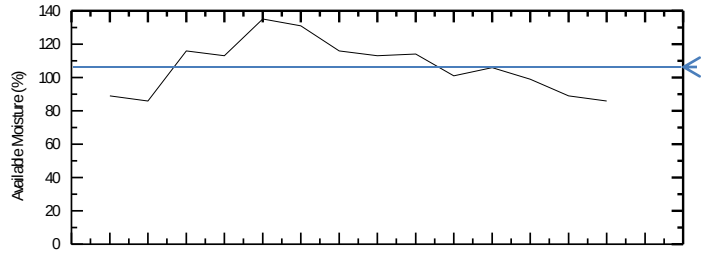
Soil Water Sensors for Irrigation Scheduling

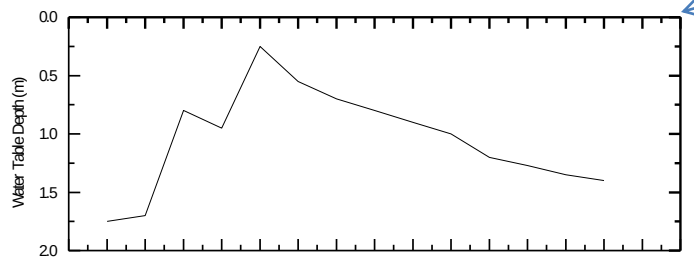
Ted Harms Irrigation Specialist

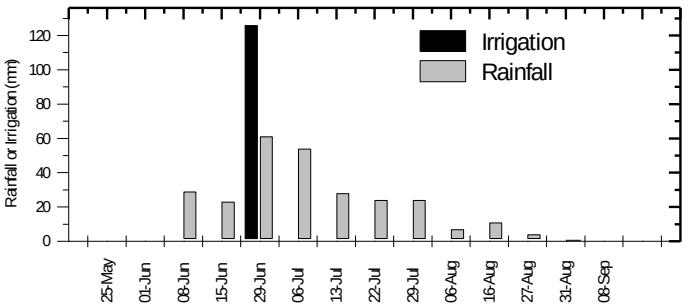
Why am I not getting my yields?



Full

Ground Surface





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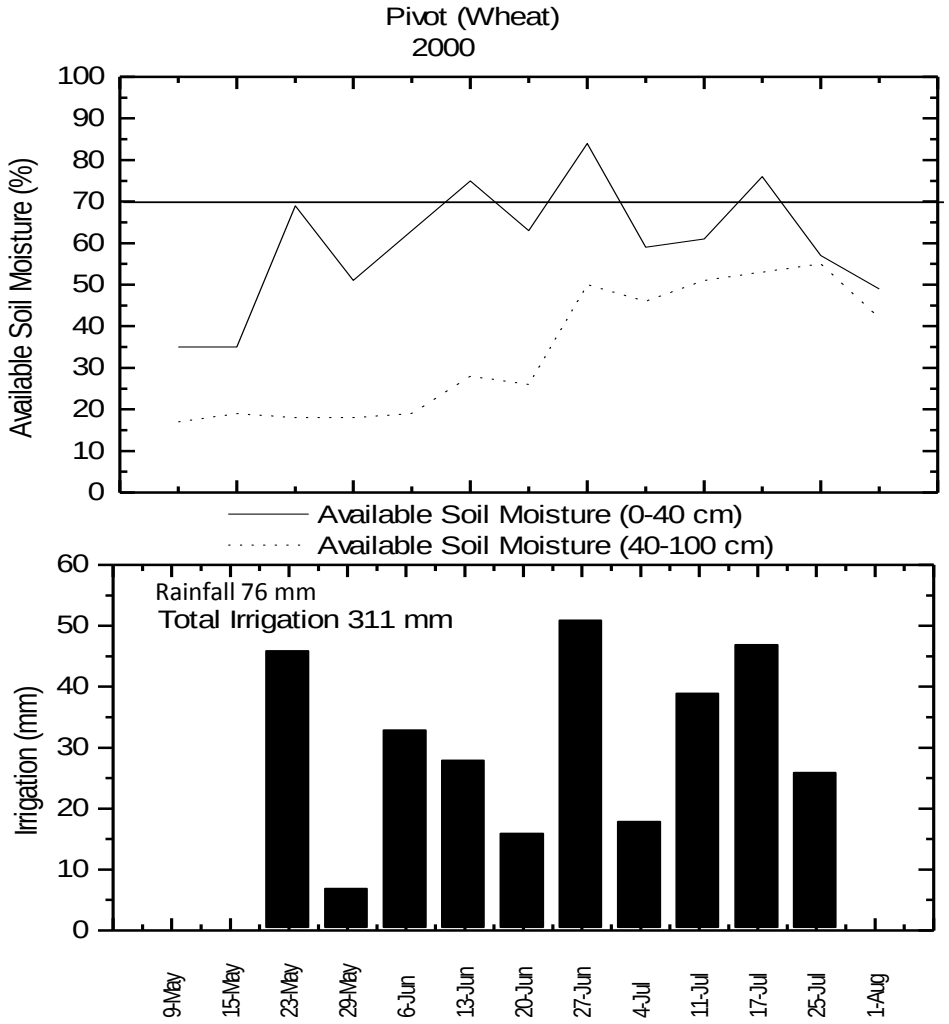
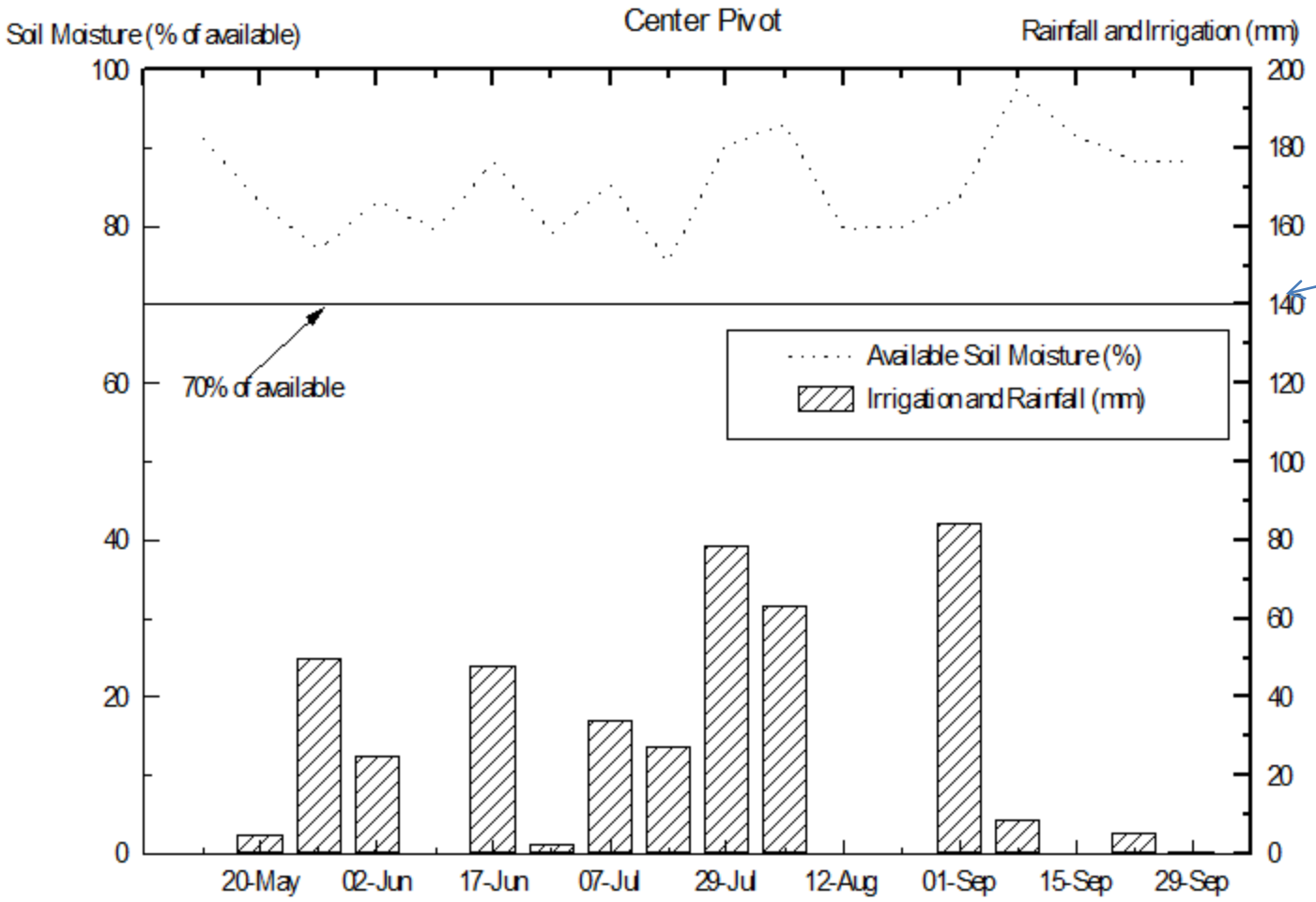


Management Allowed Depletion

When informed of where the soil water level is at in the field



Management Allowed Depletion

Information from soil water sensors is quite valuable for decision making

- Fontanelle AquaView study results showed $11.35/acre in fuel savings and $25.55/acre increase in yield using corn at $4.50/bu.
- “If you equate that to a 130-acre pivot it would mean the grower has an additional income of nearly $4,800 on that field,” Lammers says. That doesn’t account for reduced costs in repairs and labor.
- Irrigation specialist in Mississippi reported a 25% increase in water use efficiency by weekly monitoring of soil water.

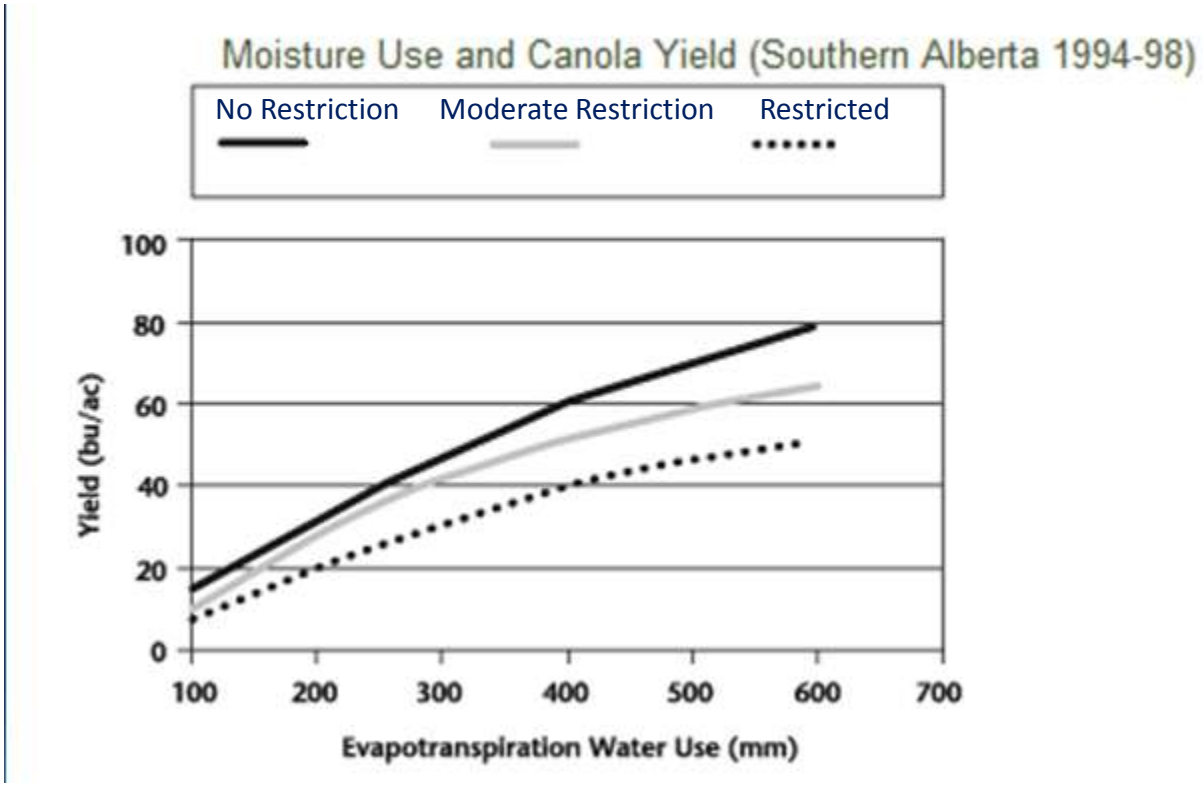
What is it costing me?

Environmentally Smart Nitrogen Study (ESN)

One set of treatments and replications in Vauxhall (no soil water monitoring), one in Brooks (weekly soil water monitoring).

Difference in marketable yield with regular soil water monitoring was $1000/ha

What is it costing me?

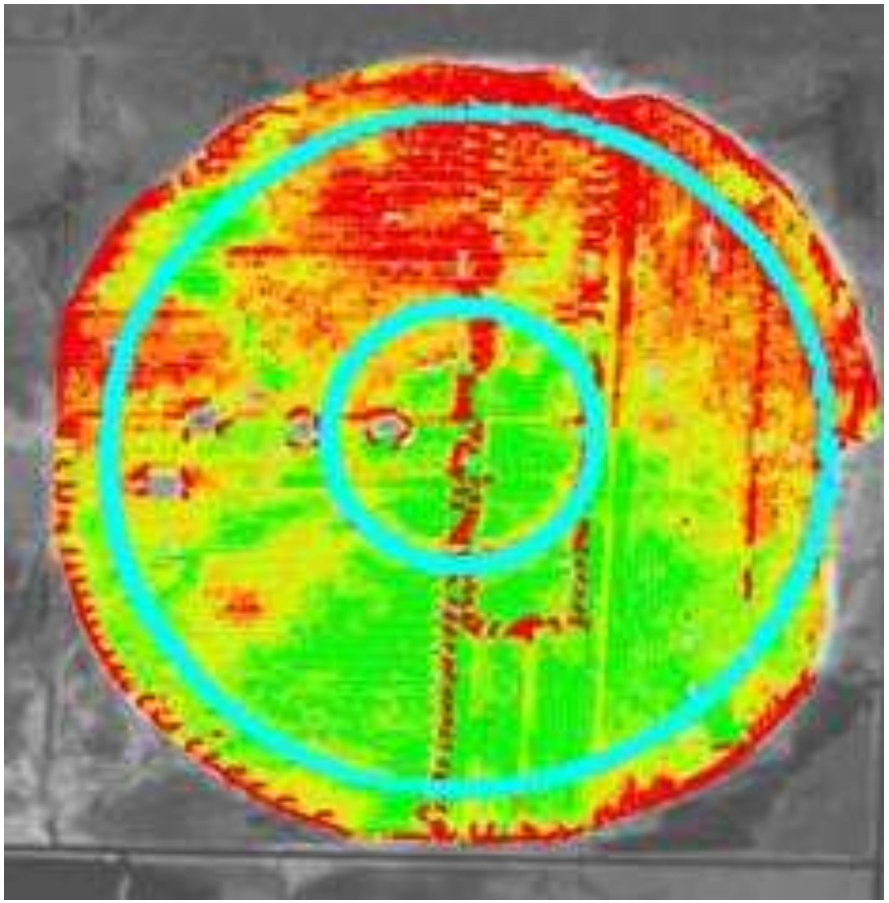


If you fertilize for 80 bu/ac and water for 50 bu/ac

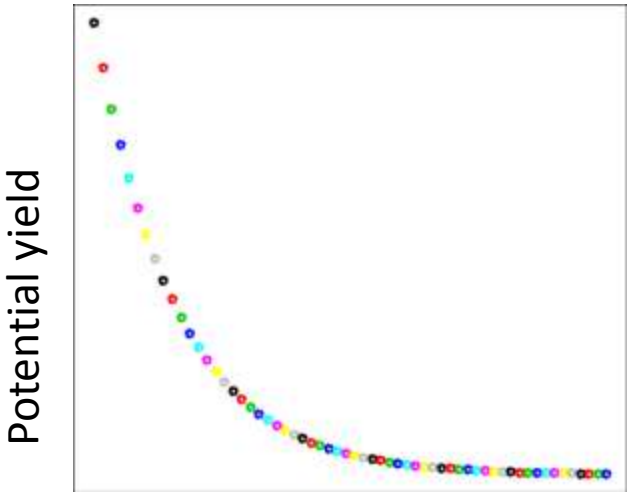
you get 50 bu/ac

Proper management of one component of the production cycle cannot compensate for improper management of another component

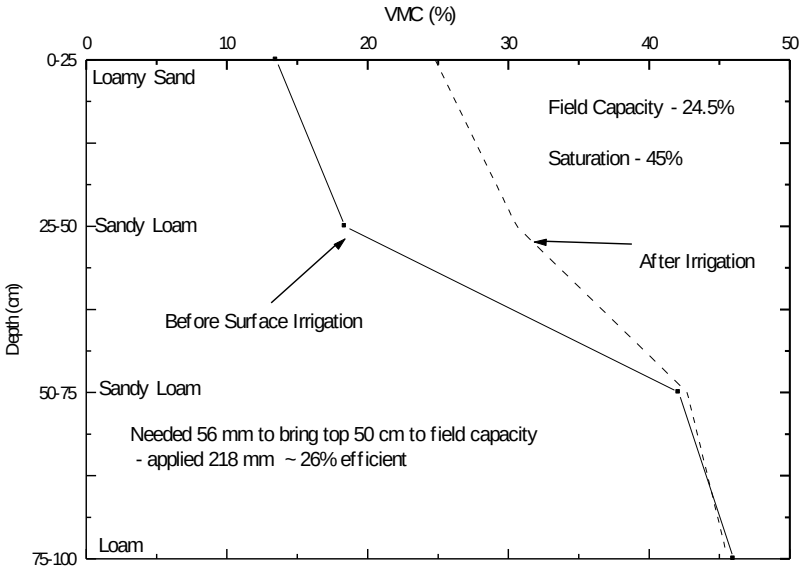
How do you currently make decisions on when to irrigate?



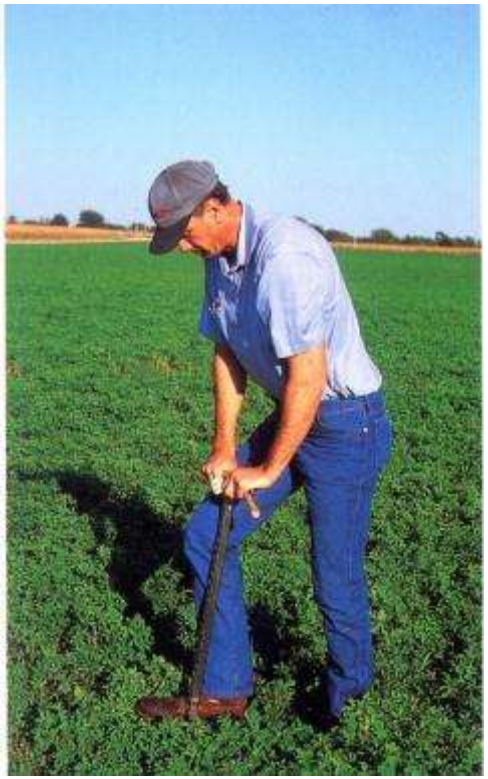
Hopefully not like this – wait for the crop to show symptoms of stress.



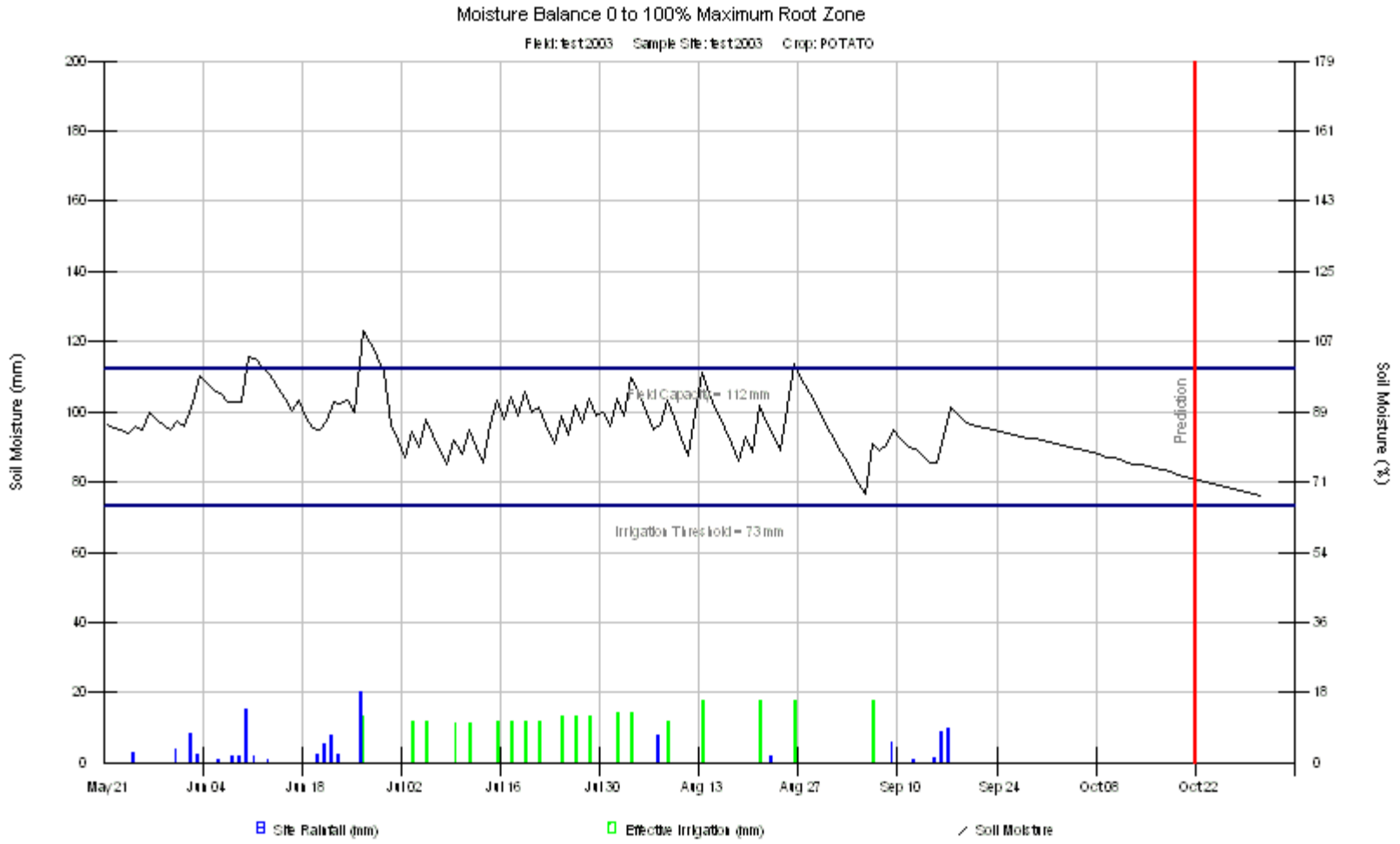
What is in the shopping bag for monitoring soil water?



Samplers for Soil Water



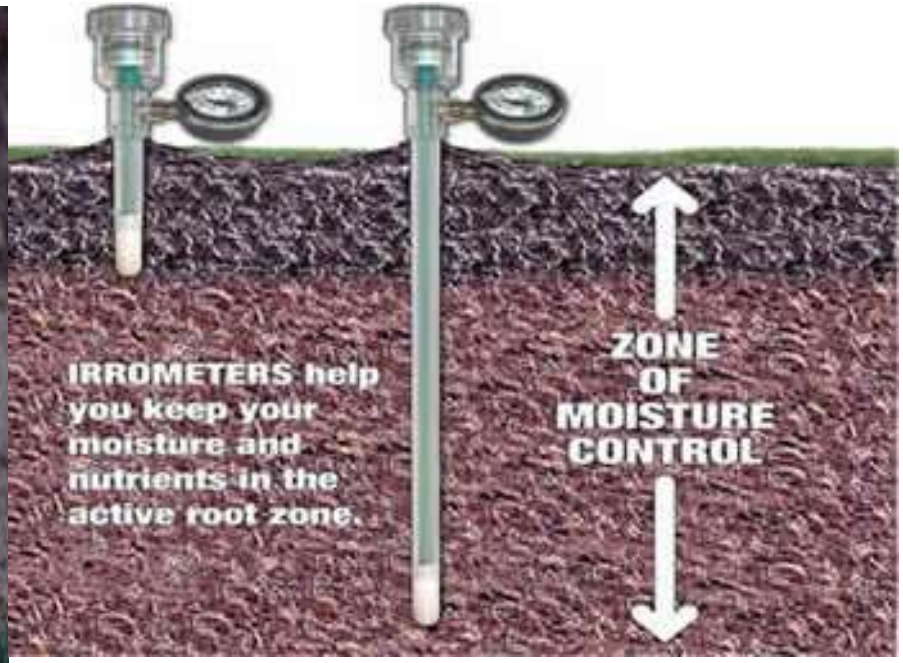
When a shovel or step on sampler do not fit any more.



How the heck can I use these things to help me make irrigation management decisions?

Soil Tension

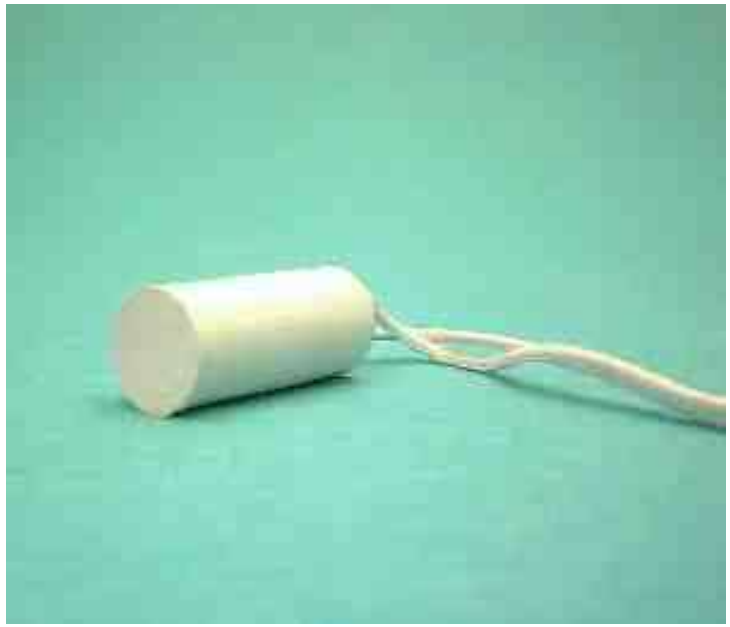
Tensiometer

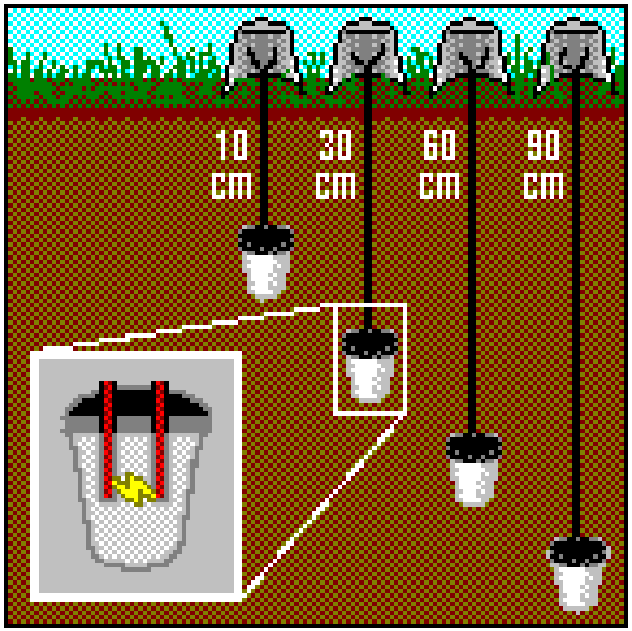


Watermark

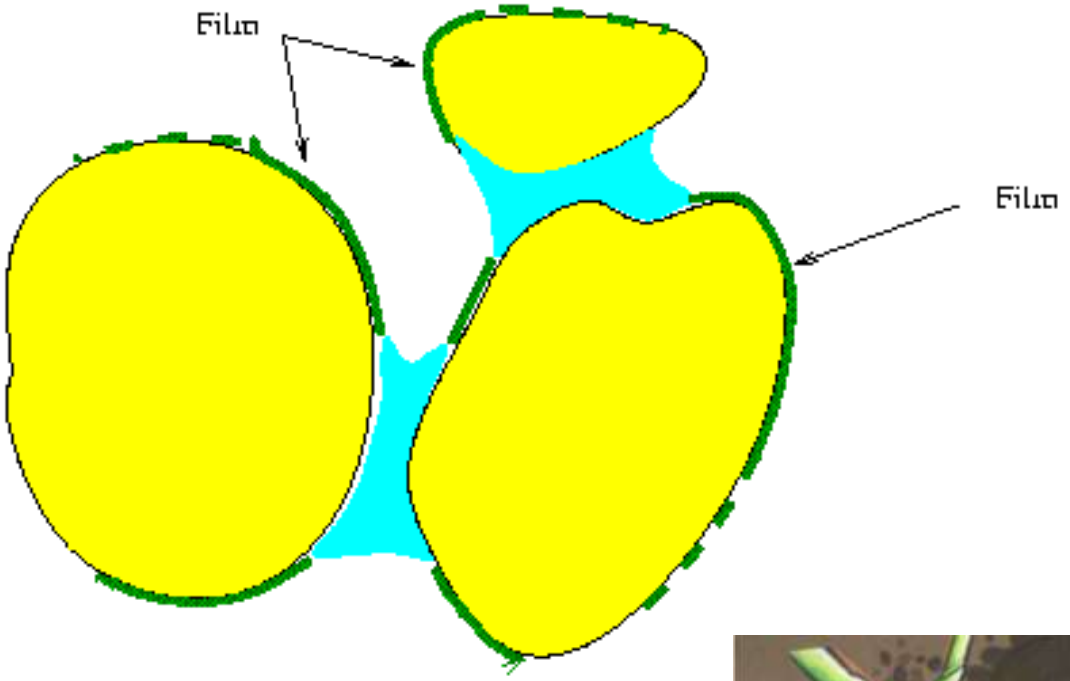
Equitensiometer

Gypsum Block



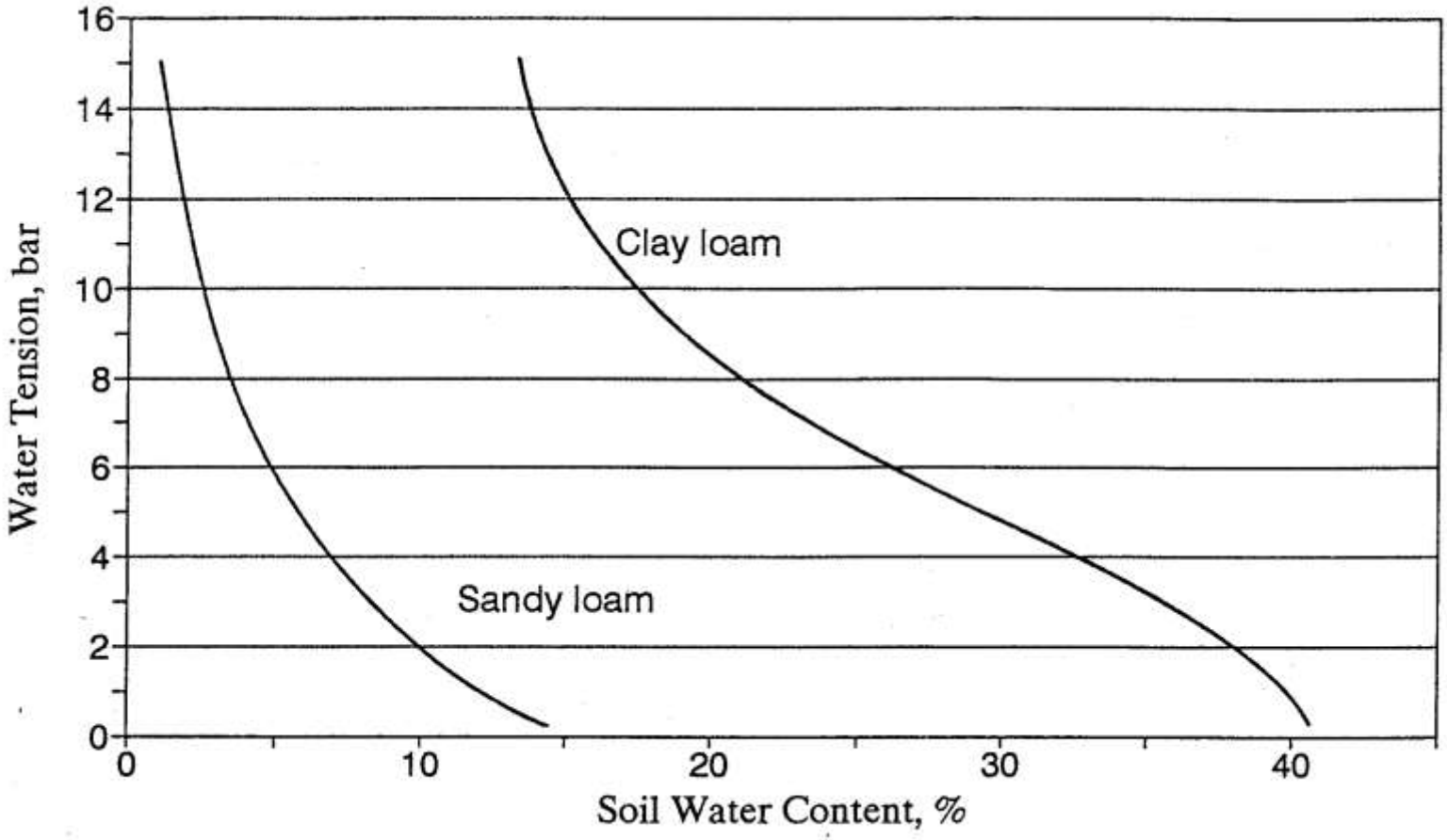


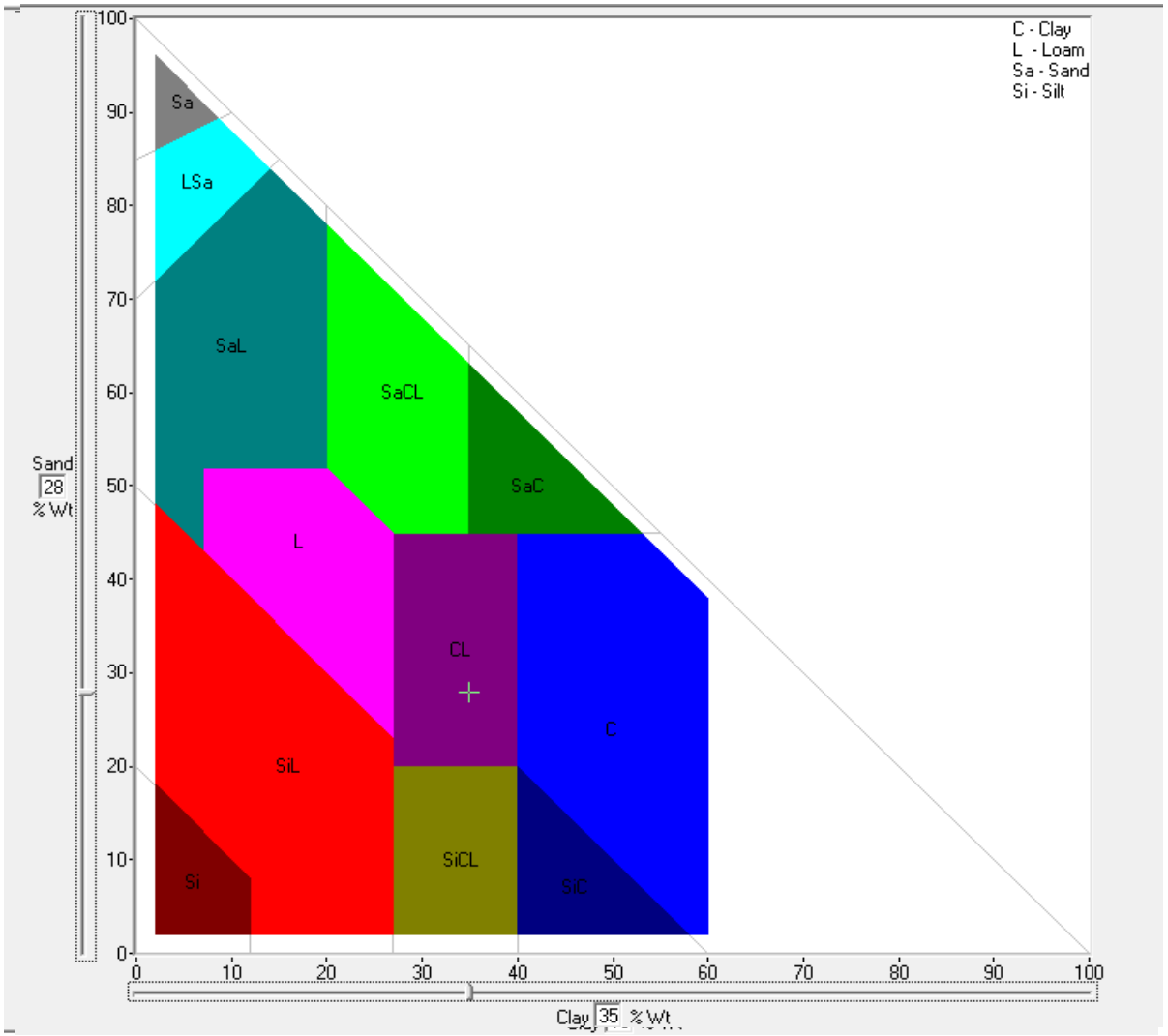
Lots of water in soil – tension is low

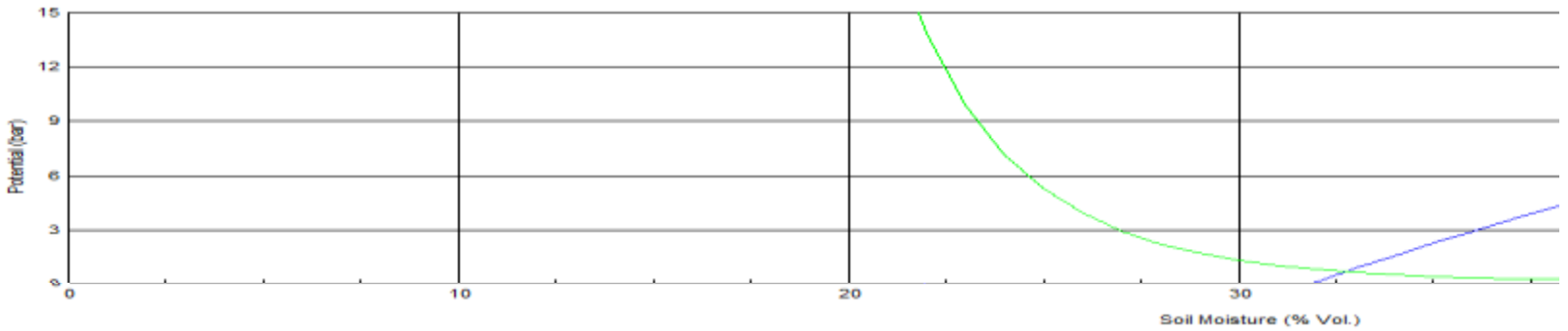


As soil dries, tension goes up.

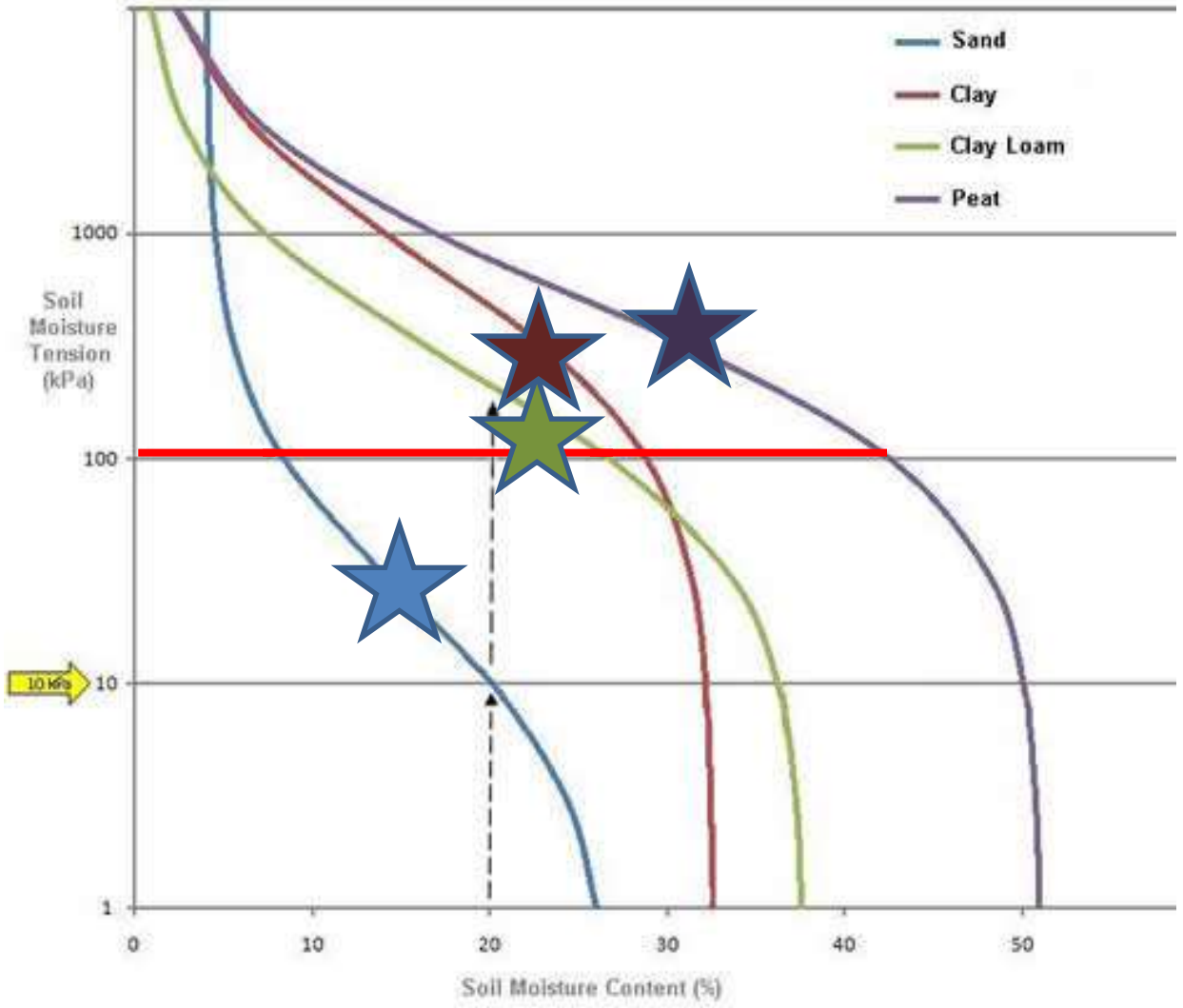
Soil tension related to soil moisture.




C - Clay
L - Loam
Sa - Sand
Si - Silt
Sa
LSa
SaL
SaCL
SaC
L
CL
C
SiL
SiCL
SiC
Si
Sand
28
% Wt
Clay
35
% Wt
0
10
20
30
40
50
60
70
80
90
100


Potential (bar)
15
12
9
6
3
0
0
10
20
30
Soil Moisture (% Vol.)

When should I irrigate? Depends on the soil texture of the field.



At a soil tension of approximately - 200 kPa, tensiometers do not work

Probes that measure the dielectric properties of the soil. (EM Probes)

- Dielectric constant is a measure of the intensity a current can pass through an object.
- How the probes work.
  - Dielectric constant of air is less than 1.
  - Dielectric constant of the mineral component is around 4.
  - Dielectric constant of water is 81.

  - So, if something changes with the readings, it is due to changes in soil water content.

Frequency Domain

Time Domain Reflectometry

Time Domain Reflectometry (TDR)

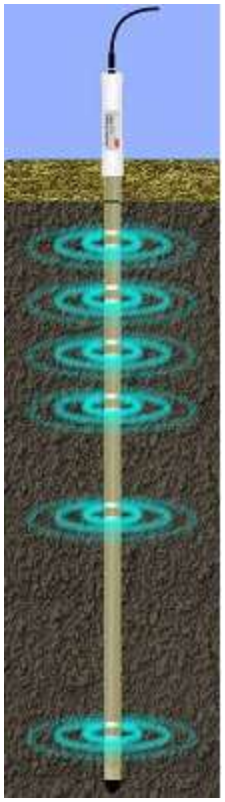
- Measure the propagation velocity of a electromagnetic wave to travel the length of the electrodes and return.
- Inversely related to dielectric permittivity therefore - faster the velocity, lower the dielectric permittivity meaning less water – slower the velocity, higher water content.

Capacitance Sensors (includes RF and FDR sensors)

- Measures soil capacitance.
- Soil acts as the dielectric completing a capacitance circuit.
- A detector compares emitted and received frequency in soil medium.

John Deere Field Connect Helps Producers Monitor Soil Moisture

Frequency Domain Reflectrometry



Output is in volumetric water content percent

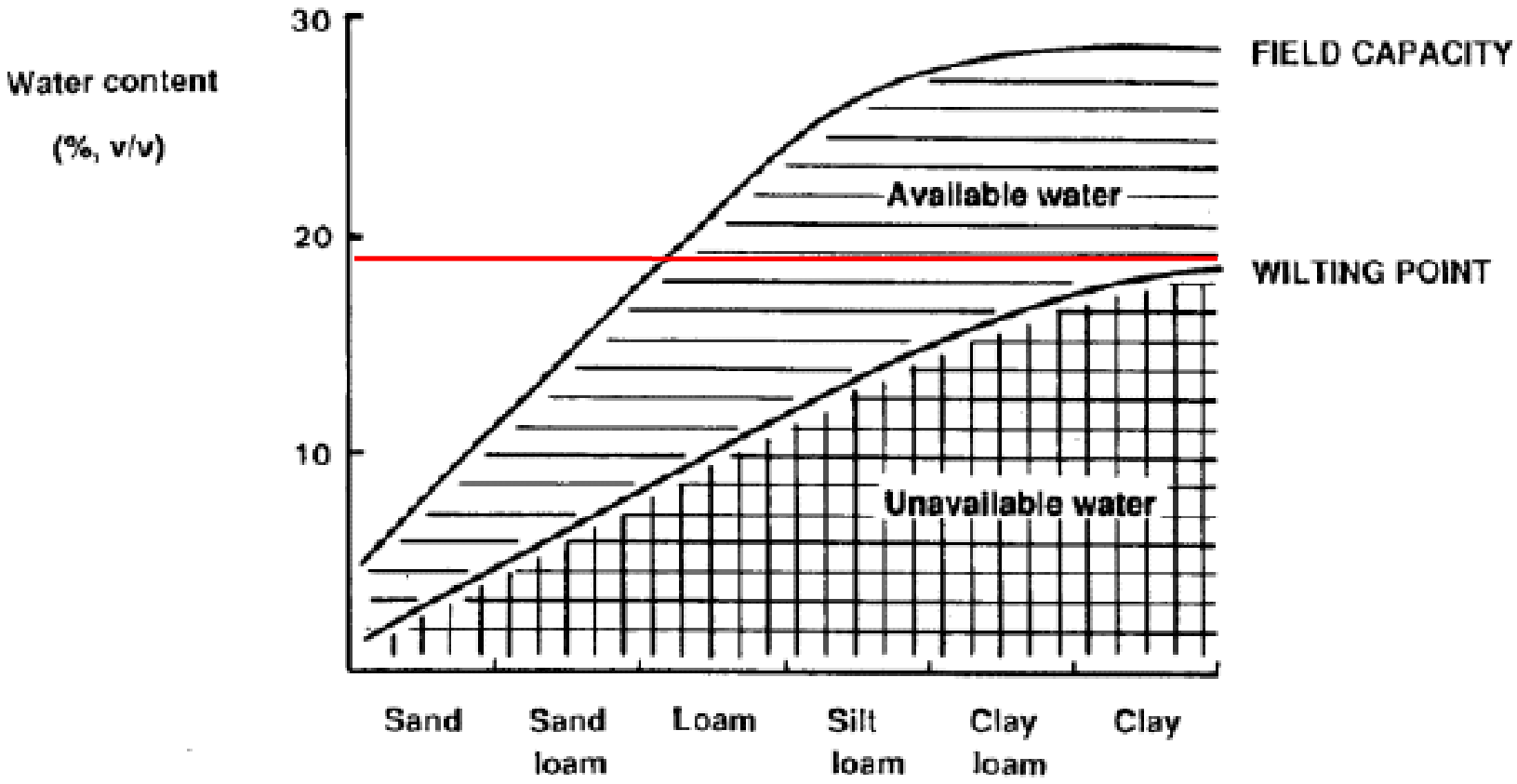
Reading of 19%
Volumetric Water Content

What does that mean for irrigation scheduling?

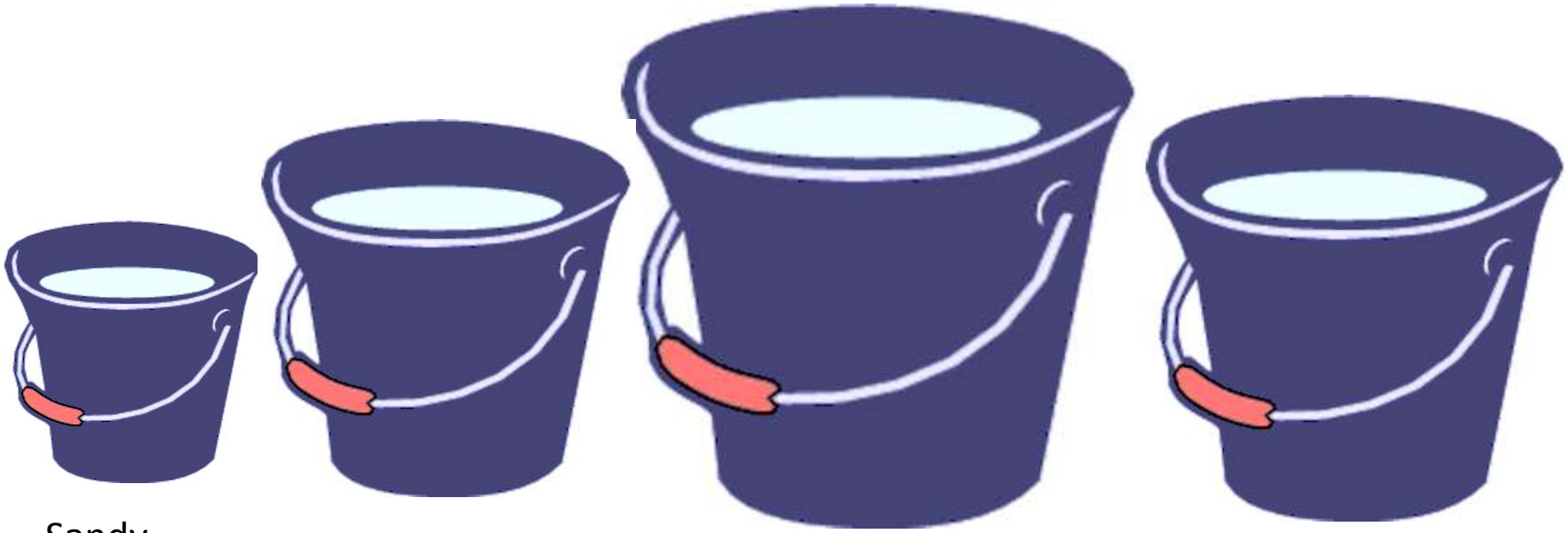
Do I have lots of plant available water in the profile – do I need to irrigate?

Reading doesn't indicate anything about plant available water without knowing your soil texture.

Have to know soil texture.



What is the bucket size for my soils?



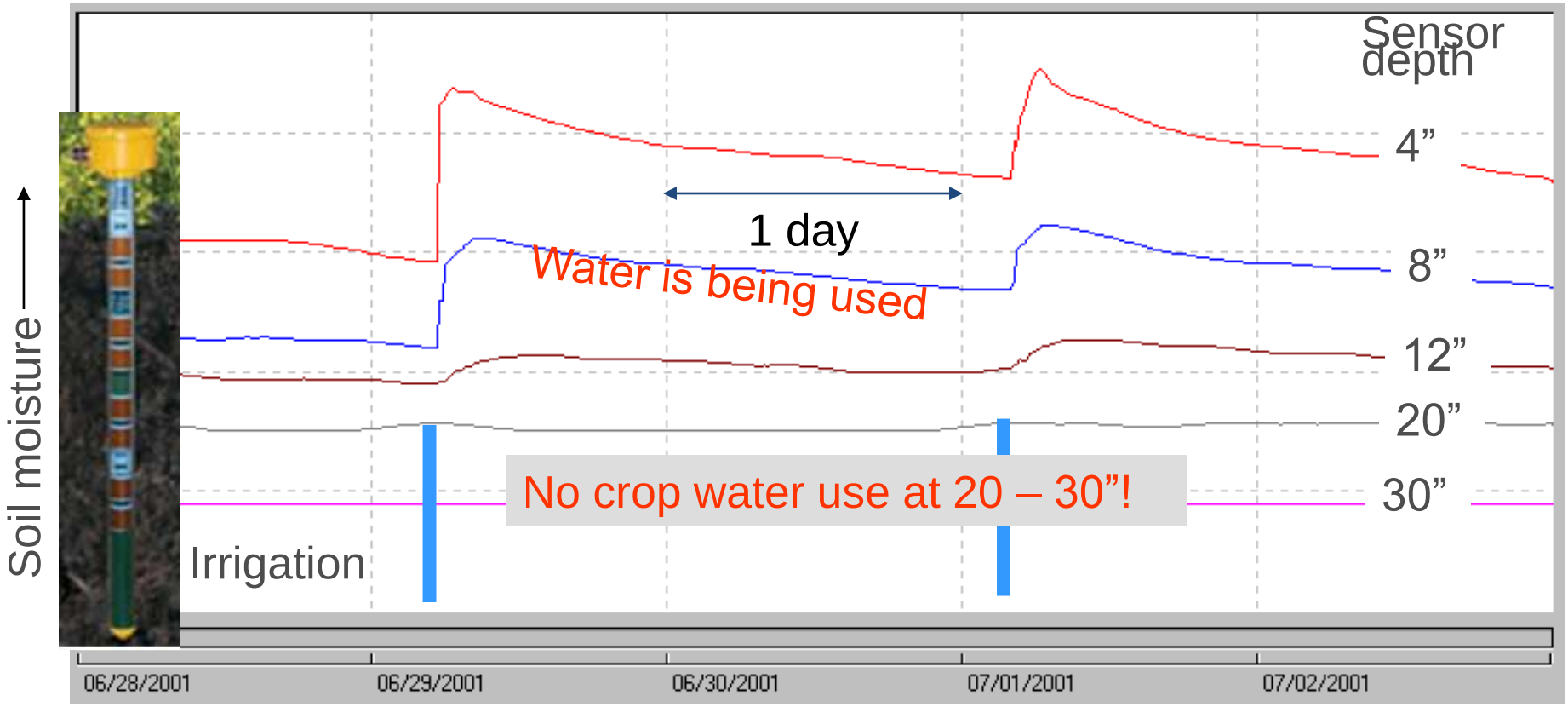
Sandy Loam

Loam

Silt Loam

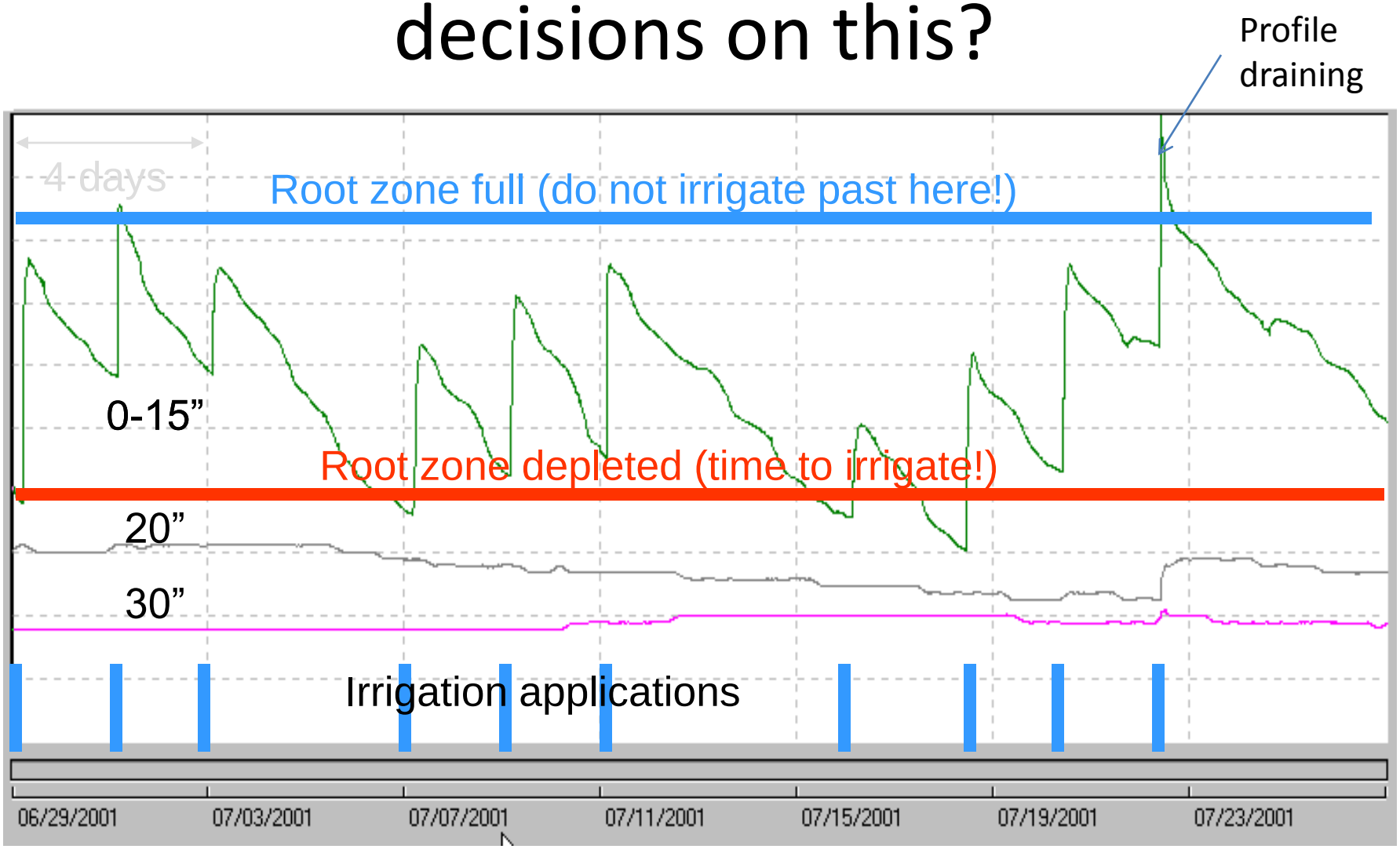
Clay Loam

Real-time soil moisture monitoring

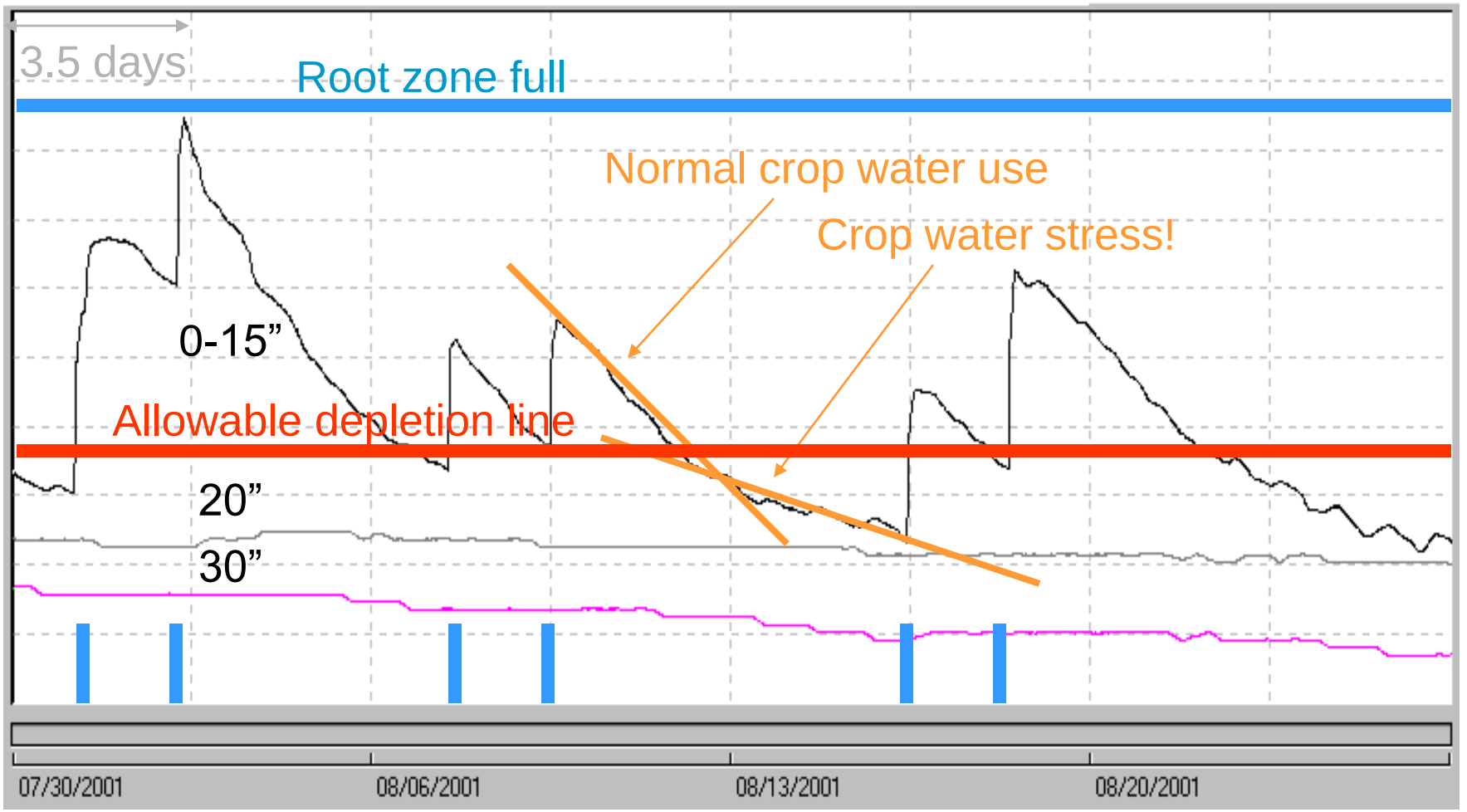


Most of these probes require the operator to set the full and refill points.

How can I base irrigation scheduling decisions on this?



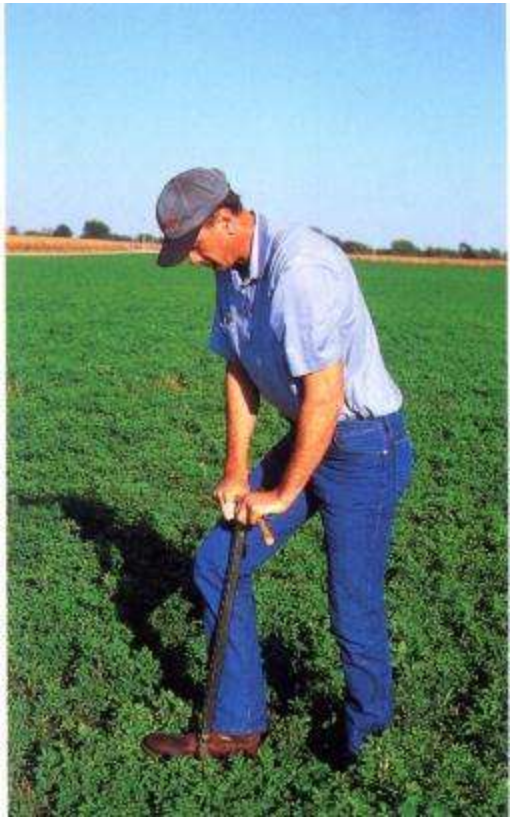
Irrigation decisions based on plant response



What has been the uptake by irrigation producers to use of soil water instruments for irrigation scheduling?

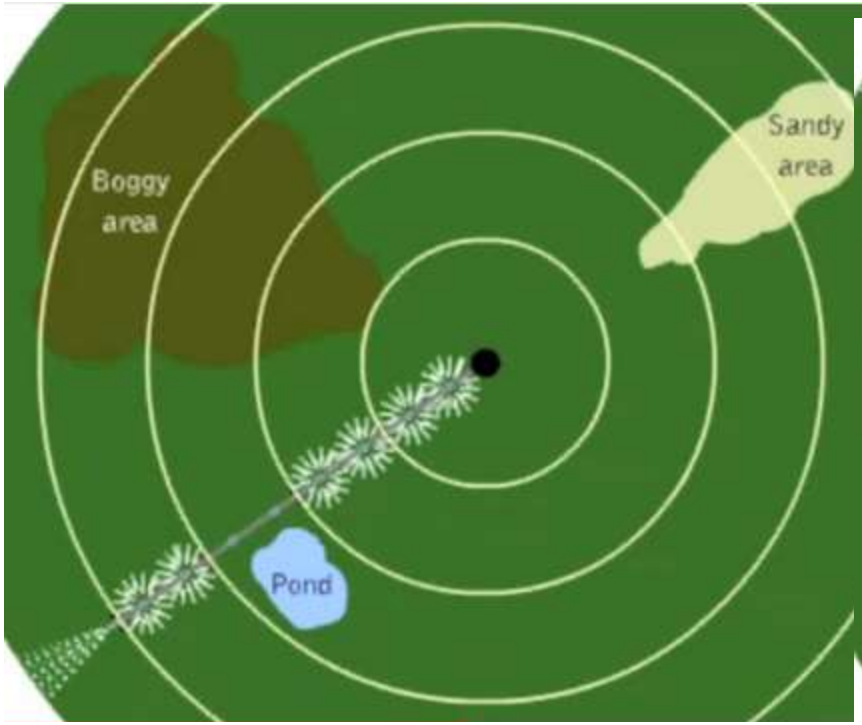
- United States – 10.4% of the irrigators use soil water instruments for irrigation scheduling. (Henggeler et al., 2010)
- Southern Alberta -Henning et al. 2008, reported about 9% of irrigators in the Taber area and 6% in the Raymond area.
- Australia and New Zealand – about the same.

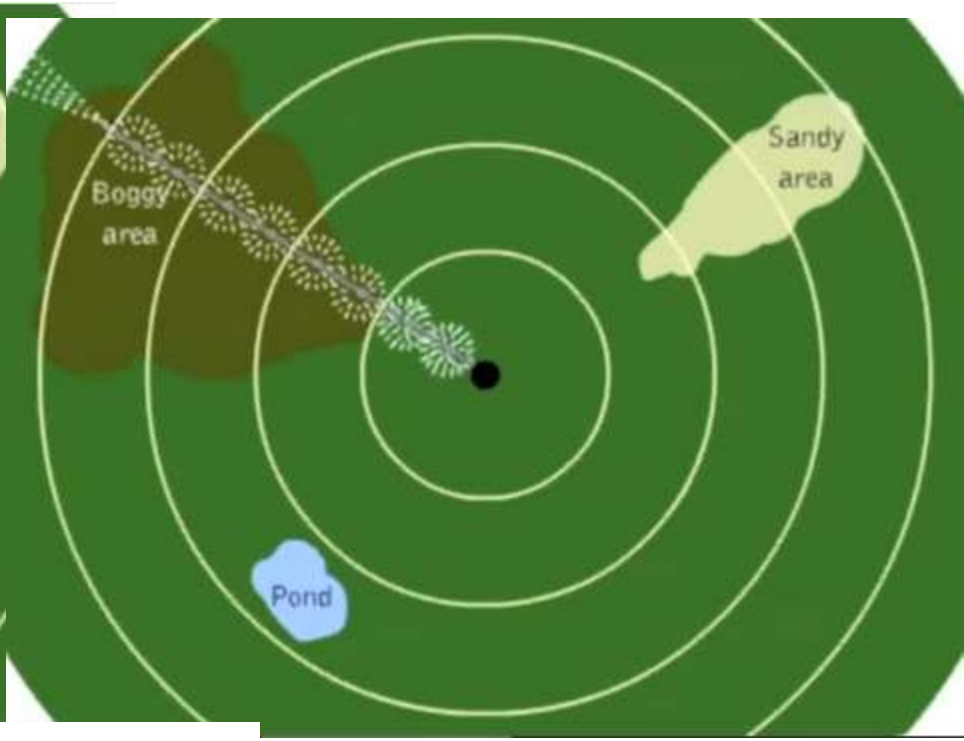
So what is the instrument of choice for monitoring soil water in irrigated fields?



70% of irrigators in Taber area and 40% of irrigators in Raymond area use manual samplers for checking soil water and scheduling irrigations (Henning et al., 2008)

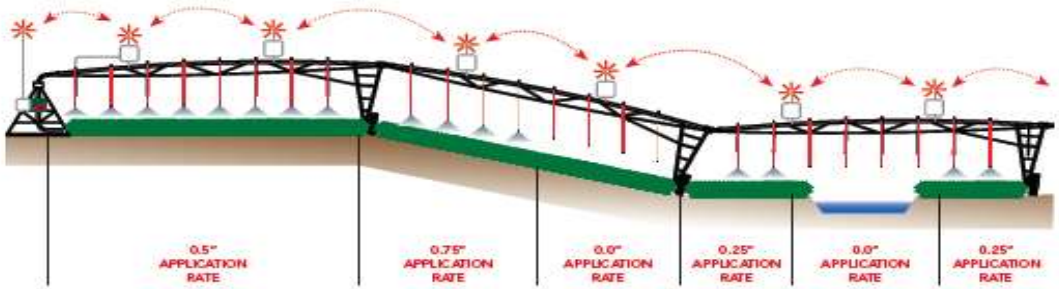
Where physical sampling doesn't make sense anymore is with Variable Rate Irrigation





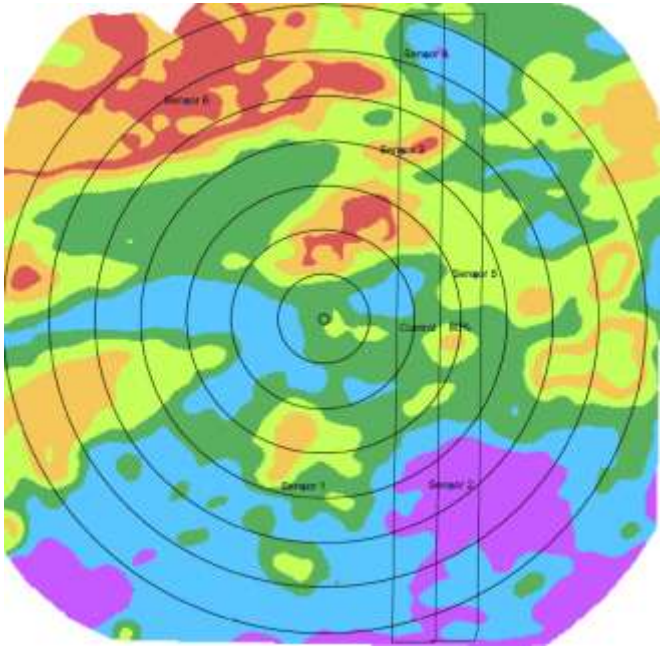
INDIVIDUAL SPRINKLER CONTROL

Each sprinkler is programmed to turn on/off or pulse at a customized rate depending on crop, terrain or obstacle.

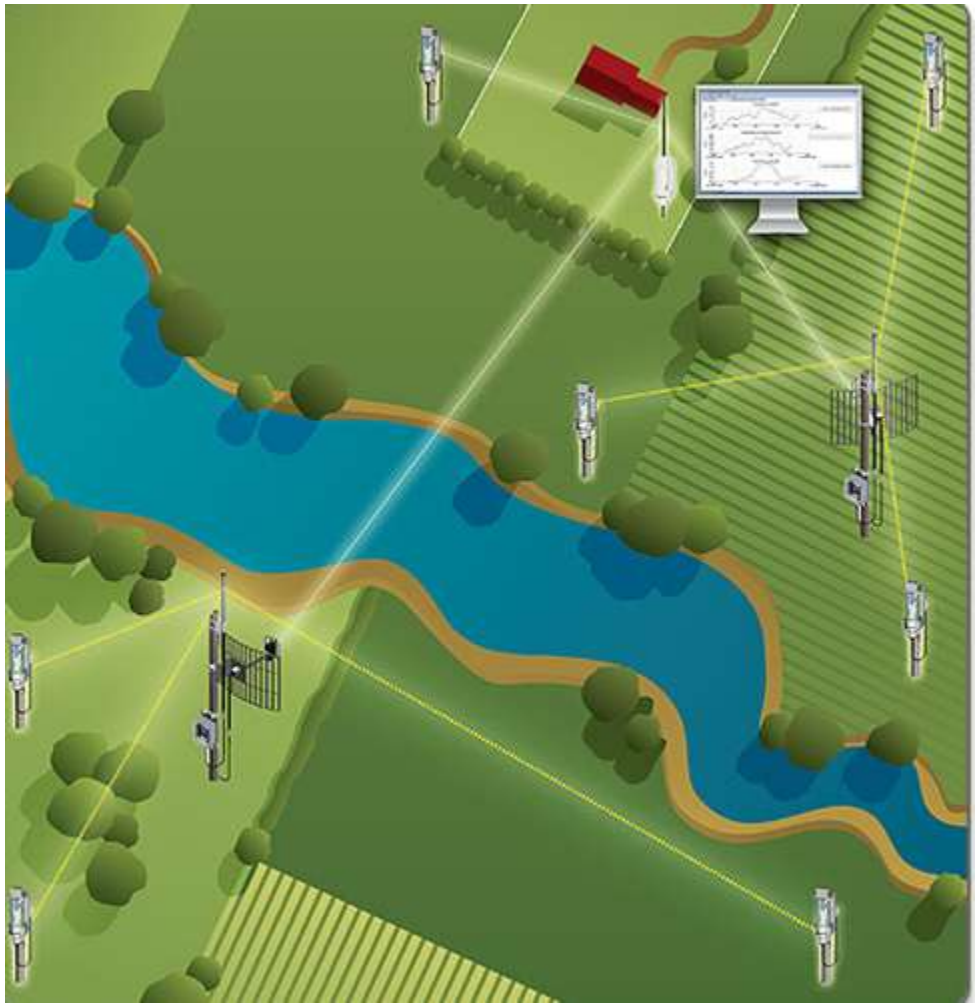


Variable Rate Irrigation

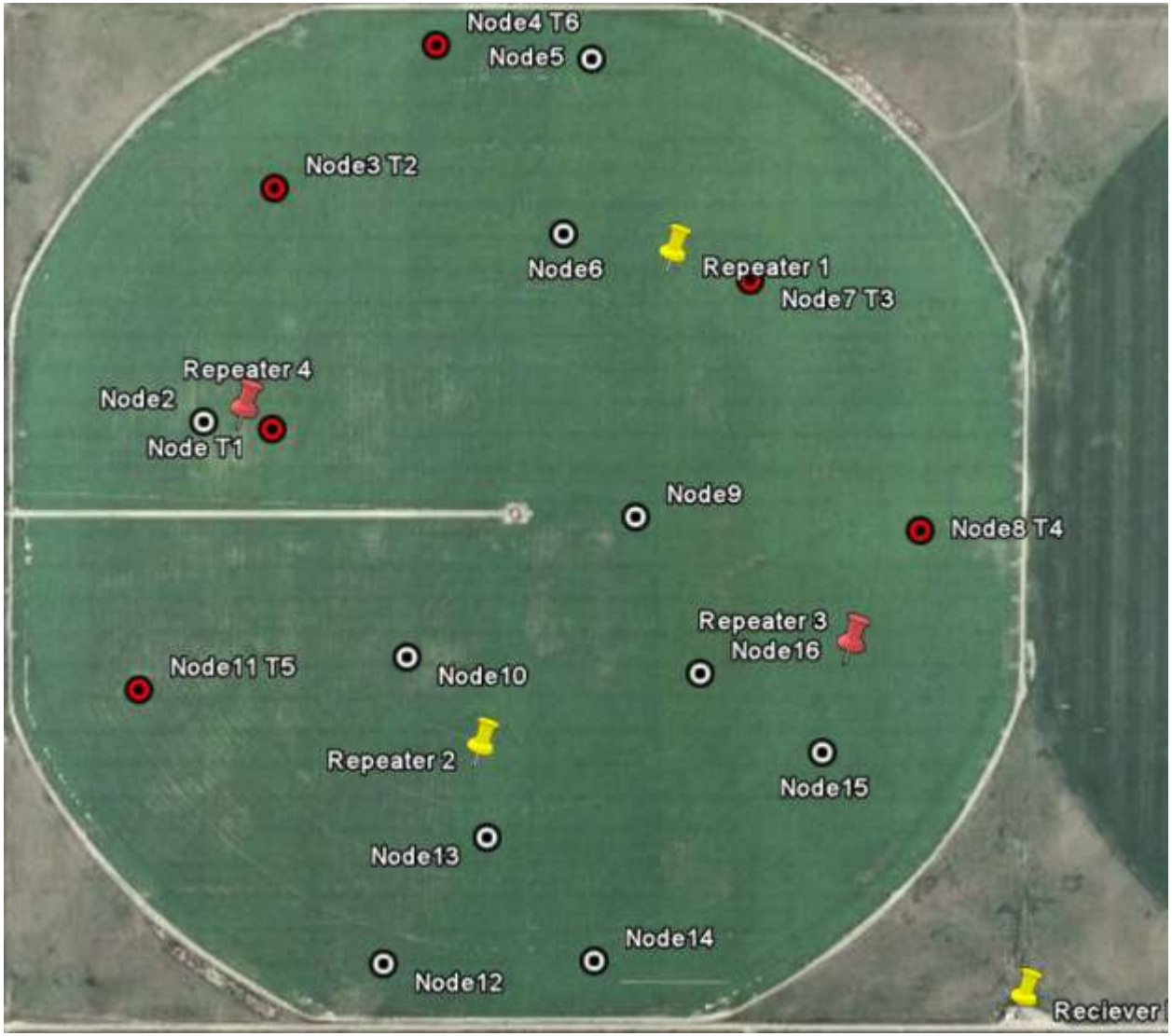
- Need to know what the soil water status is so the pivot can be programmed to apply varying rates of irrigation water to different zones within the field.
- Need to know how much water was applied to each zone.
- Need that information prior to and immediately after an irrigation event.



Wireless Soil Water Sensors

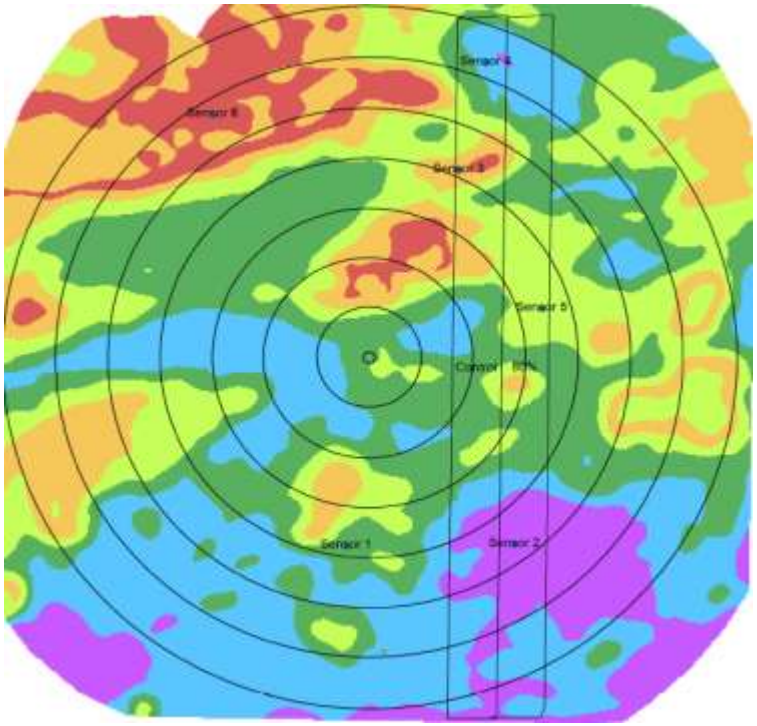


HoboNode Network from Onset


Node4 T6
Node5
Node3 T2
Node6
Repeater 1
Node7 T3
Repeater 4
Node2
Node T1
Node9
Node8 T4
Repeater 3
Node16
Node11 T5
Node10
Repeater 2
Node15
Node13
Node14
Node12
Reciever

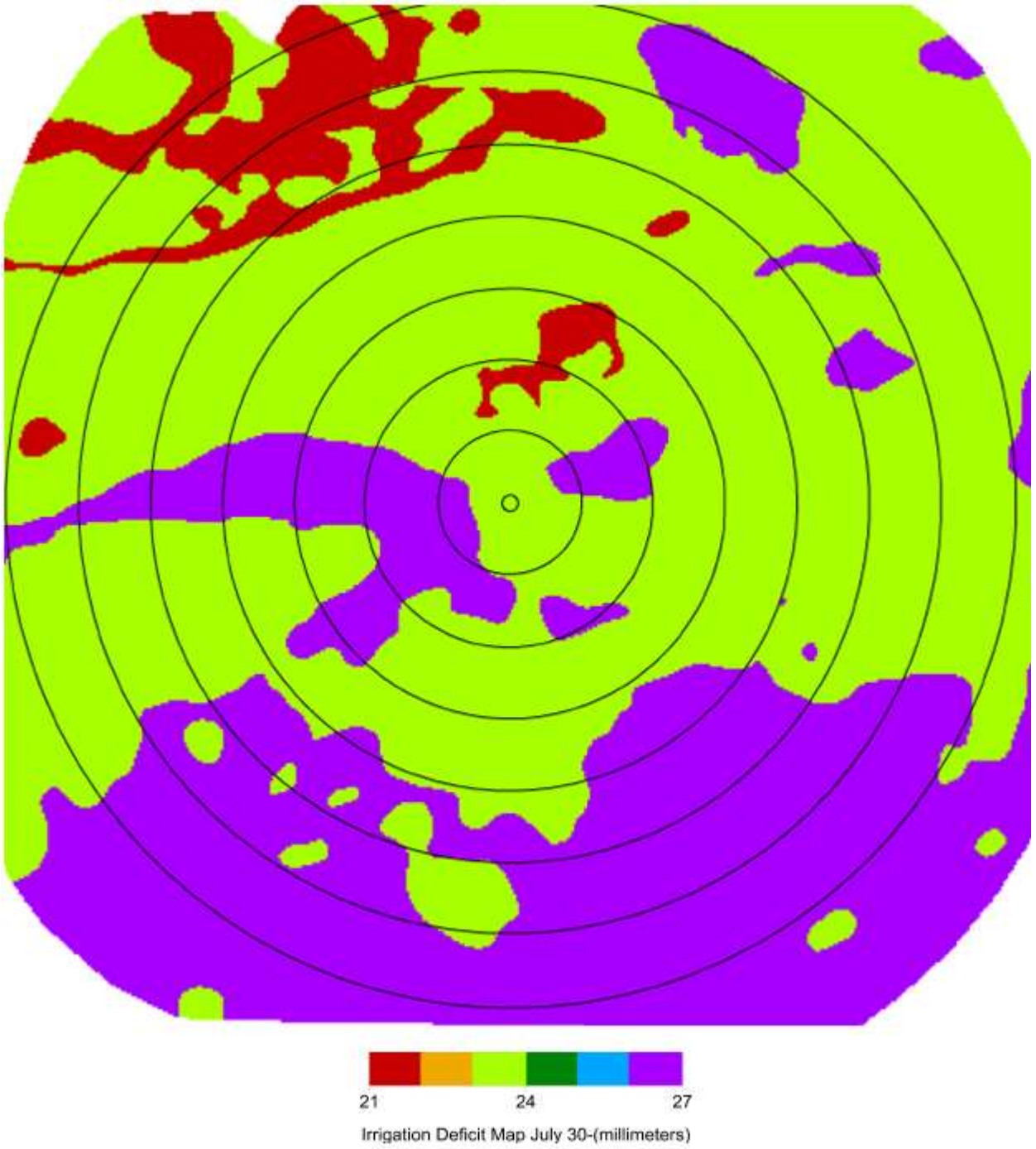
Wireless TDR soil water sensor with wireless tipping bucket rain gauge communicate hourly to data logger at pivot point.

Daily Communication to Brooks via Cellular Modem



Example of soil water and precipitation/irrigation values from the Campbell Scientific instrumentation.

	Site 1		Site 2			Site 3	
Time of Day	Soil Water (VWC%)	Irrigation or Rainfall (0.1 mm)	Soil Water (VWC%)	Irrigation or Rainfall (0.1 mm)	Soil Water (VWC%)	Irrigation or Rainfall (0.1 mm)	Soil Water (VWC%)
12:00:00	0.081	0	0.047	0	0.193	0	0.135
1:00:00	0.149	150	0.147	126	0.295	159	0.184
2:00:00	0.198	0	0.179	0	0.28	0	0.241
3:00:00	0.18	0	0.168	0	0.258	0	0.242
4:00:00	0.167	0	0.16	3	0.247	1	0.237
5:00:00	0.159	0	0.156	3	0.24	0	0.233
6:00:00	0.153	0	0.152	0	0.234	0	0.23
7:00:00	0.148	0	0.148	0	0.23	0	0.227
8:00:00	0.144	0	0.145	0	0.226	0	0.224
9:00:00	0.14	0	0.142	0	0.222	0	0.223
11:00:00	0.136	0	0.138	2	0.217	0	0.219
12:00:00	0.133	0	0.137	0	0.214	0	0.218



Irrigation Deficit Map July 30-(millimeters)

What is the bottom line?

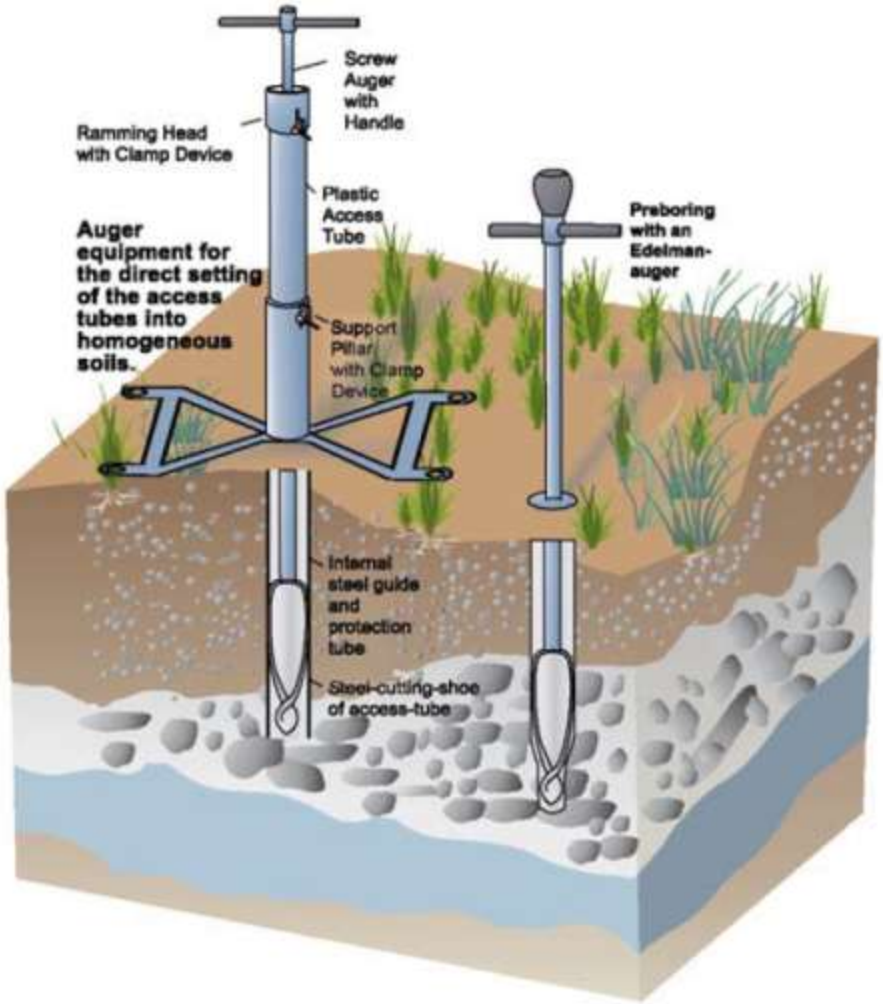
Many areas of the world, consultants are monitoring soil water on a continuous basis and advising clients on soil water status within irrigated fields.

Communication is via cellular, internet, satellite, or wi-fi.

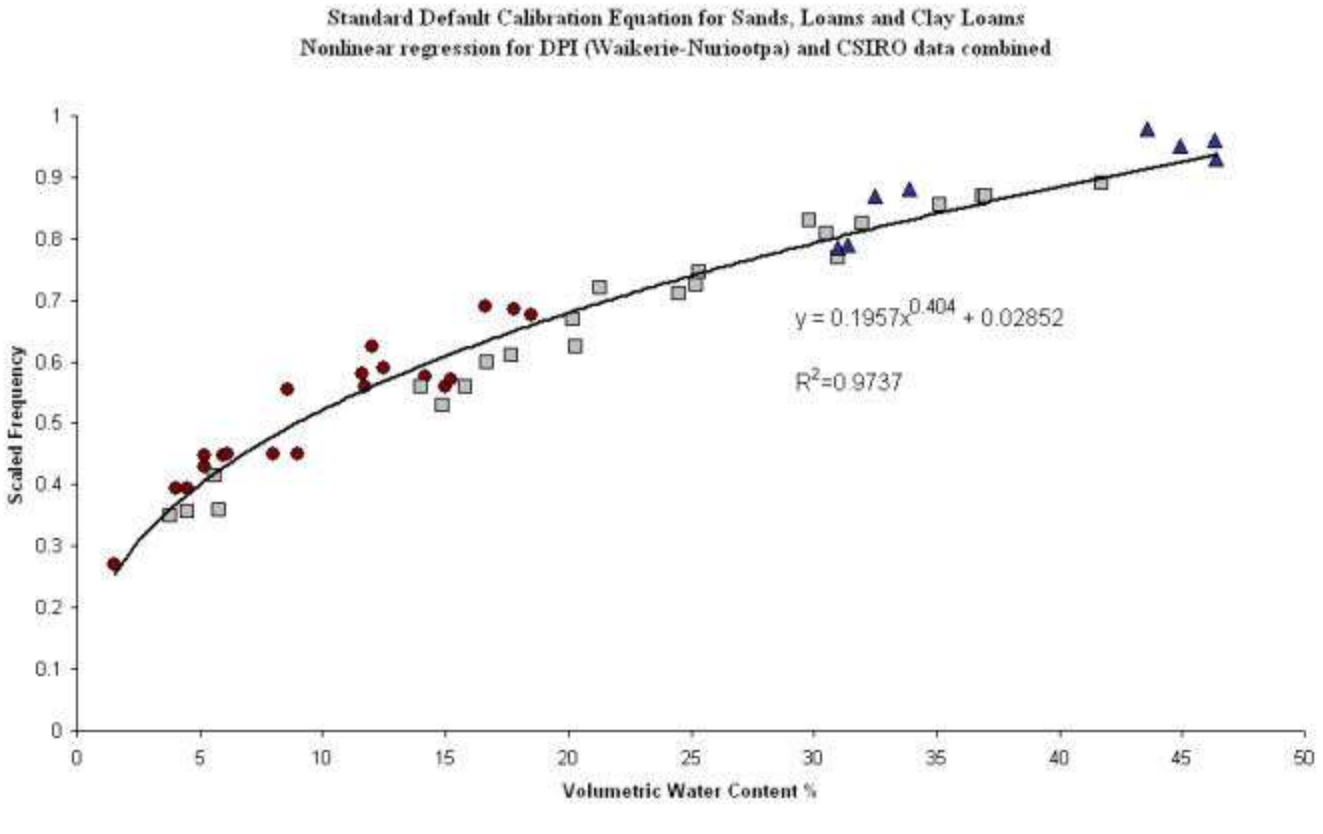
What is the bottom line?

- Irrigation decisions made based on the information obtained from the sensors improves irrigation efficiencies (water and energy) and usually improves yield (maximize returns).
- All of these soil water monitoring systems are currently expensive add-ons to an irrigation system. **They all work but**,
- All of them sample the water content of a small soil volume, so how many of these sensors do I need? becomes the question.

- Many require the purchase of expensive access tubes with an installation kit and precise installation procedures for close soil contact.



Most of them require soil specific calibrations to improve accuracy



IN MY OPINION

- The expertise required for interpretation of sensor data (to determine when do I irrigate and how much?) and programming the specialized software, not to mention the time required for installation, limits this technology to the research or consultants realm.