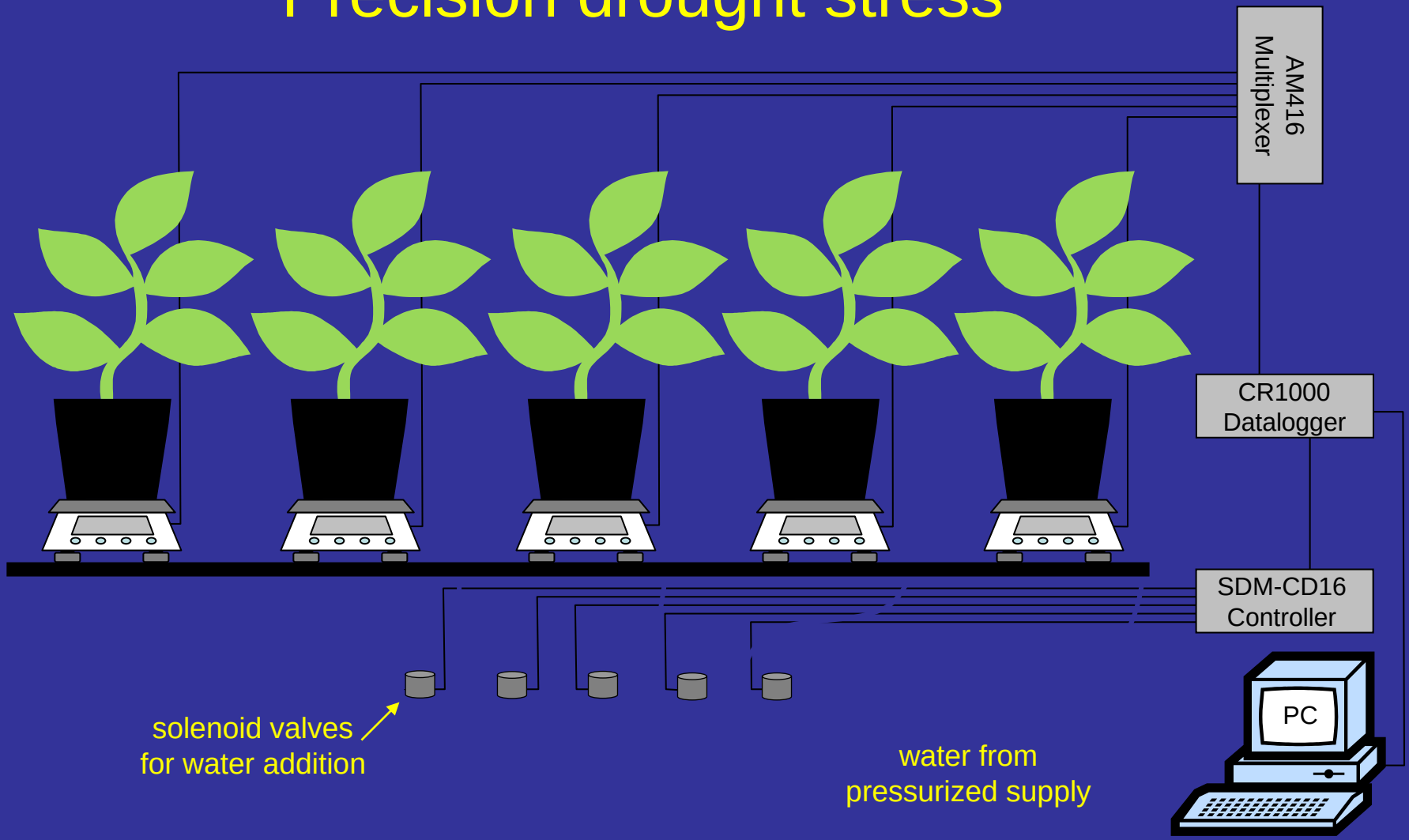
----------16 hour photoperiod ----------

Trends in Daily Stomatal Conductance of Four Plant Species

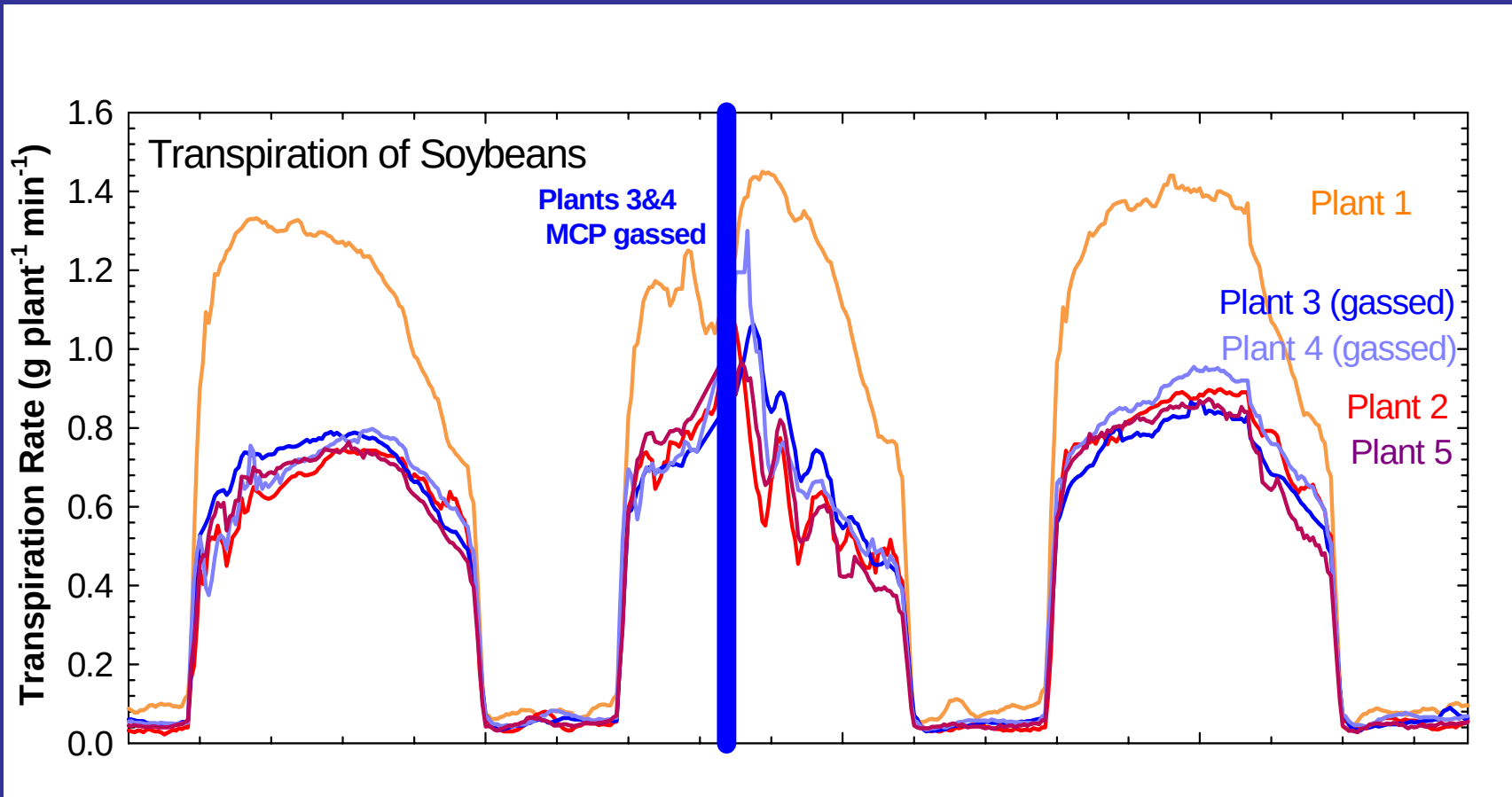
Average of four replicate plants per species, three days per plant, normalized to conductance at mid-day.

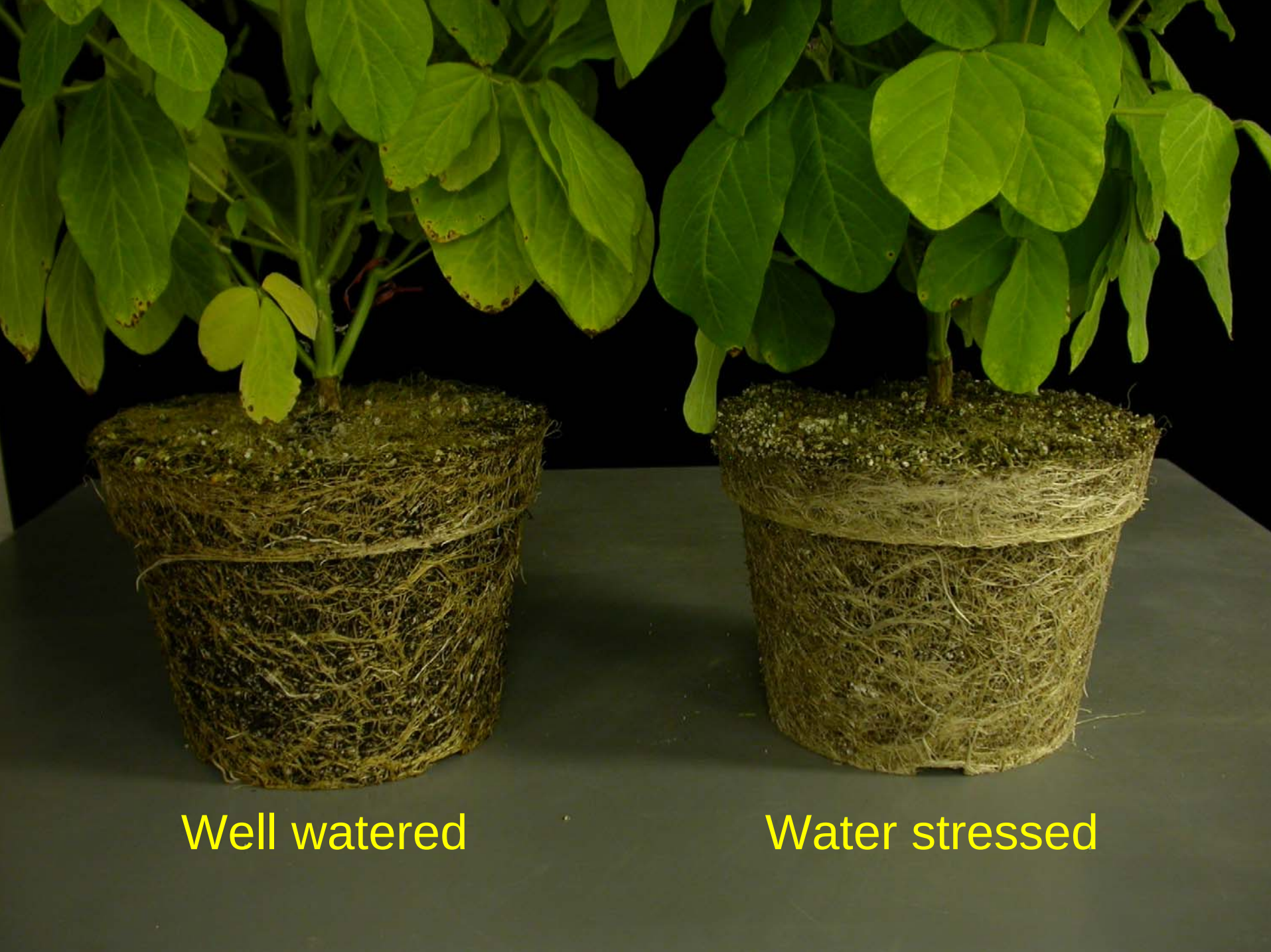


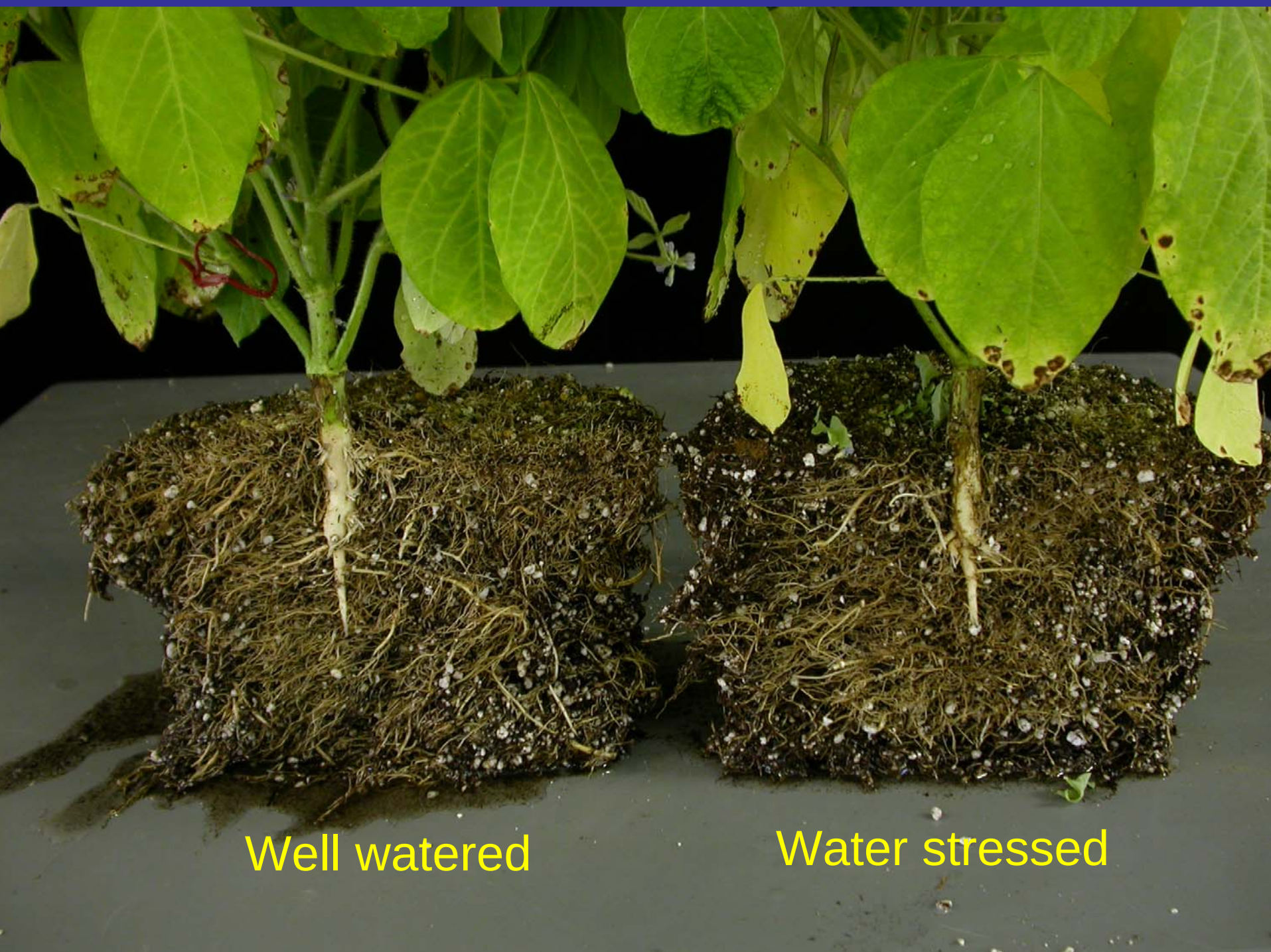
Precision drought stress



One well watered control plant
Four drought stressed plants

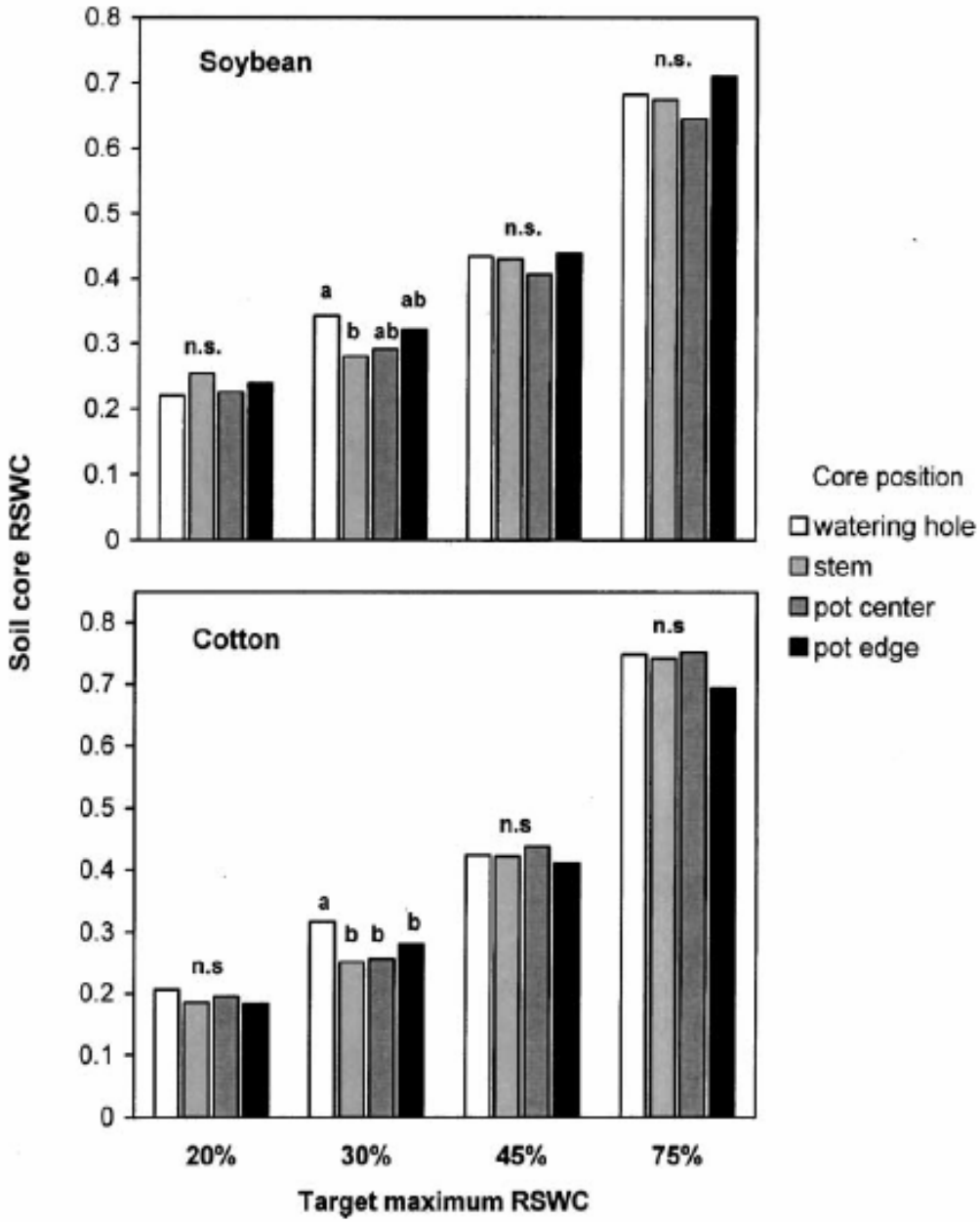



Well watered
Water stressed

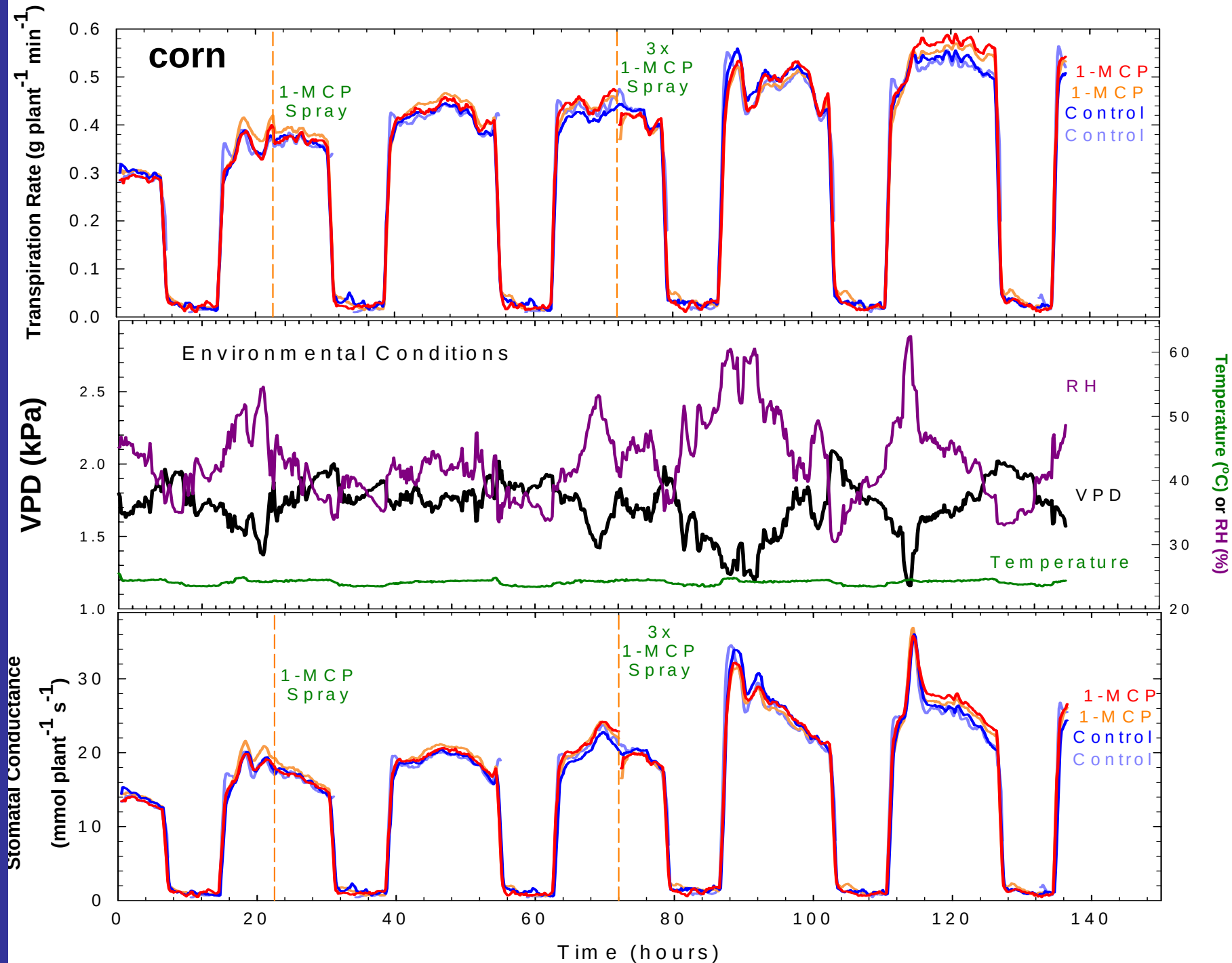

Well watered
Water stressed

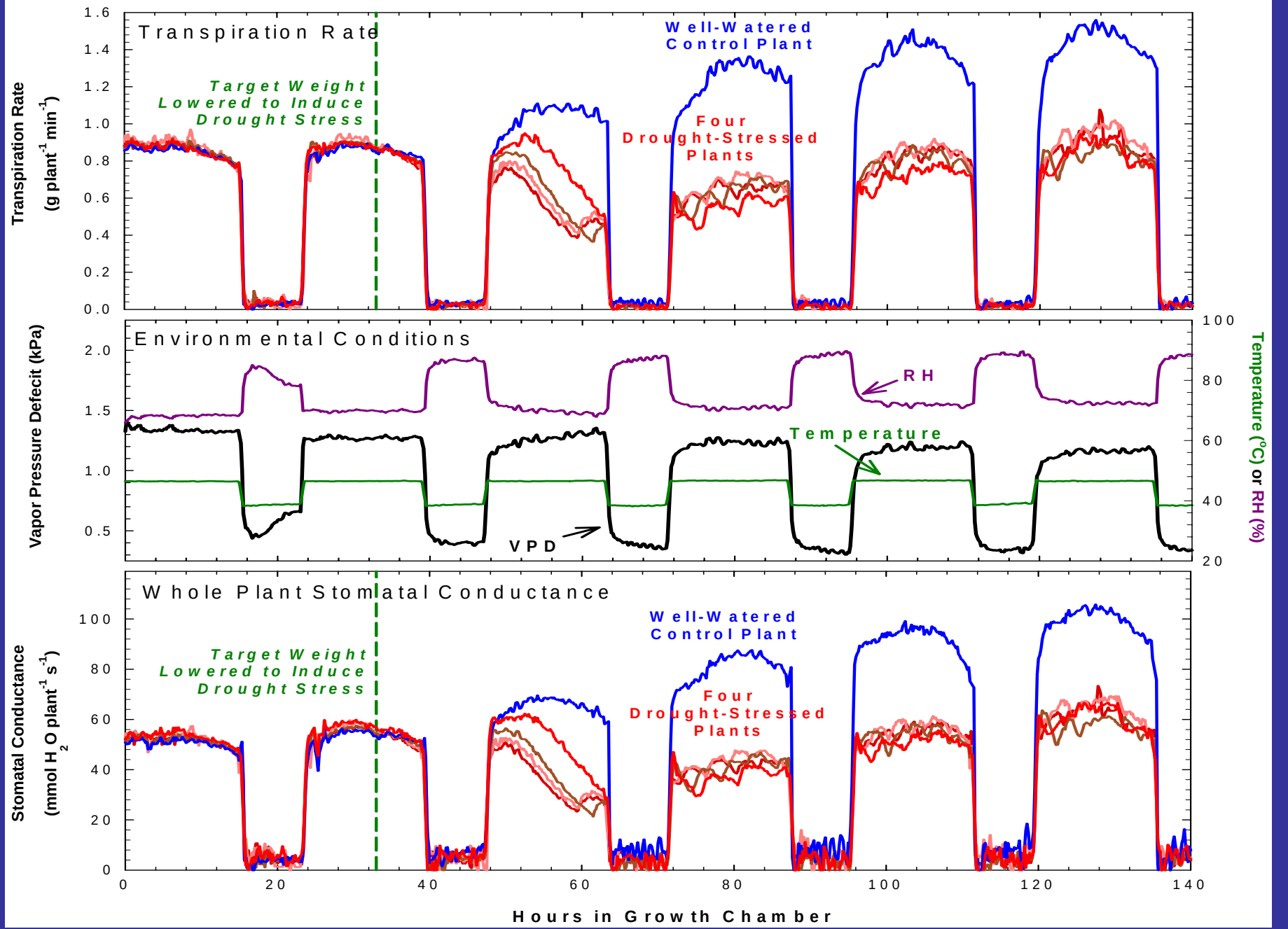
A PRECISE GRAVIMETRIC METHOD FOR SIMULATING DROUGHT STRESS IN POT EXPERIMENTS

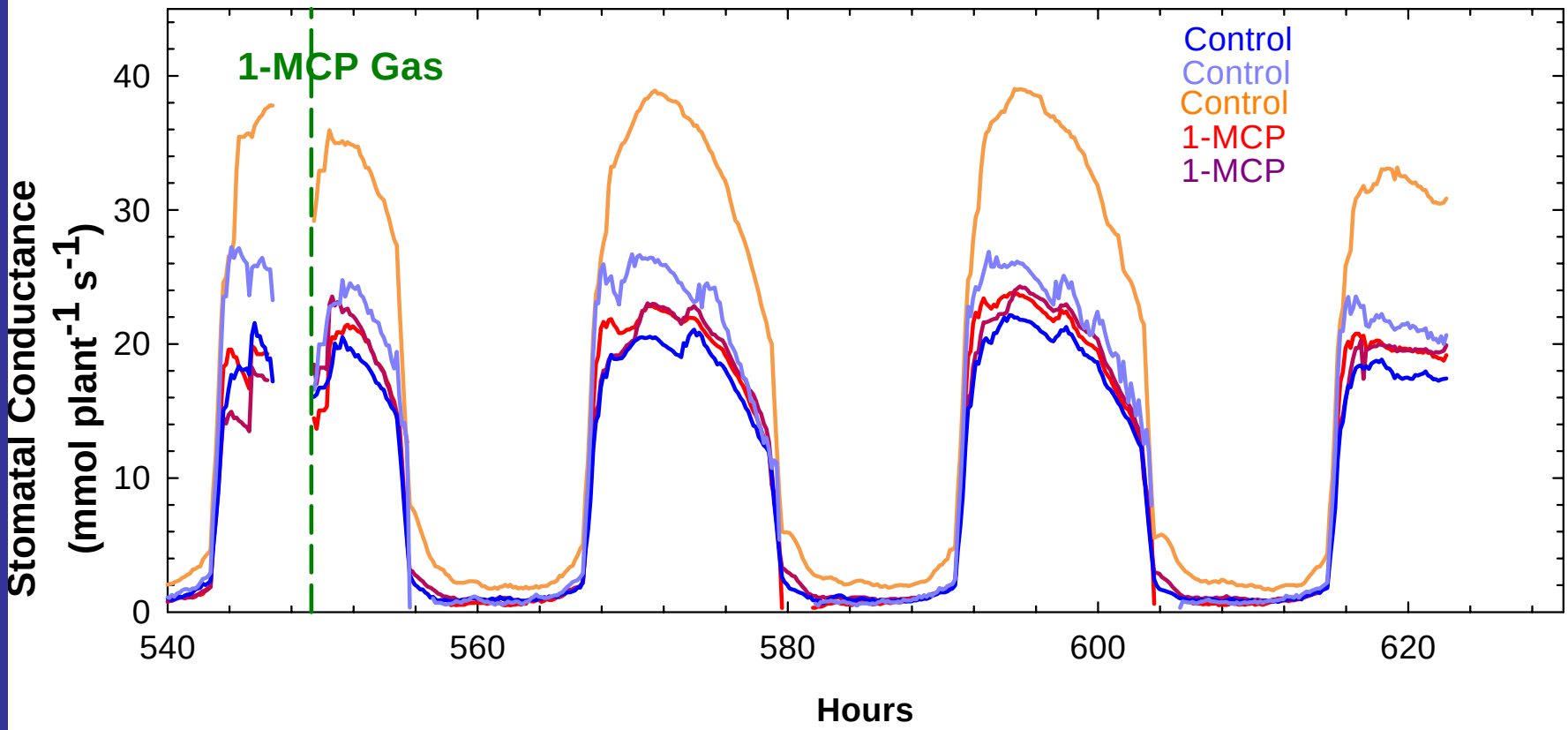
HUGH J. EARL*



$$\text{Stomatal conductance} = \frac{\text{Transpiration}}{\text{VPD}}$$


corn
Transpiration Rate (g plant-1 min-1)
1-MCP Spray
3x 1-MCP Spray
1-MCP
1-MCP
Control
Control
Environmental Conditions
VPD (kPa)
RH
VPD
Temperature
Temperature (°C) or RH (%)
Stomatal Conductance (mmol plant-1 s-1)
Time (hours)


Transpiration Rate
Target Weight Lowered to Induce Drought Stress
Well-Watered Control Plant
Four Drought-Stressed Plants
Transpiration Rate (g plant-1 min-1)
Environmental Conditions
RH
Temperature
VPD
Vapor Pressure Defecit (kPa)
Temperature (°C) or RH (%)
Whole Plant Stomatal Conductance
Target Weight Lowered to Induce Drought Stress
Well-Watered Control Plant
Four Drought-Stressed Plants
Stomatal Conductance (mmol H2O plant-1 s-1)
Hours in Growth Chamber



Stomatal conductance of 'NG2448R' cotton
Following a three hour, 660 ppb 1-MCP gas treatment.

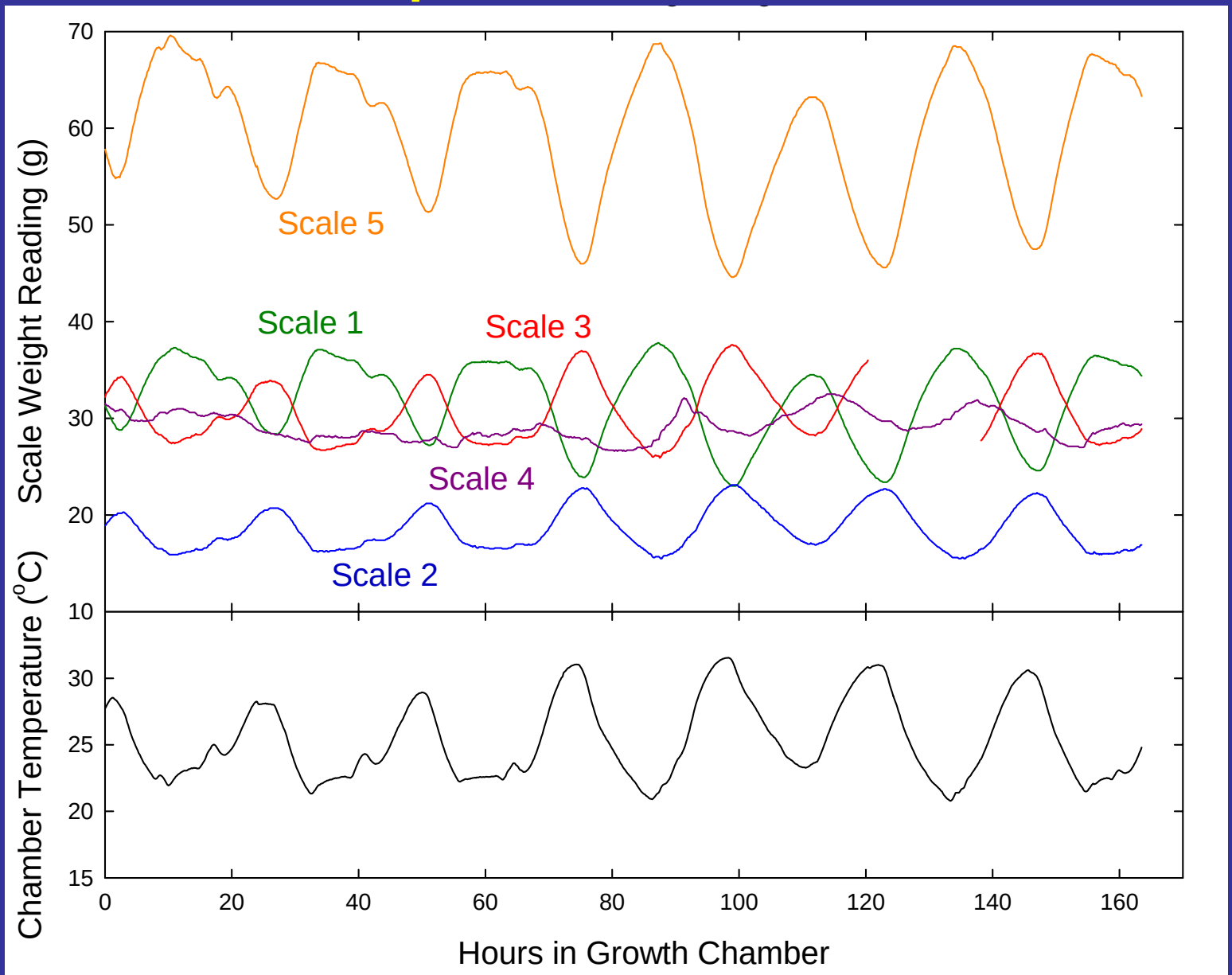
Comparison of Balances

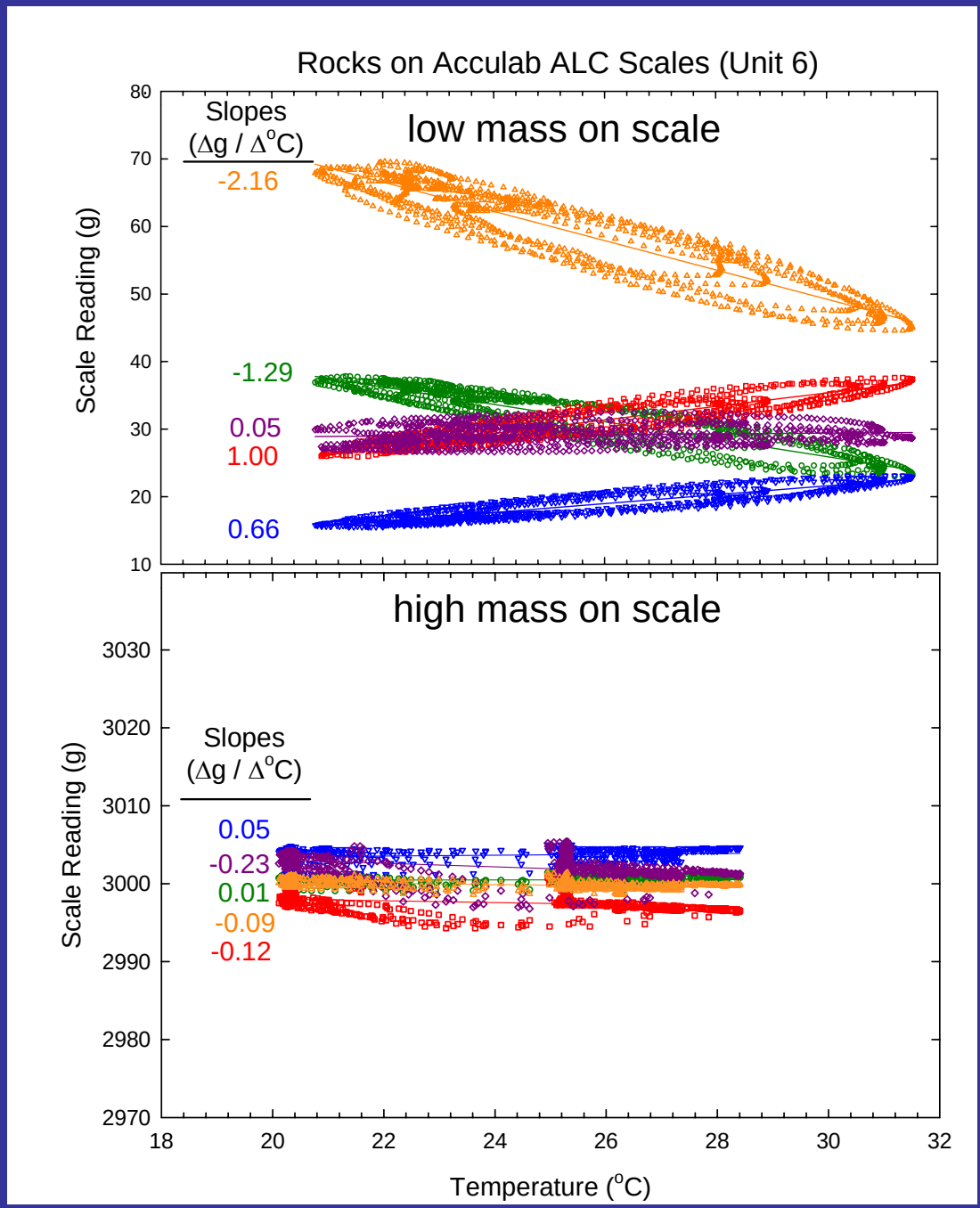
- Acculab Vicon 3101 (3100g x 0.1g) $300
- Acculab ALC 4100.1 (4100g x 0.1g) $750

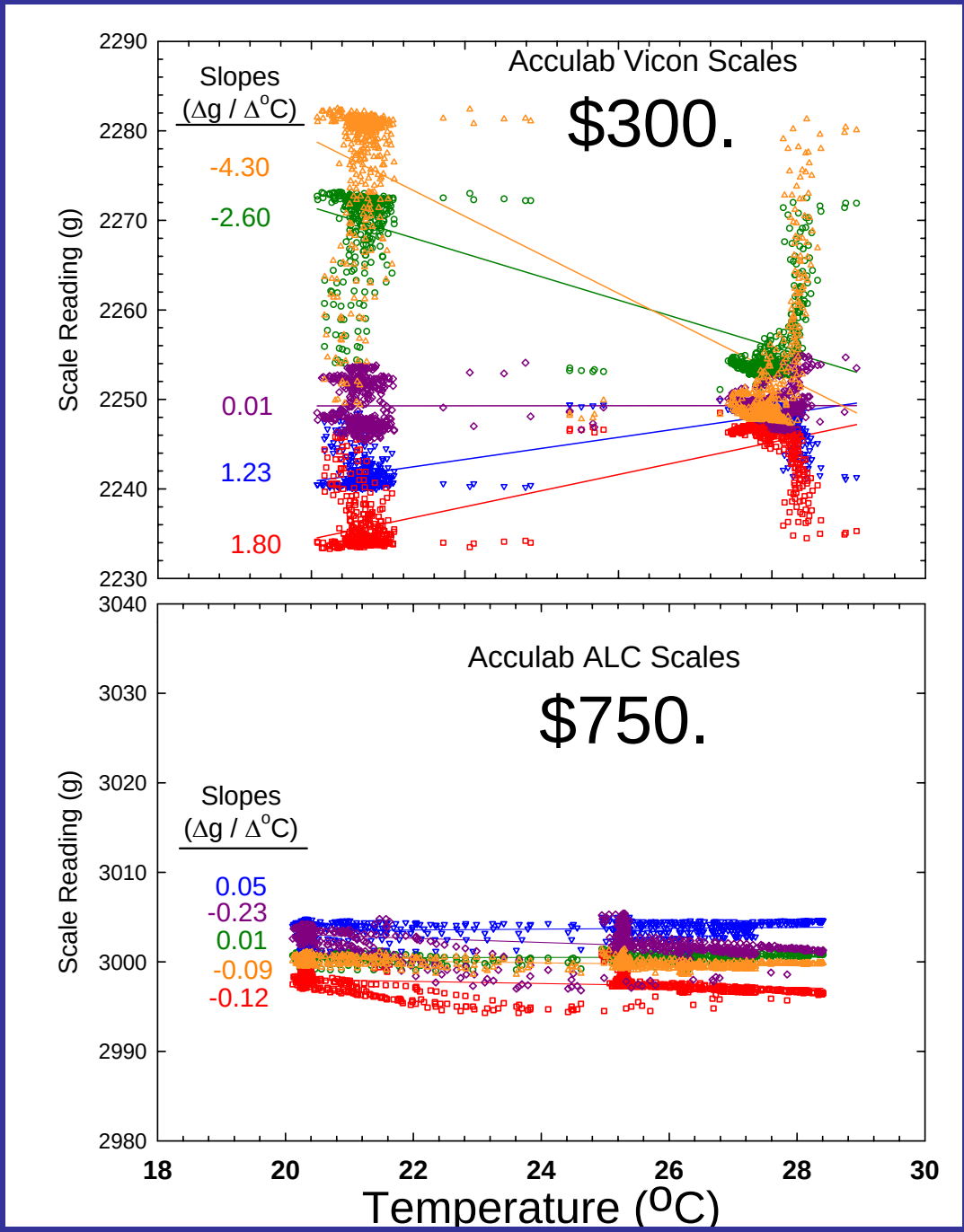
- The less expensive balance is not temperature compensated.

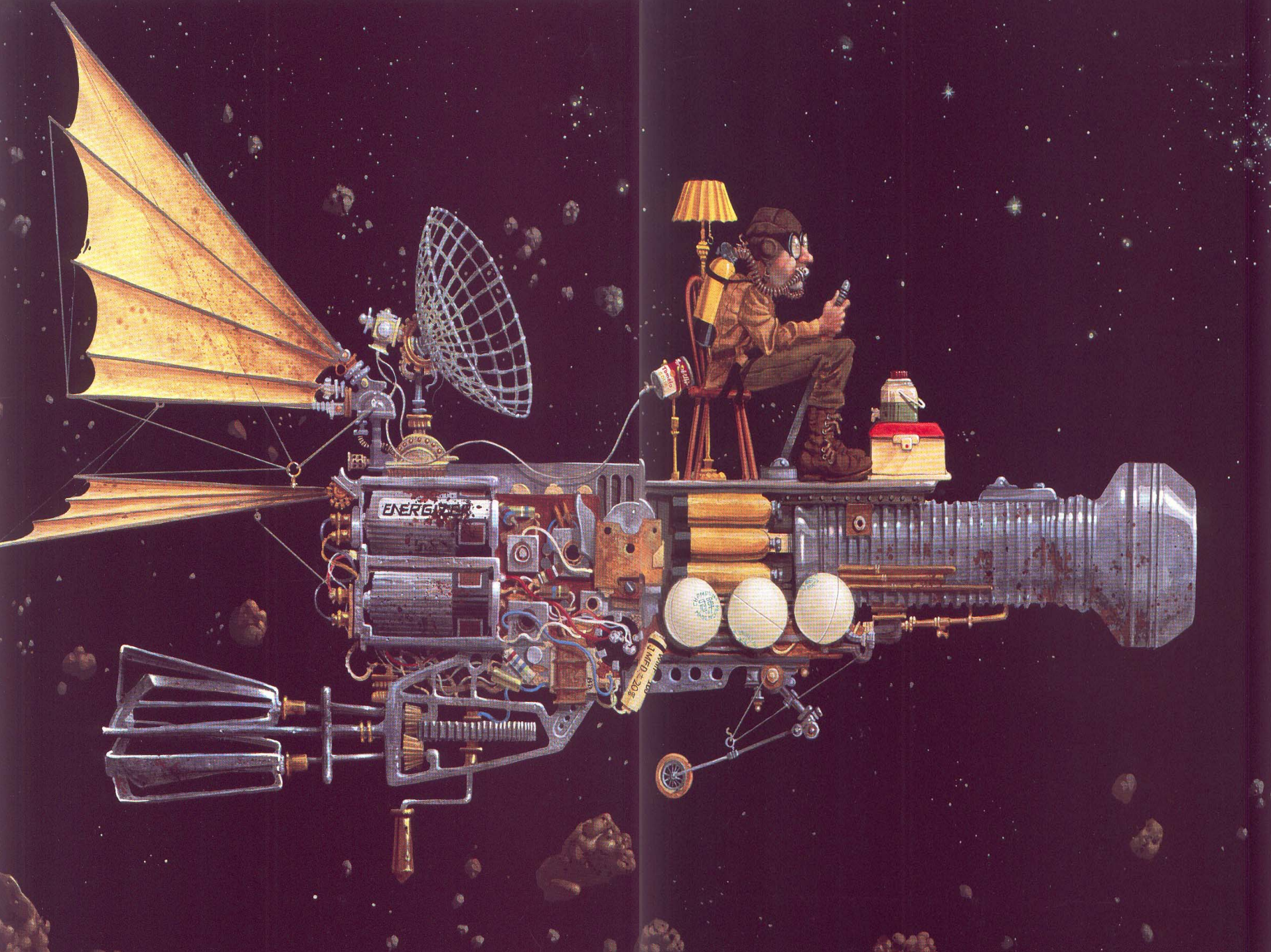
- Is it $450 better?

Temperature effects

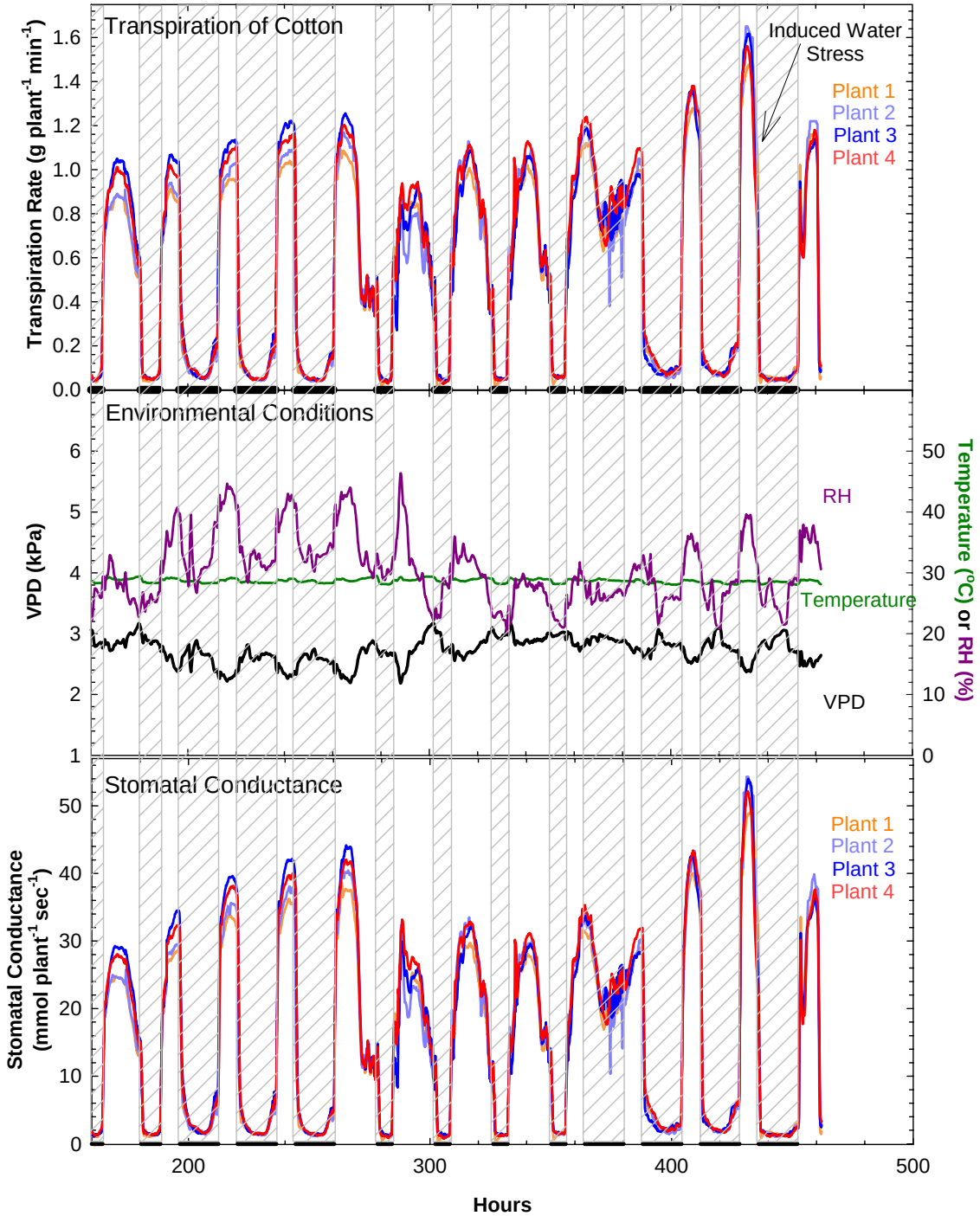



Rocks on Acculab ALC Scales (Unit 6)
low mass on scale
Slopes
(Δg / Δ°C)
-2.16
-1.29
0.05
1.00
0.66
Scale Reading (g)
high mass on scale
Slopes
(Δg / Δ°C)
0.05
-0.23
0.01
-0.09
-0.12
Scale Reading (g)
Temperature (°C)

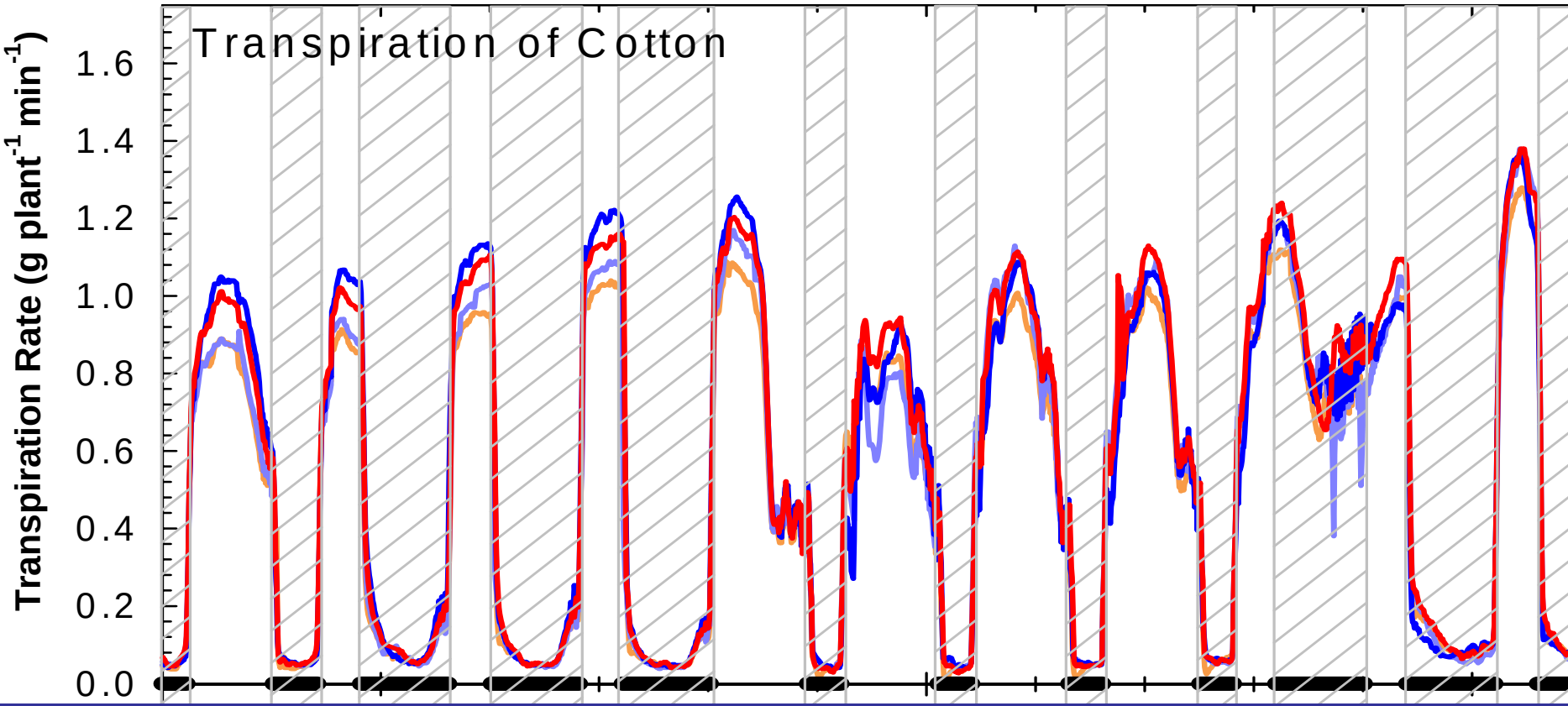

Acculab Vicon Scales
$300.
Slopes
(Δg / Δ°C)
-4.30
-2.60
0.01
1.23
1.80
Scale Reading (g)
2290
2280
2270
2260
2250
2240
2230
Acculab ALC Scales
$750.
Slopes
(Δg / Δ°C)
0.05
-0.23
0.01
-0.09
-0.12
Scale Reading (g)
3040
3030
3020
3010
3000
2990
2980
18
20
22
24
26
28
30
Temperature (°C)



Photoperiod effects on cotton

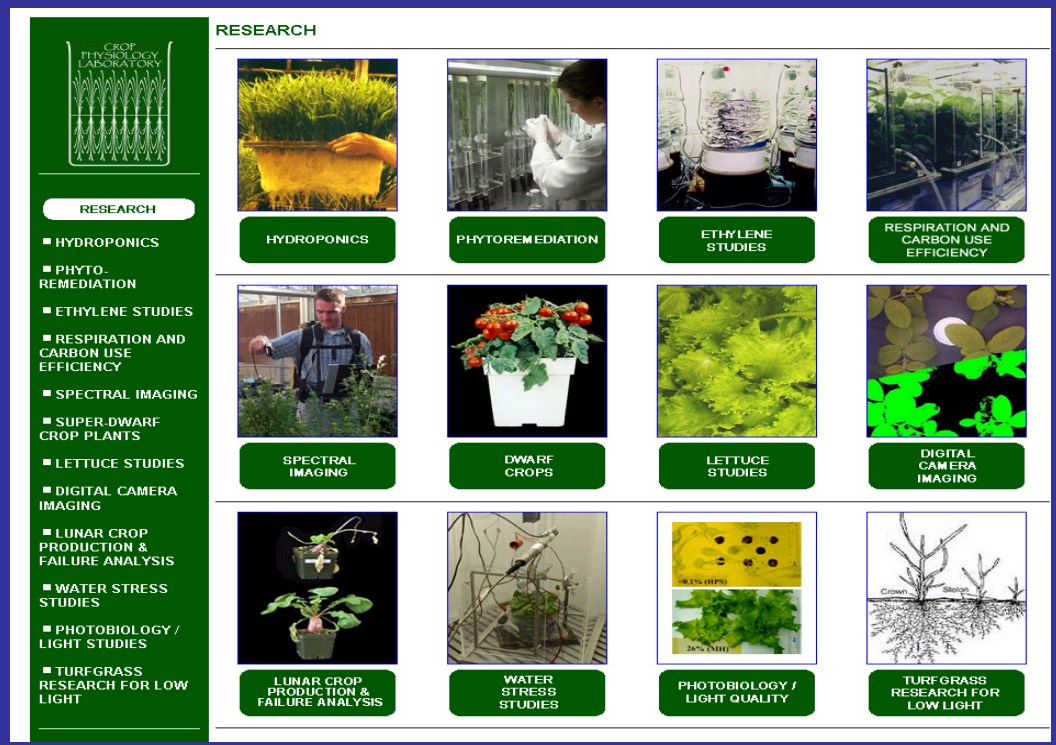


Jet lag in cotton



this talk
will be on the
Utah State
University
Crop Physiology
Lab
Website

www.usu.edu/cpl



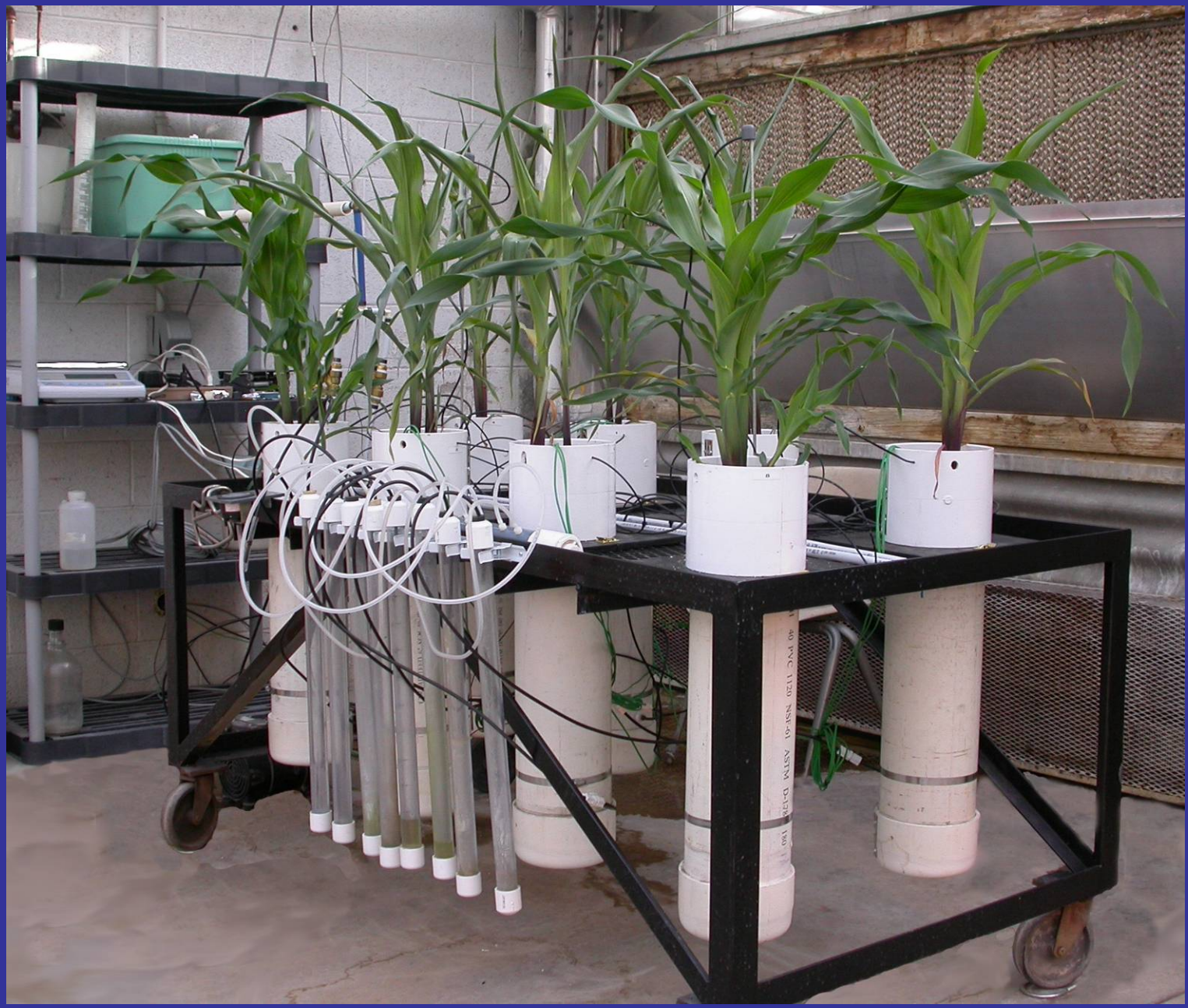
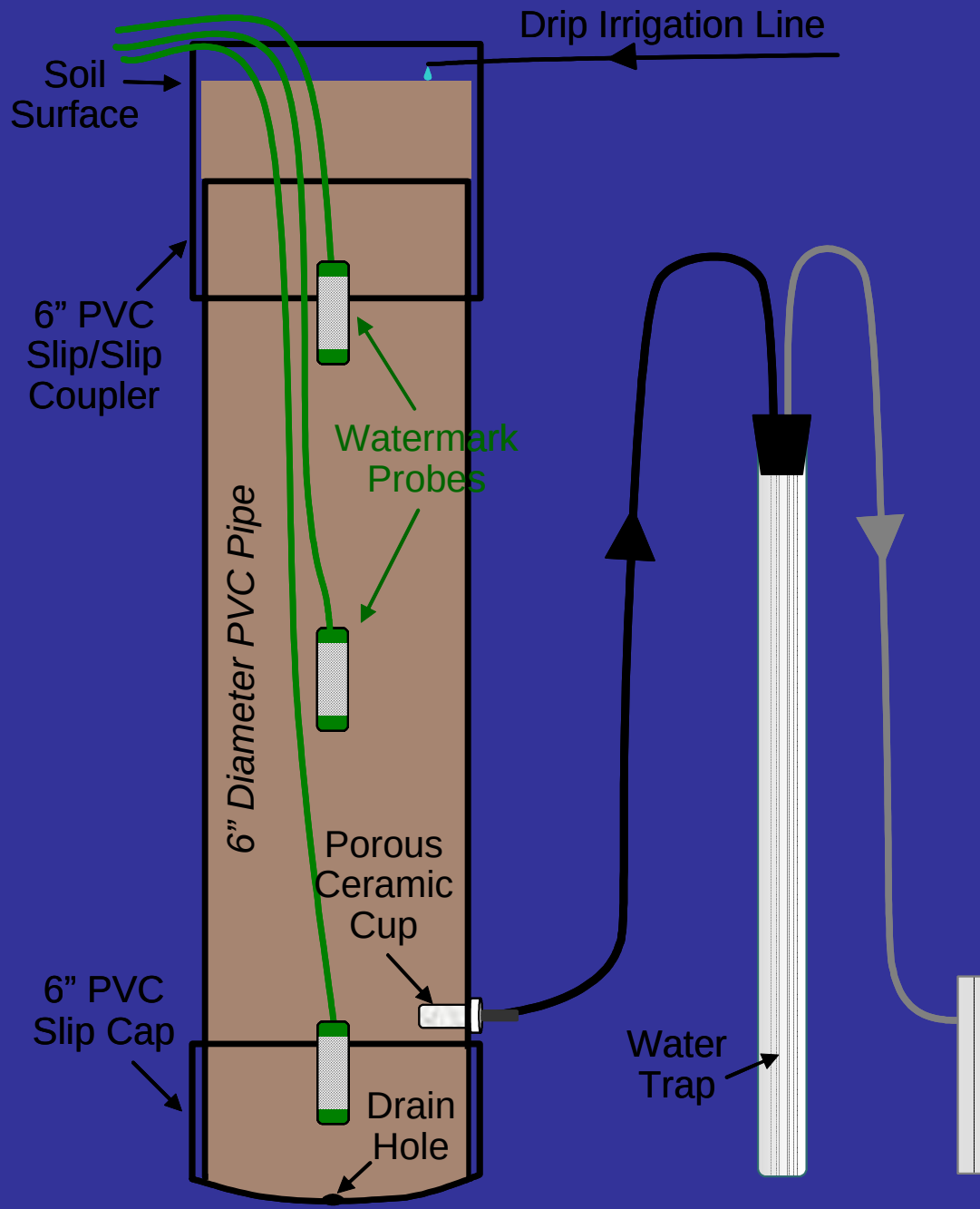
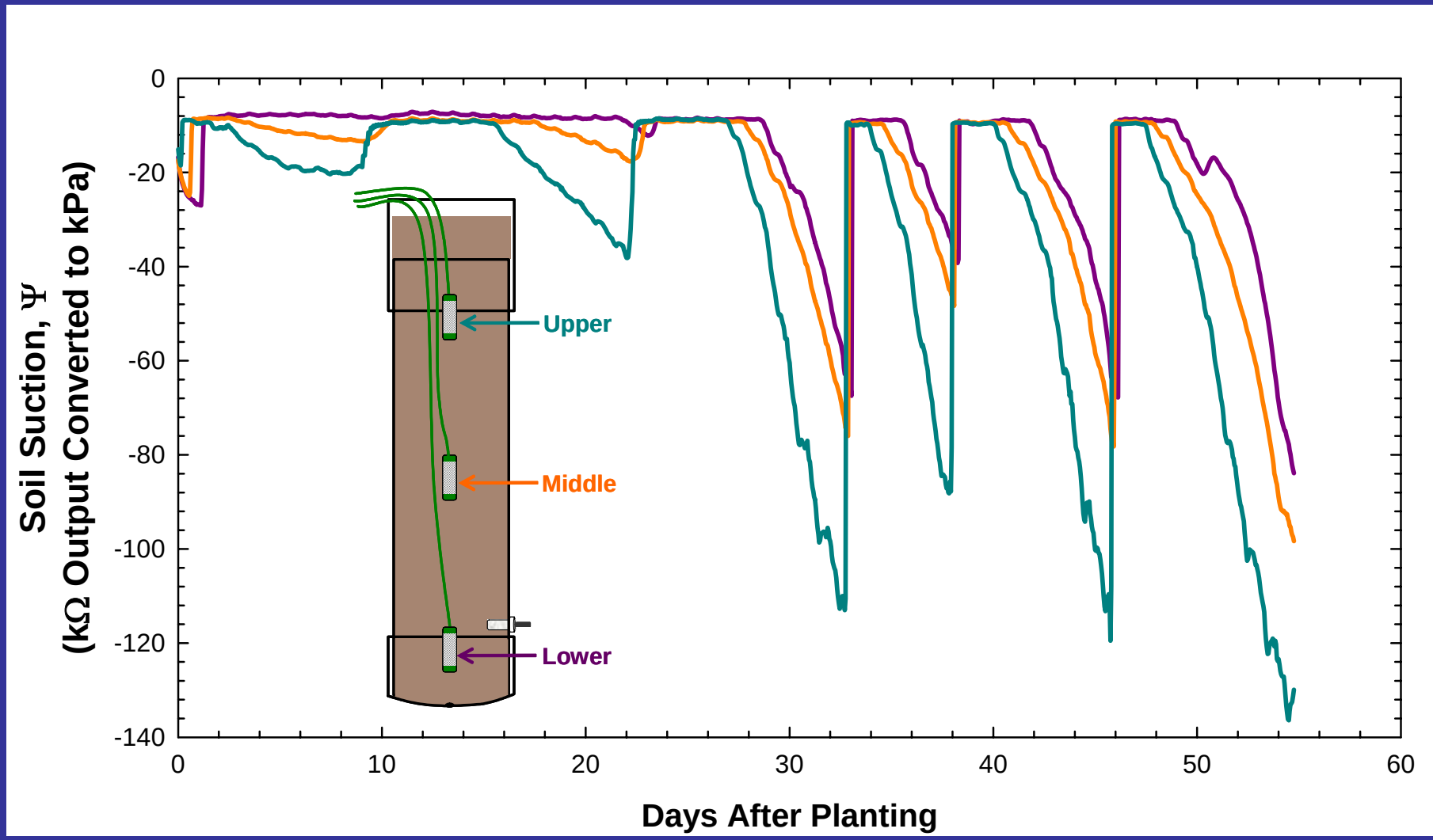
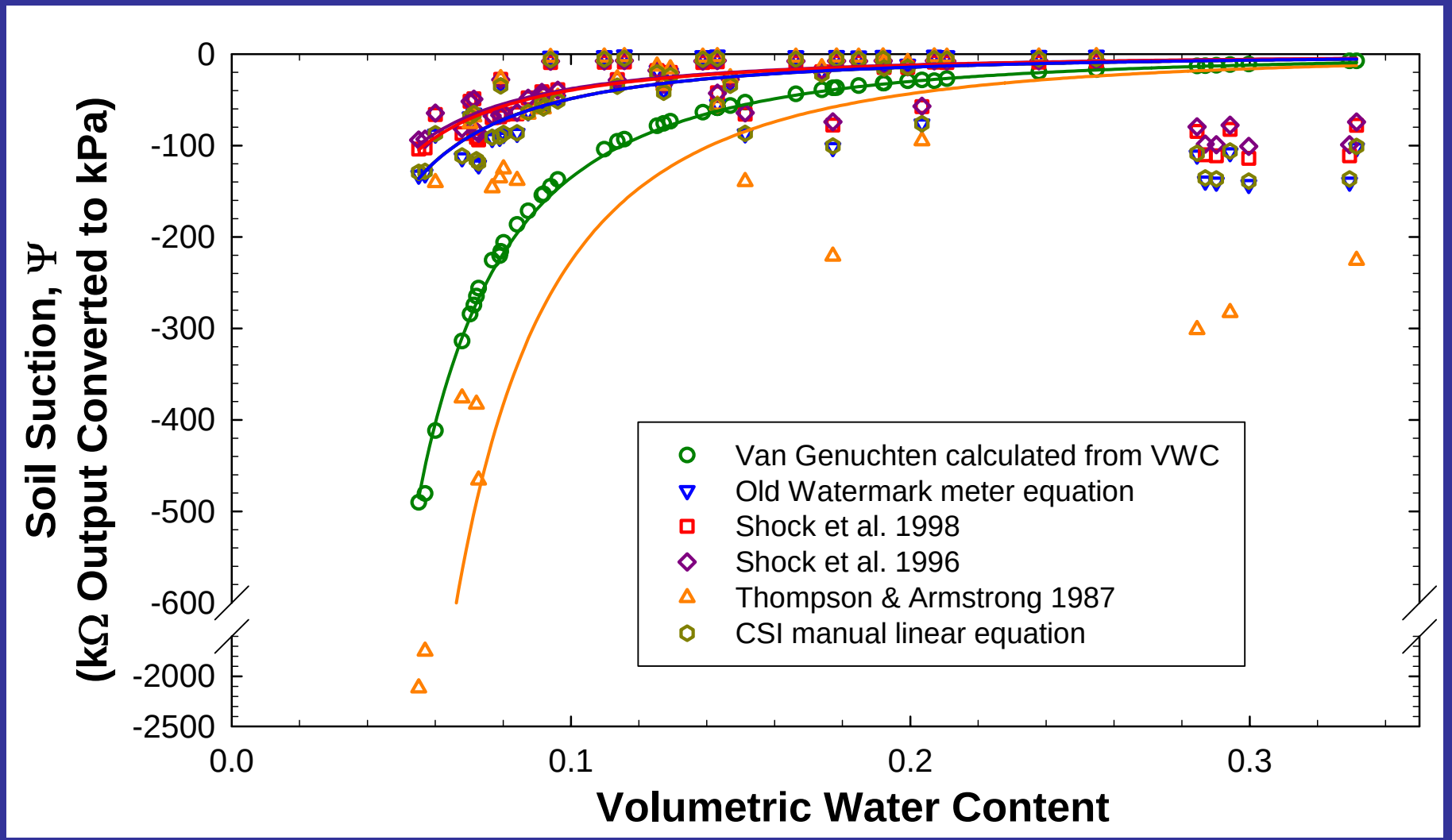


Figure 2. Eight replicate columns in the greenhouse.


Drip Irrigation Line
Soil Surface
6” PVC Slip/Slip Coupler
Watermark Probes
6” Diameter PVC Pipe
Porous Ceramic Cup
6” PVC Slip Cap
Drain Hole
Water Trap


Soil Suction, Ψ
(kΩ Output Converted to kPa)
0
-20
-40
-60
-80
-100
-120
-140
0
10
20
30
40
50
60
Days After Planting
Upper
Middle
Lower


Soil Suction, Ψ
(kΩ Output Converted to kPa)
0
-100
-200
-300
-400
-500
-600
-2000
-2500
0.0
0.1
0.2
0.3
Volumetric Water Content
Van Genuchten calculated from VWC
Old Watermark meter equation
Shock et al. 1998
Shock et al. 1996
Thompson & Armstrong 1987
CSI manual linear equation


Floor office avg 22.87
Floor main avg 19.50
Pressure 87.06
South average 18.95
Center average 19.99
West average 19.93
Office average 19.77
Main average 19.57
InsideCO2 624.00
Outside air 31.44
Office return 26.23
Main return 24.76
HighTemp1 72.06
FloorRet 26.85
HighTempLoop 70.06
LowTempLoop 26.97
Return1 38.73
Return2 45.40
Return3 34.28
Return4 36.06
Nbathroom 17.88
Sbathroom 21.37
Calroom 20.68
Noffice 20.23
Soffice 19.44
Confroom 19.02
Efrontdoor 19.23
Wfrontdoor 18.31
SWcorner 18.06
SWdoor 20.19
NWdoor 21.79
NWcorner 18.72
Nwall 19.01
NEpost 19.99
SEpost 20.08
SWpost 20.06
NWpost 19.83
InsideAir 19.89
InsideRH 18.77
NbathroomF 20.47
SbathroomF 23.77
CalroomF 23.37
NofficeF 23.20
SofficeF 22.47
ConfroomF 23.93
EfrontdoorF 22.29
WfrontdoorF 20.28
SWcornerF 15.95
SWdoorF 18.67
NWdoorF 17.33
NWcornerF 18.37
NwallF 17.00
NEpostF 21.47
SEpostF 22.60
SWpostF 20.26
NWpostF 20.29
OutsideAir -6.78
OutsideRH 89.33