

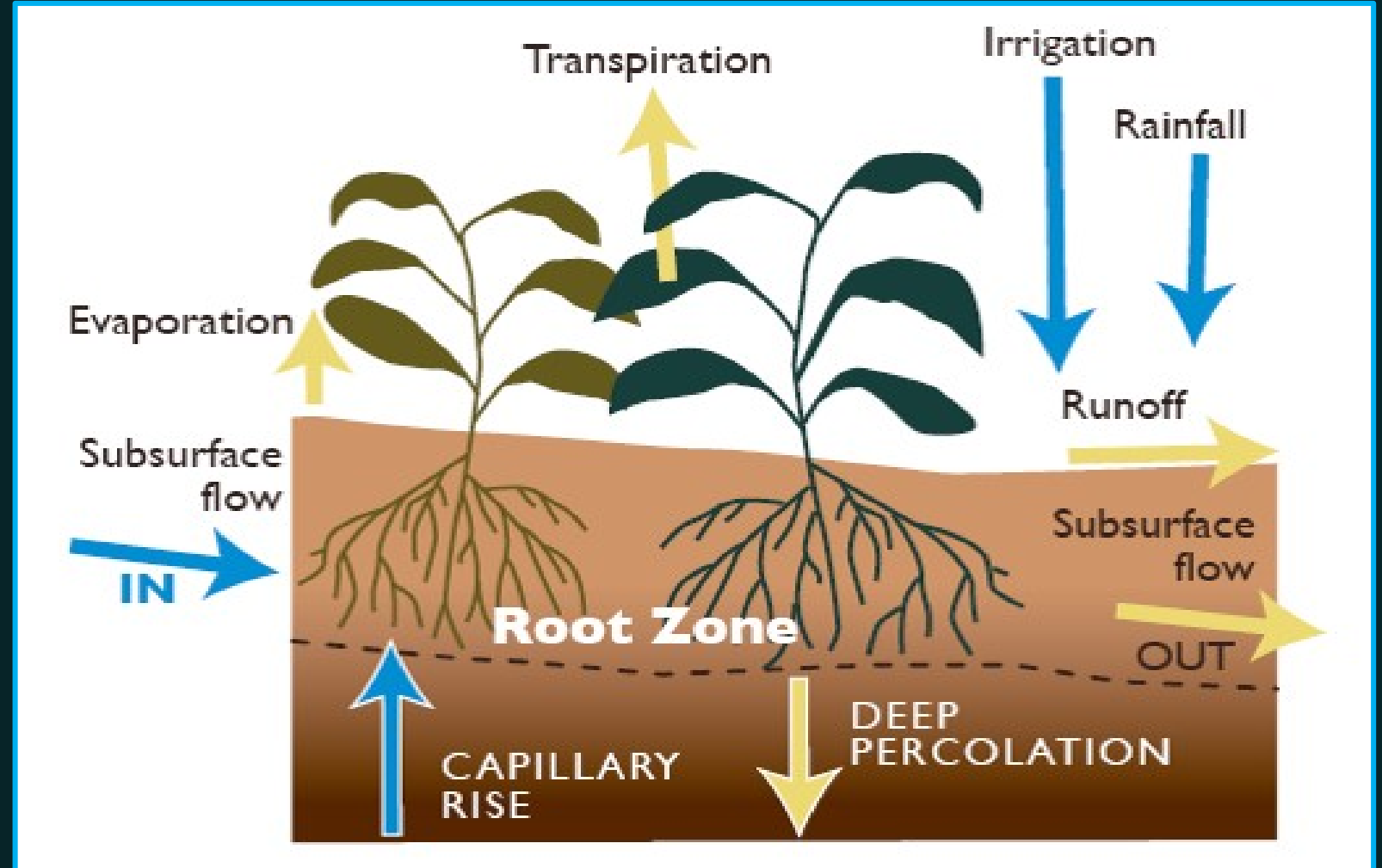
Irrigation Water Management Plan

Hamid Farahani, PhD

Water Management Engineer
USDA NRCS - East NTSC
Greensboro, North Carolina
hamid.farahani@gnb.usda.gov
336-370-3350

Peter Robinson, PE

Water Management Engineer
USDA NRCS - West NTSC
Portland, Oregon
peter.robinson@por.usda.gov
503-273-2417



When planning for on-farm water management ---

There are certain questions we should ask ...

- What are my goals for managing water?
- How much water will I have and when?
- How much water do I need?
- How much water should I apply?
- How often should I apply?
- How fast should I apply?
- How can I tell what's adequate?
- Why should I care?
- What is the cost of management?
- What new technical capabilities will I need?



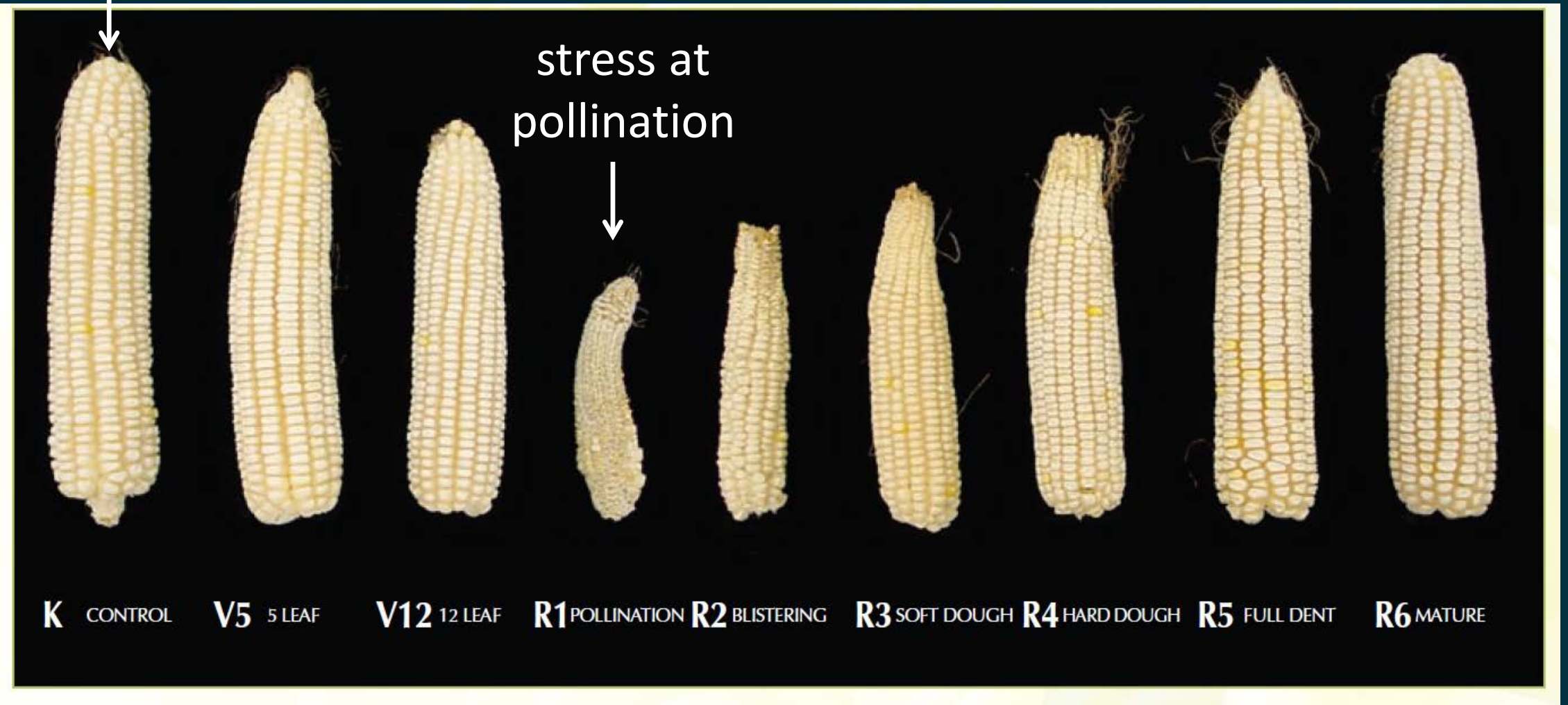
Overarching goal is to minimize crop water stress and thus yield loss

Effect of stress on corn yield

(stage of growth dependent)

No stress

stress at
pollination



Water management reduces other problems as well
(problems like runoff, erosion, agrochemical loss, pollution)



Water quality degradation



Irrigation Engineering and Management

- Planning
- Selection
- Design
- Installation

→ **Greater focus**

- Management
- Evaluation
- Economics

→ Lesser focus

Proper irrigation water management (IWM) is critical to success or failure of an irrigation system regardless of its robustness.

Irrigation Water Management Plan

Definition:

Describes the process of determining and controlling the volume, frequency, and rate of water application to ensure an environmentally friendly and economically viable irrigation practice.

Irrigation Water Management Plan

Conservation Practice Standard (CPS) 449 - IWM

- Describes the minimum criteria for a sound IWM Plan
- Can be stand-alone or as part of a new or improved irrigation system
- Obligates the producer to implement the Plan and maintain records

Conservation Activity Plan (CAP) 118 - IWMP

- Usually the big picture Plan, written by TSPs
- More of an Assessment and a Plan
- Producer may or may not implement the CAP recommendations

Irrigation Water Management (CPS 449)

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER MANAGEMENT

(Aa.)

CODE 449

DEFINITION

The process of determining and controlling the volume, frequency, and application rate of irrigation water.

PURPOSE

- Improve irrigation water use efficiency
- Minimize irrigation induced soil erosion
- Decrease degradation of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all irrigated lands.

An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, air quality, etc.) must be in place and capable of efficiently applying water to meet the intended purpose(s).

CRITERIA

General Criteria Applicable to All Purposes

Develop an Irrigation Water Management (IWM) Plan that will guide the irrigator or decision-maker in the proper management and application of irrigation water.

When irrigation water is limited, develop an IWM Plan that will meet critical crop growth stages.

Include in the IWM plan the method for determining the flow rate or total volume of

irrigation water required for each irrigation event.

Include in the IWM plan the method for determining the timing and amount of each irrigation event using at least one of the following methods:

- ~~Evapo~~-transpiration of the crop, using appropriate crop coefficients and reference ~~evapo~~-transpiration data,
- Soil moisture monitoring, and/or
- Scientific plant monitoring (e.g. leaf water ~~potential~~, or leaf canopy temperature measurements).

When irrigation water is not available on demand, such as when provided by an irrigation district, use the planned availability to determine the timing of the irrigation event. In this case, adjust irrigations amounts appropriately.

In locations where rain ~~is expected~~ during the growing season, and where a soil water balance is calculated, include measurements from a rain gauge (or other accurate method of determining local rainfall) that represent the managed field(s).

Base the volume of water needed for each irrigation event on:

- the available water-holding capacity of the soil for the crop rooting depth,
- the management allowed soil water depletion,
- the current soil moisture status,
- the current crop/forage growth stage,

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard, contact your Natural Resources Conservation Service Grass Office or visit the Field Office Technical Guide.

NRC-S, NHCP
September 2014

Irrigation Water Management Plan



Peter Robinson

Water Management Engineer

WNTSC Portland, OR

peter.robinson@por.usda.gov

Irrigation Water Management Plan

General Criteria Applicable to All Purposes

Develop an Irrigation Water Management (IWM) Plan that will guide the irrigator or decision-maker in the proper management and application of irrigation water.

Irrigation Water Management Plan

When to irrigate



How much to irrigate

Irrigation Water Management Plan

It
Takes
Time

Working with an irrigator
on an IWM Plan can be
time intensive

Irrigation Water Management Plan



State developed job sheets are out there.

tinyurl.com/IWMPlan

Check Lists are helpful.

Irrigation Water Management Plan

**If a goal is not
written down then it
is just a dream.**

Talk with the irrigator.
Discuss the options.

Then say...."Let's write
that down."

Irrigation Water Management Plan

Include in the IWM plan the method for determining the flow rate or total volume of irrigation water required for each irrigation event.

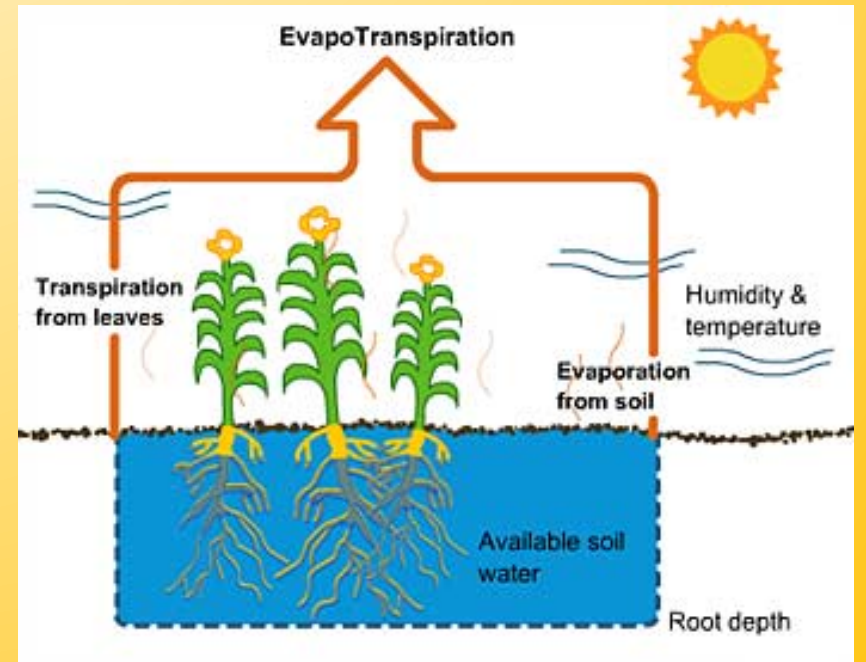


Irrigation Water Management Plan

Include in the IWM plan the method for determining the timing and amount of each irrigation event using at least one of the following methods:

and/or

Evapotranspiration of the crop, using appropriate crop coefficients and reference evapotranspiration data



Irrigation Water Management Plan

Include in the IWM plan the method for determining the timing and amount of each irrigation event using at least one of the following methods:

and/or

Soil moisture monitoring

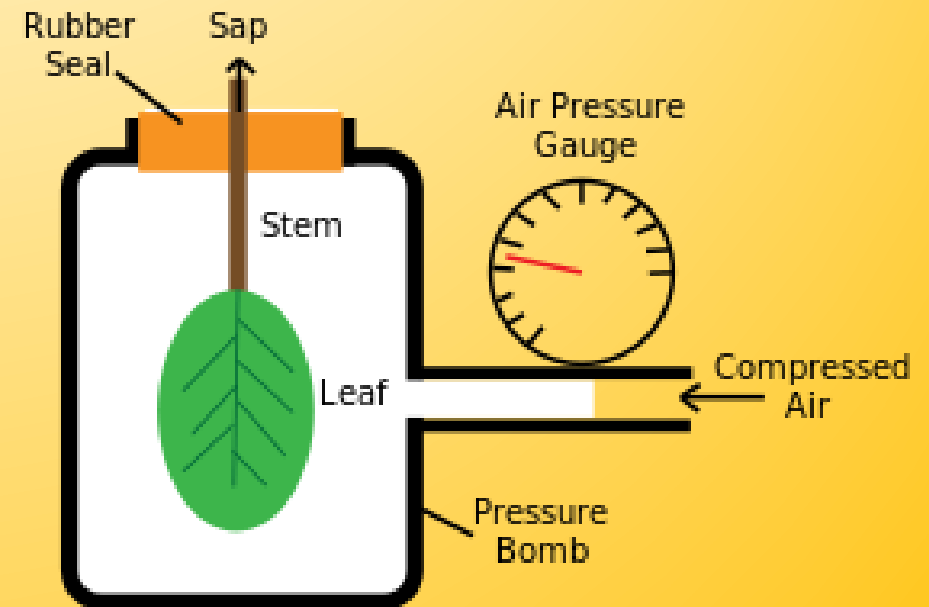


Irrigation Water Management Plan

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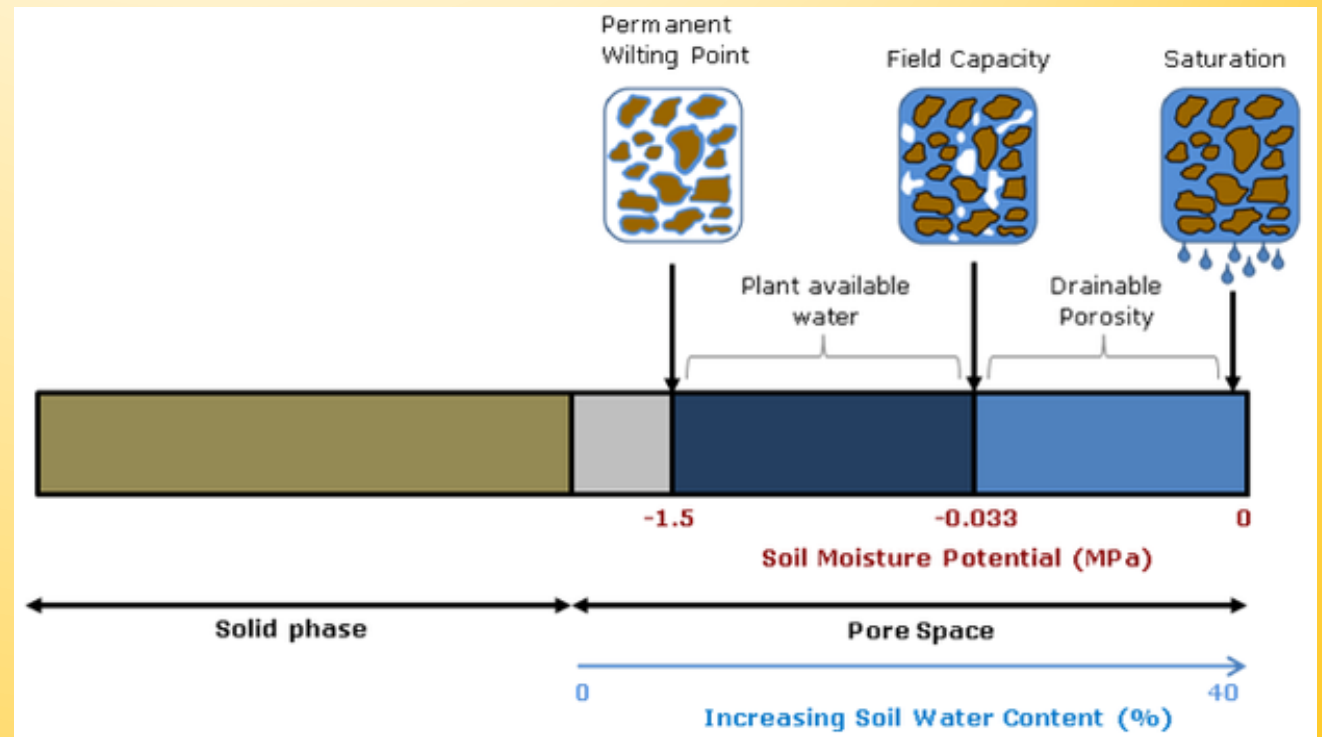
and/or

Scientific plant monitoring (e.g. leaf water potential or leaf/canopy temperature measurements).



Base the volume of water needed for each irrigation event on:

the available
water-holding
capacity of
the soil for the
crop rooting
depth
(1 of 6)



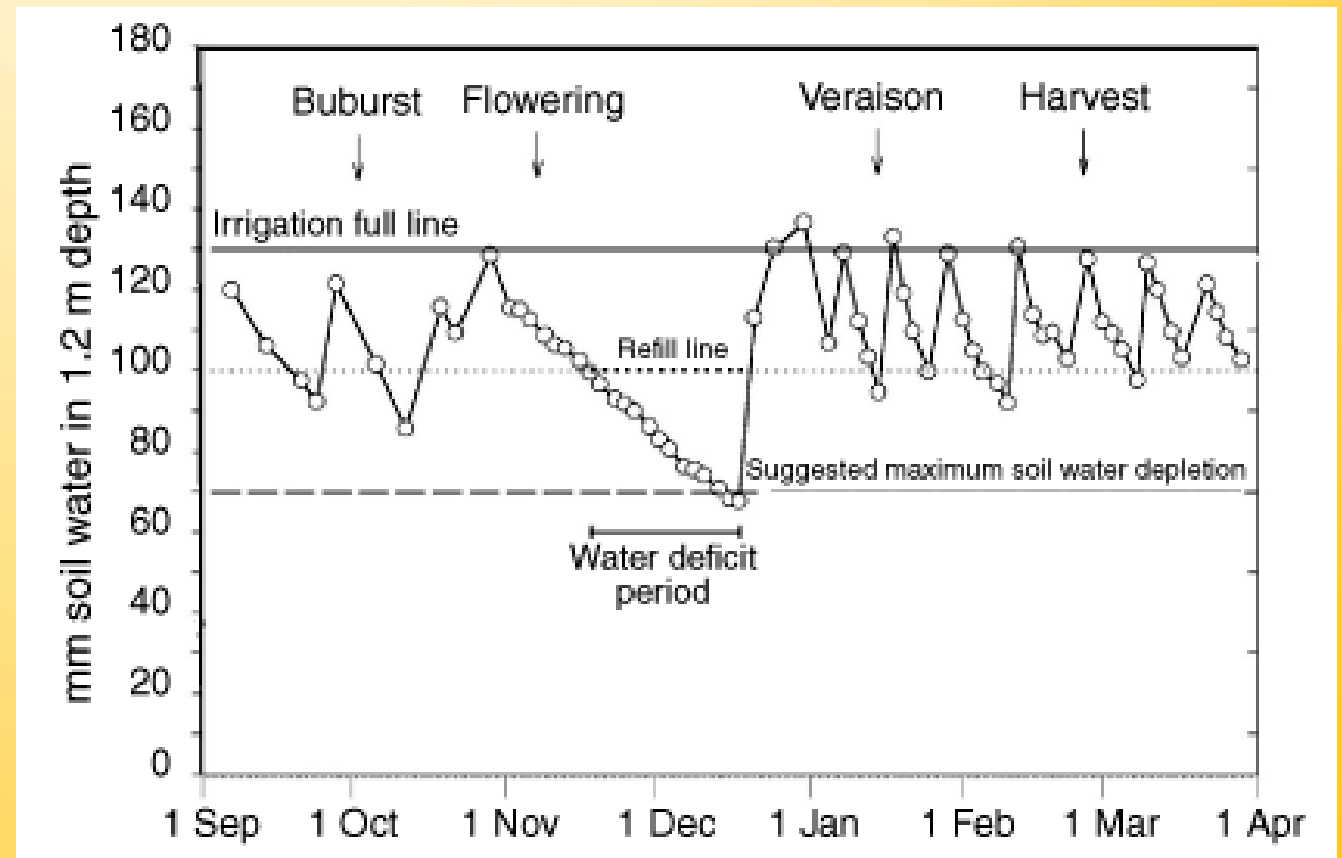
Base the volume of water needed for
each irrigation event on:

the
management
allowed soil
water
depletion,
(2 of 6)



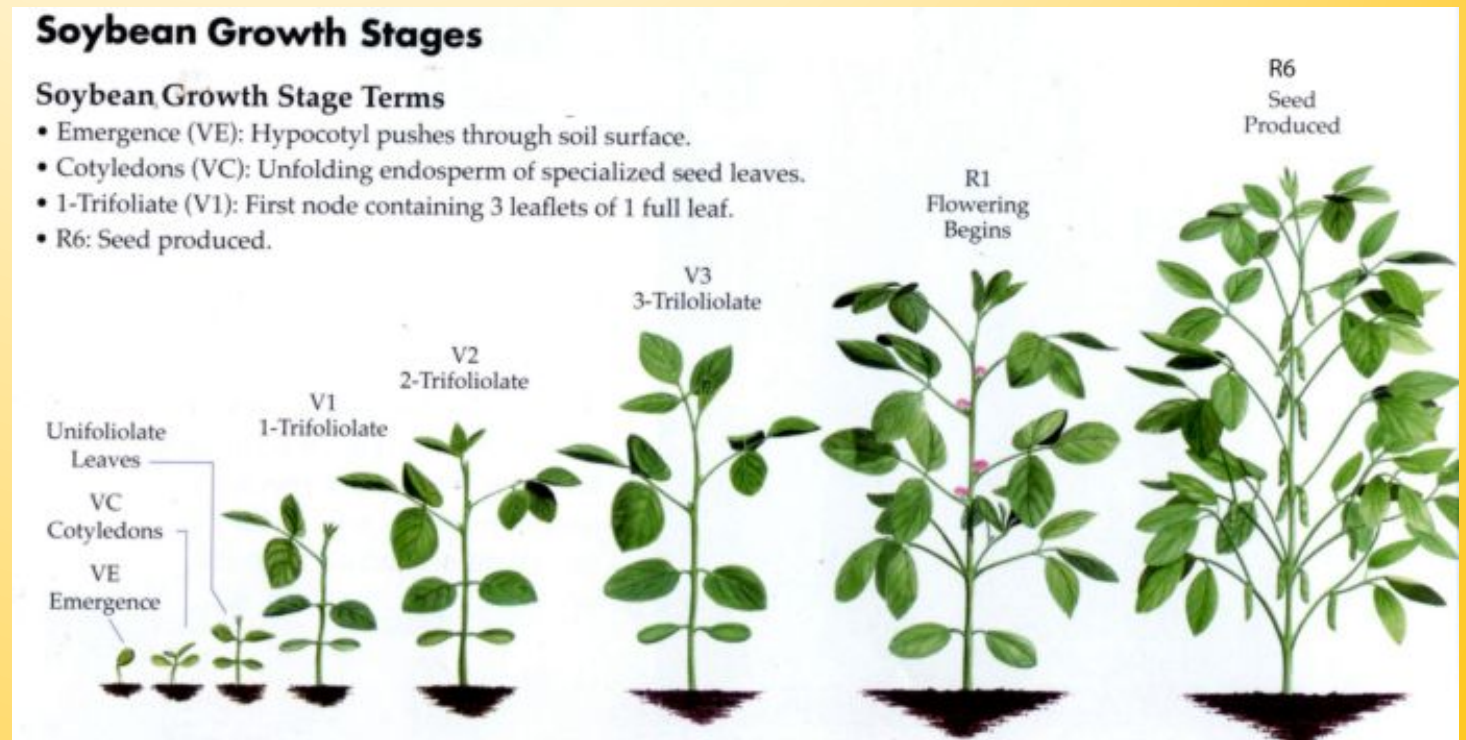
Base the volume of water needed for
each irrigation event on:

the current soil
moisture status,
(3 of 6)



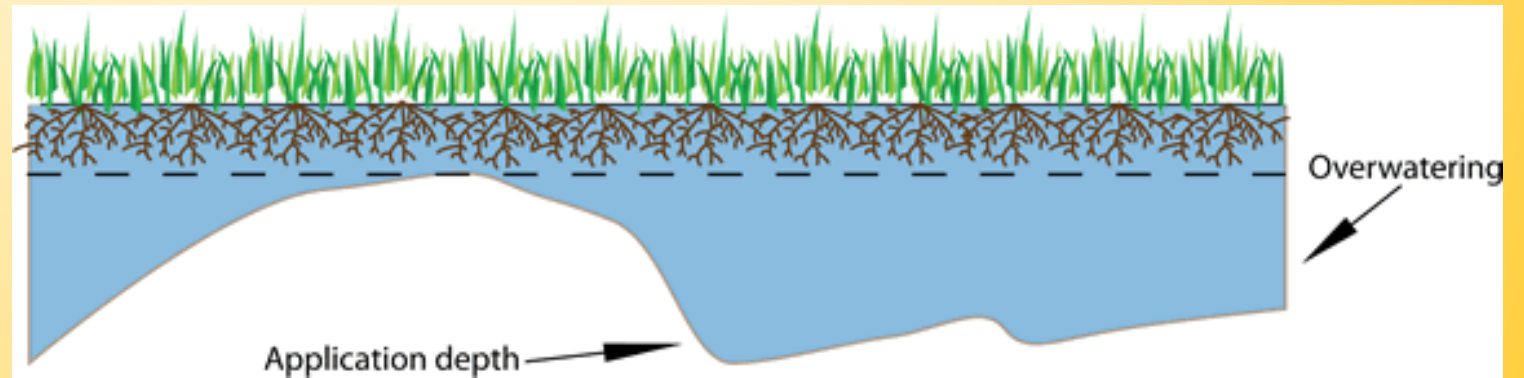
Base the volume of water needed for each irrigation event on:

the current
crop/forage
growth stage,
(4 of 6)



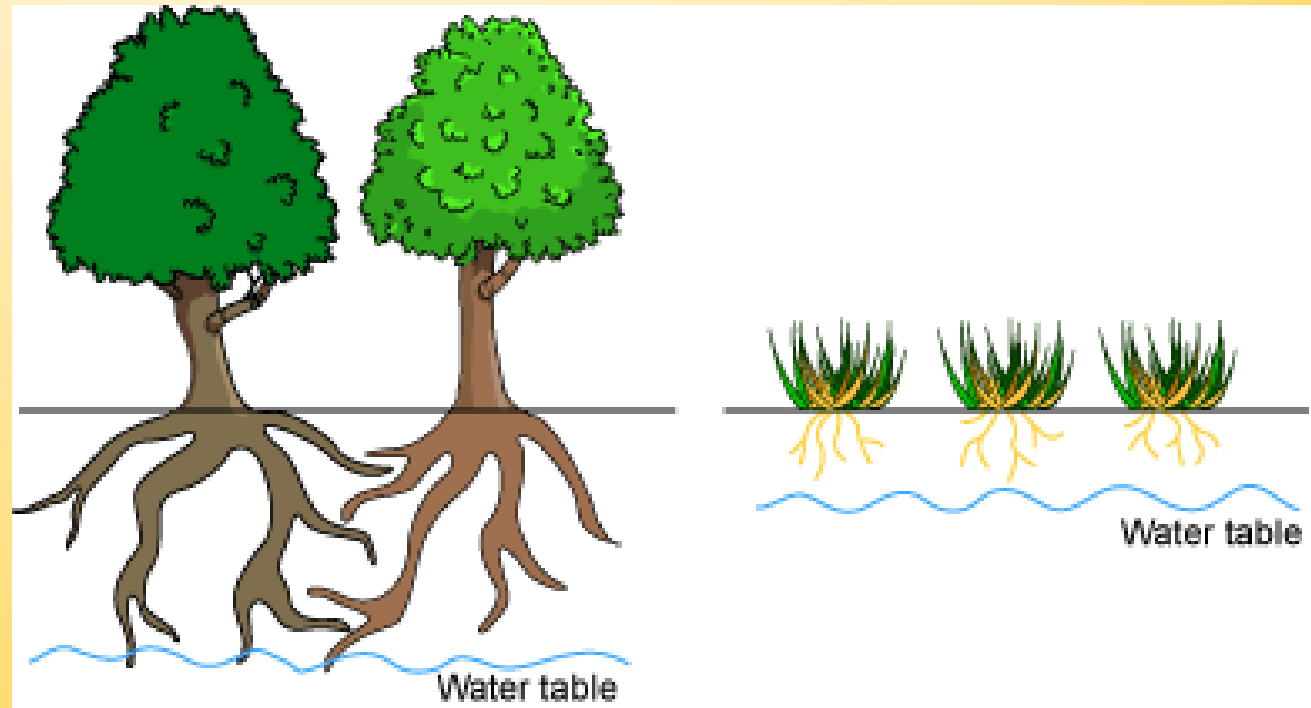
Base the volume of water needed for each irrigation event on:

the distribution
uniformity of
the irrigation
event,
(5 of 6)



Base the volume of water needed for
each irrigation event on:

the water
table
contribution.
(6 of 6)



Irrigation Water Management Plan

The Irrigation Water Management (IWM) Plan will contain, at a minimum:

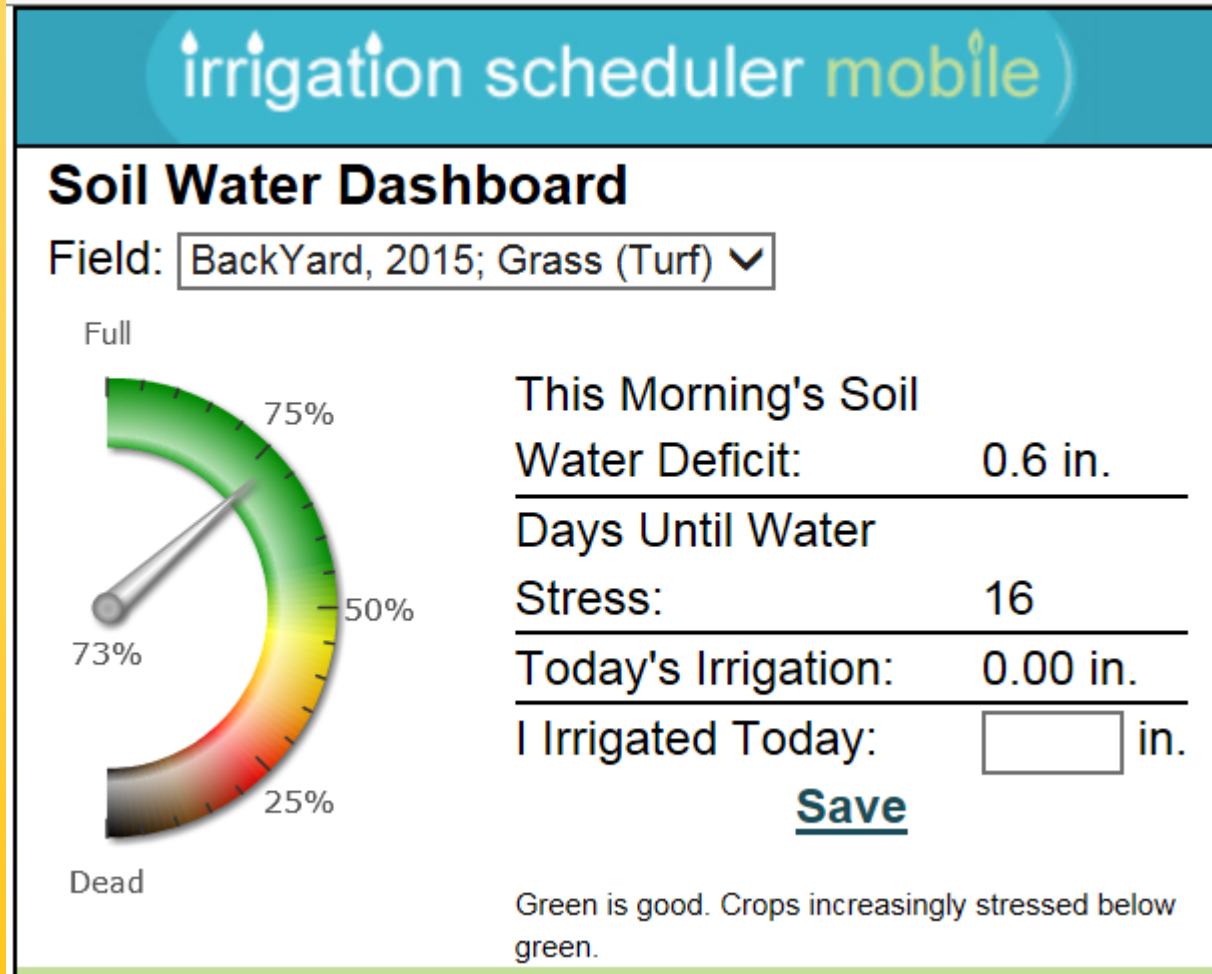
An irrigation system layout map showing the main pipeline(s), irrigated area, soil moisture sensor locations and depths (if used), and soils.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



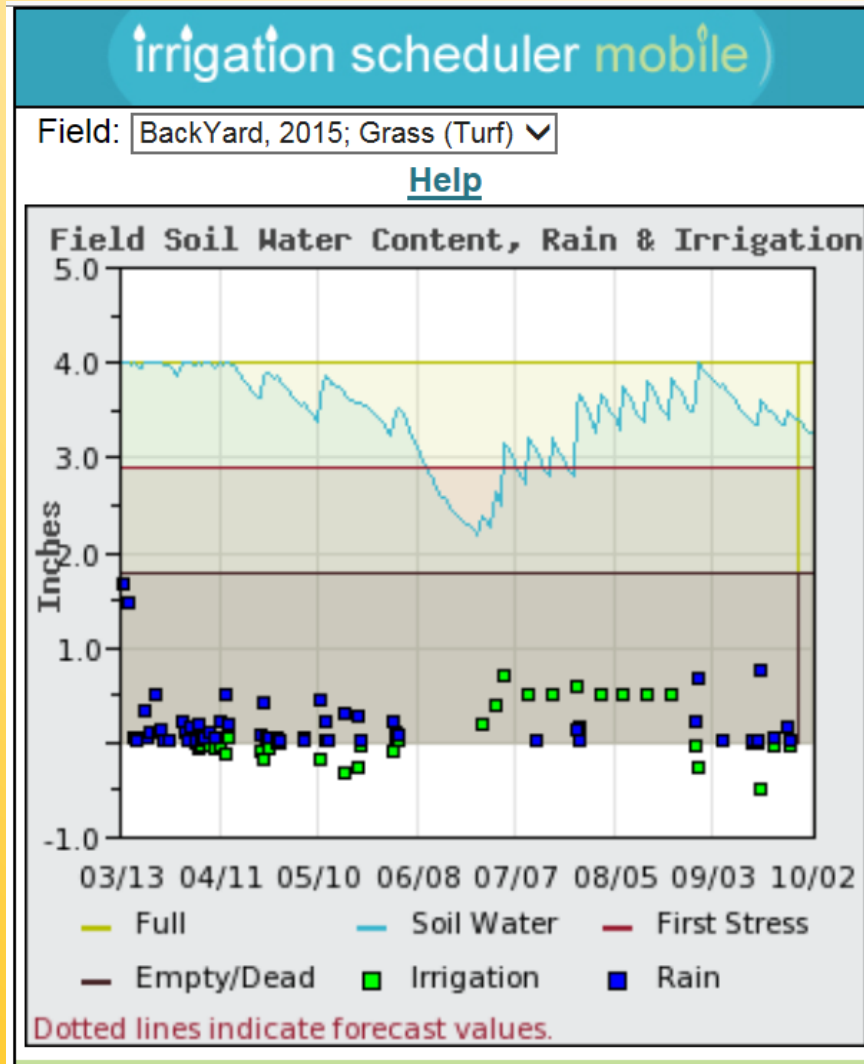
The method used to measure or determine the flow rate or volume of the irrigation applications.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



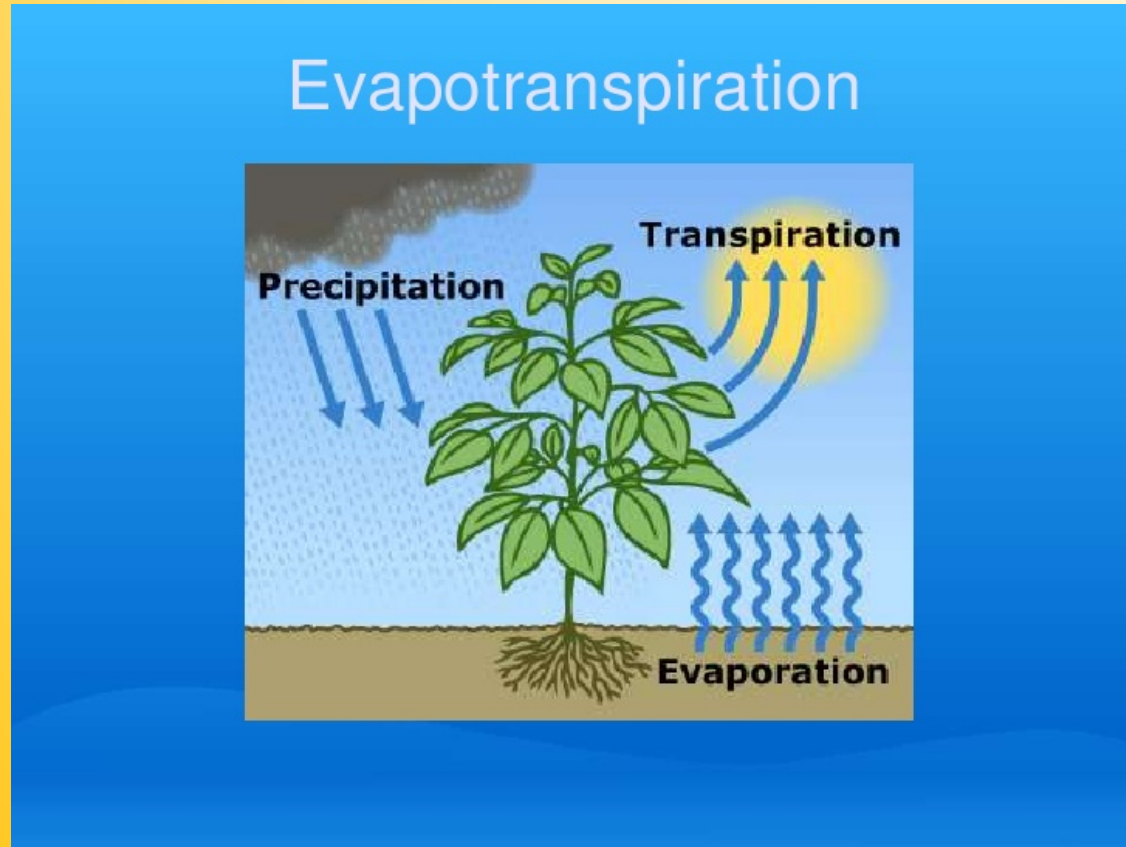
Documentation of the scientific method used for scheduling the timing and amount of irrigation applications.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



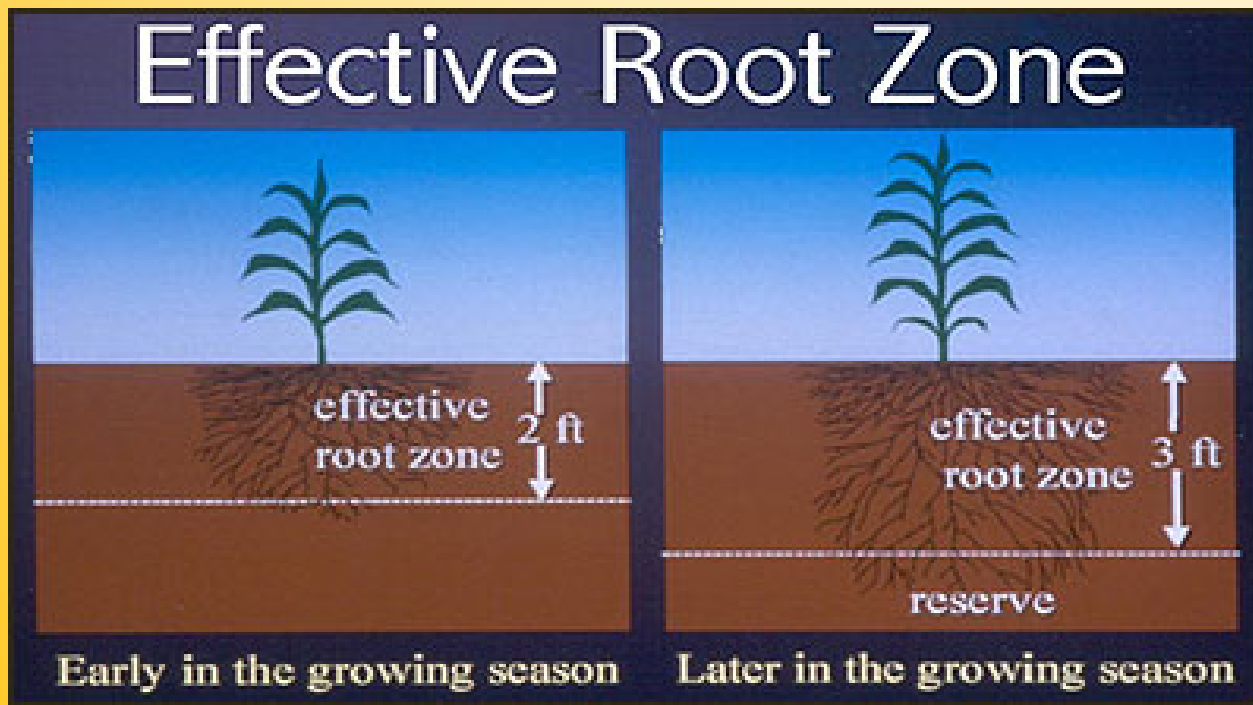
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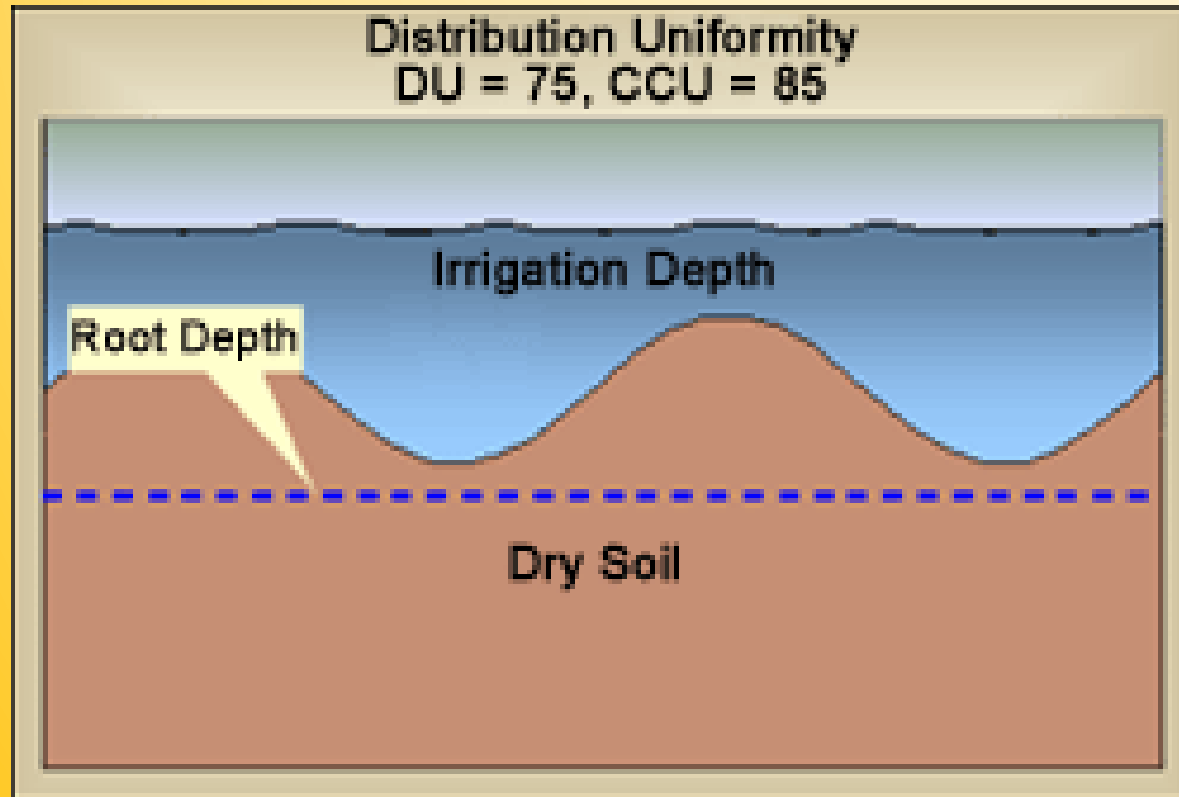
The seasonal or annual planned water application volumes by crop.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



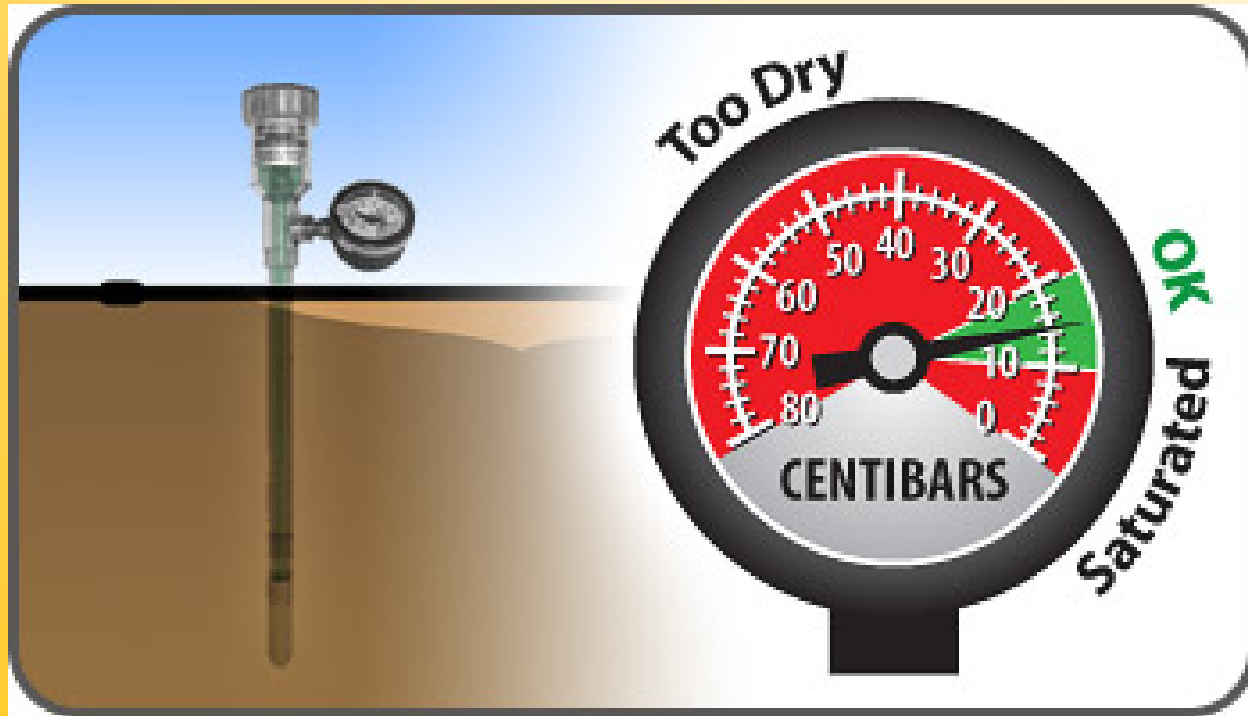
The management allowable depletion (MAD) and depth of the managed crop root zone for each crop.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



An estimate of the irrigation system distribution uniformity, based on testing, evaluation, or observation.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



The specific soil moisture monitoring objectives, if soil moisture sensors are used. Indicate how data from the soil moisture sensor locations and depths will be considered to make field-wide irrigation decisions.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



Information on how to recognize irrigation induced erosion and how to mitigate it.

The Irrigation Water Management (IWM) Plan will contain, at a minimum:



Recordkeeping documents for the irrigator to use during operation and management.

ANY
QUESTIONS
?



*Hey Buddy, I got me
an irrigation system.
Now what?*

*I don't know .
Just turn it on.*

Scheduling Irrigation

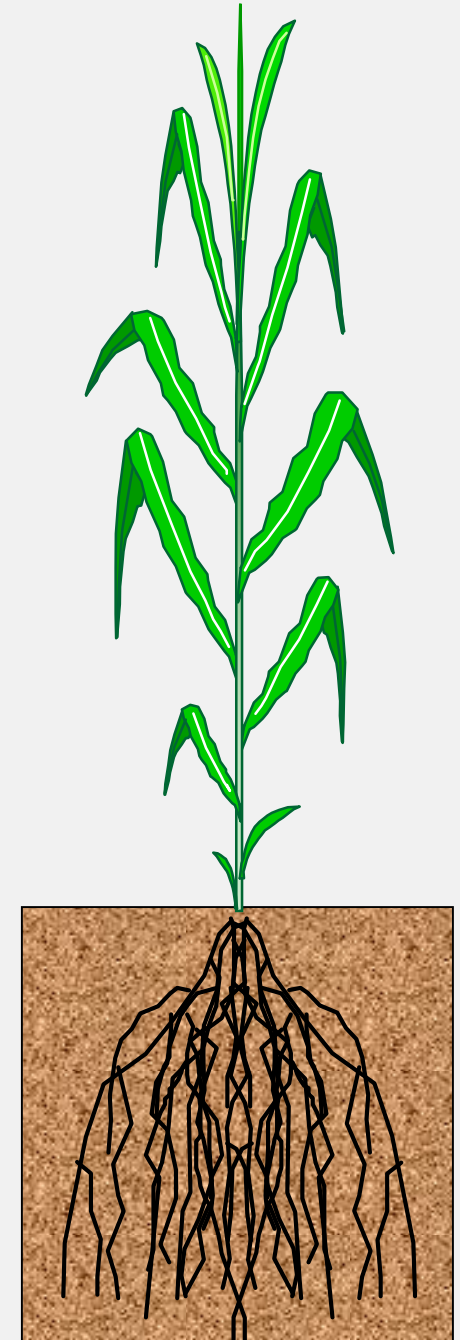
- **Timing? When to start?**

Irrigate before crop comes under water stress large enough to reduce expected yield and/or quality.

Question: What is large enough?

- **Amount? When to stop?**

Refill soil storage to meet crop water needs while limiting runoff and leaching.



Irrigation Scheduling – Timing & Amount

- Timing or when to irrigate is mostly based on:
 - Crop indicators
 - Soil moisture depletion level

- Amount or how much water to apply is mostly based on:
 - Soil moisture depletion level

Irrigation Timing...

Crop-based scheduling

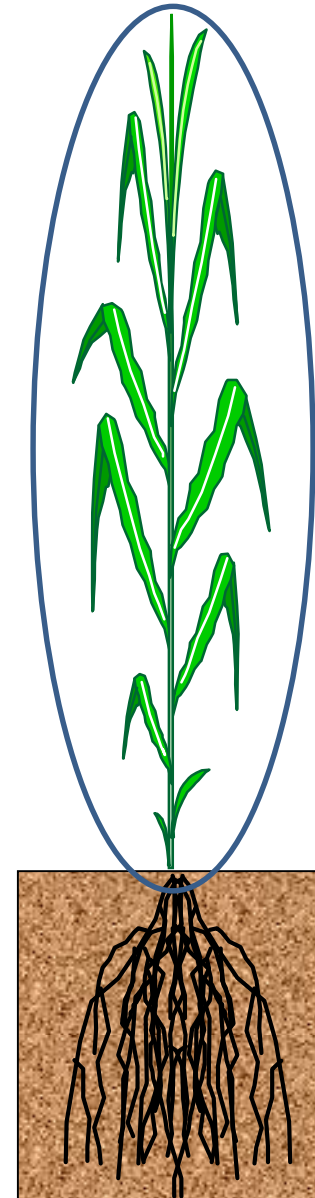
Asking the plant if it needs water:

- Visual indicators
- Leaf water potential
- Canopy temperature

Soil-based scheduling

Asking the soil if plant needs water.

The basis for this is explained by MAD.



Soil Moisture-based Scheduling

When about 30-60 percent of the available soil moisture is depleted, crops start experiencing stress large enough to impact the yield.

We refer to this as “Management Allowable Depletion (MAD).”

This understanding is the basis for most irrigation scheduling strategies in use today.

Management Allowable Depletion (MAD)

- MAD is the maximum level to which the irrigator may allow the soil moisture to be depleted to before irrigating.
- MAD is crop-dependent.
 - Field crops: 40 - 50% MAD level
 - Vegetables: 30 - 40% MAD level
- MAD is viewed as an irrigation “set point” or “start time.”

MAD - Function of the crop and its stage of growth

NOTE:

In high frequency type irrigation systems, like drip on water-sensitive crops, the crop may not be allowed to experience soil water at MAD.

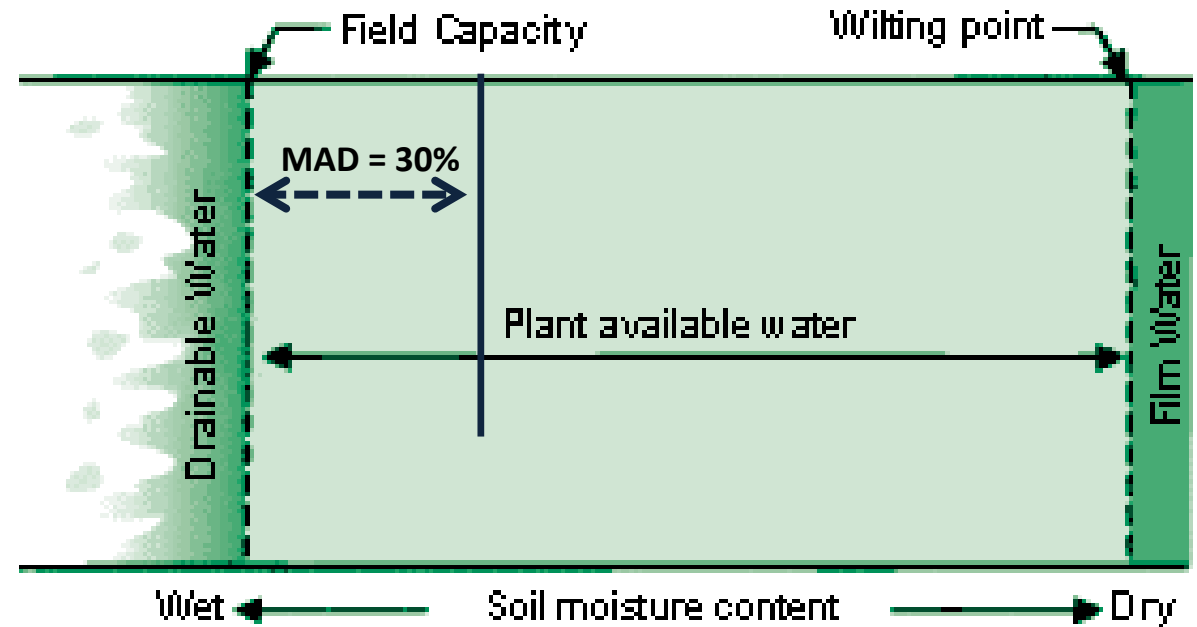
Crop	-----Crop growth stage-----			
	Establishment	Vegetative	Flowering yield formation	Ripening maturity
Alfalfa hay	50	50	50	50
Alfalfa seed	50	60	50	80
Beans, green	40	40	40	40
Beans, dry	40	40	40	40
Citrus	50	50	50	50
Corn, grain	50	50	50	50
Corn, seed	50	50	50	50
Corn, sweet	50	40	40	40
Cotton	50	50	50	50
Cranberries	40	50	40	40
Garlic	30	30	30	30
Grains, small	50	50	40 3/	60
Grapes	40	40	40	50
Grass pasture/hay	40	50	50	50
Grass seed	50	50	50	50
Lettuce	40	50	40	20
Milo	50	50	50	50
Mint	40	40	40	50
Nursery stock	50	50	50	50
Onions	40	30	30	30
Orchard, fruit	50	50	50	50
Peas	50	50	50	50
Peanuts	40	50	50	50
Potatoes	35	35	35	50 4/
Safflower	50	50	50	50
Sorghum, grain	50	50	50	50
Spinach	25	25	25	25
Sugar beets	50	50	50	50
Sunflower	50	50	50	50
Tobacco	40	40	40	50
Vegetables				
1 to 2 ft root depth	35	30	30	35
3 to 4 ft root depth	35	40	40	40

For medium to fine textured soils:

Scheduling Irrigation Using MAD

When: Irrigate each time soil moisture reaches the MAD level.

How much: Apply sufficient water to bring profile to near Field Capacity.



To use MAD, need knowledge of soil moisture content

Option 1 - Estimate soil moisture

Option 2 - Measure soil moisture

Field Capacity, Wilting Point, and MAD

Soil Texture	Field Capacity (%)	Wilting Point (%)	Moisture content at 50% MAD
Coarse Sand	10	5	7.5
Sand	15	7	11
Loamy Sand	18	7	12.5
Sandy Loam	20	8	14
Loam	25	10	17.5
Silt Loam	30	12	21
Silt Clay Loam	38	22	30
Clay Loam	40	25	32.5
Silt Clay	40	27	33.5
Clay	40	28	34

Example: Loam Soil – What would you do if soil moisture content is:
22%?
18%?
13%?

Estimating Soil Moisture Content

1) Solve Soil Moisture Budget since last irrigation:

$$SM_{\text{today}} = (SM_{\text{last time}} + \text{Rain}) - (\text{ET} + \text{Runoff} + \text{Deep percolation})$$

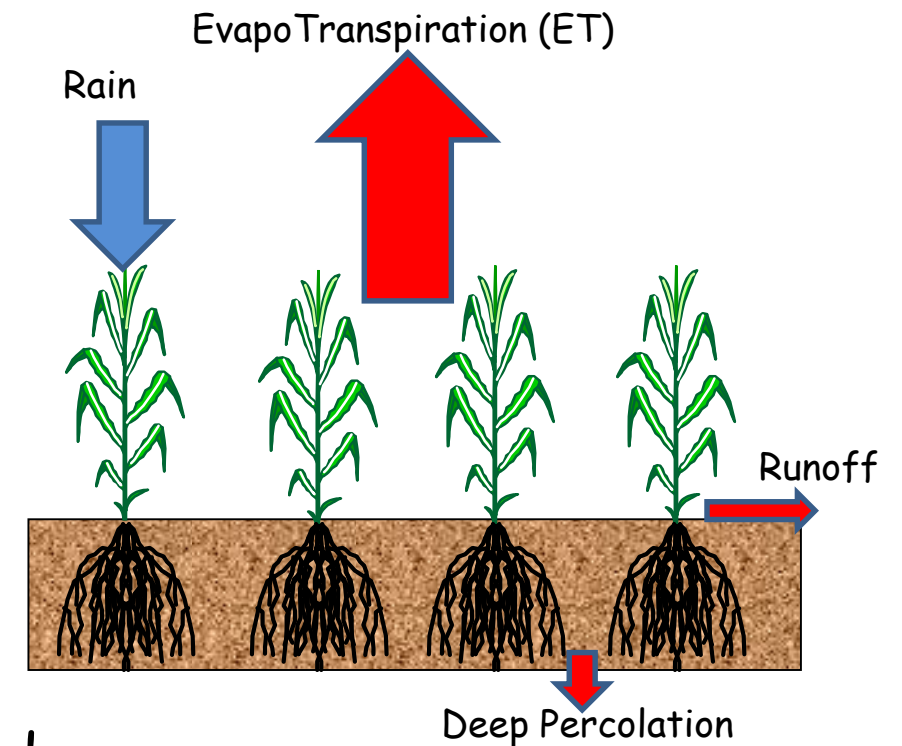
$$SM_{\text{today}} = (SM_{\text{last time}} + \text{Rain}) - \text{ET}$$

The only unknown is ET.

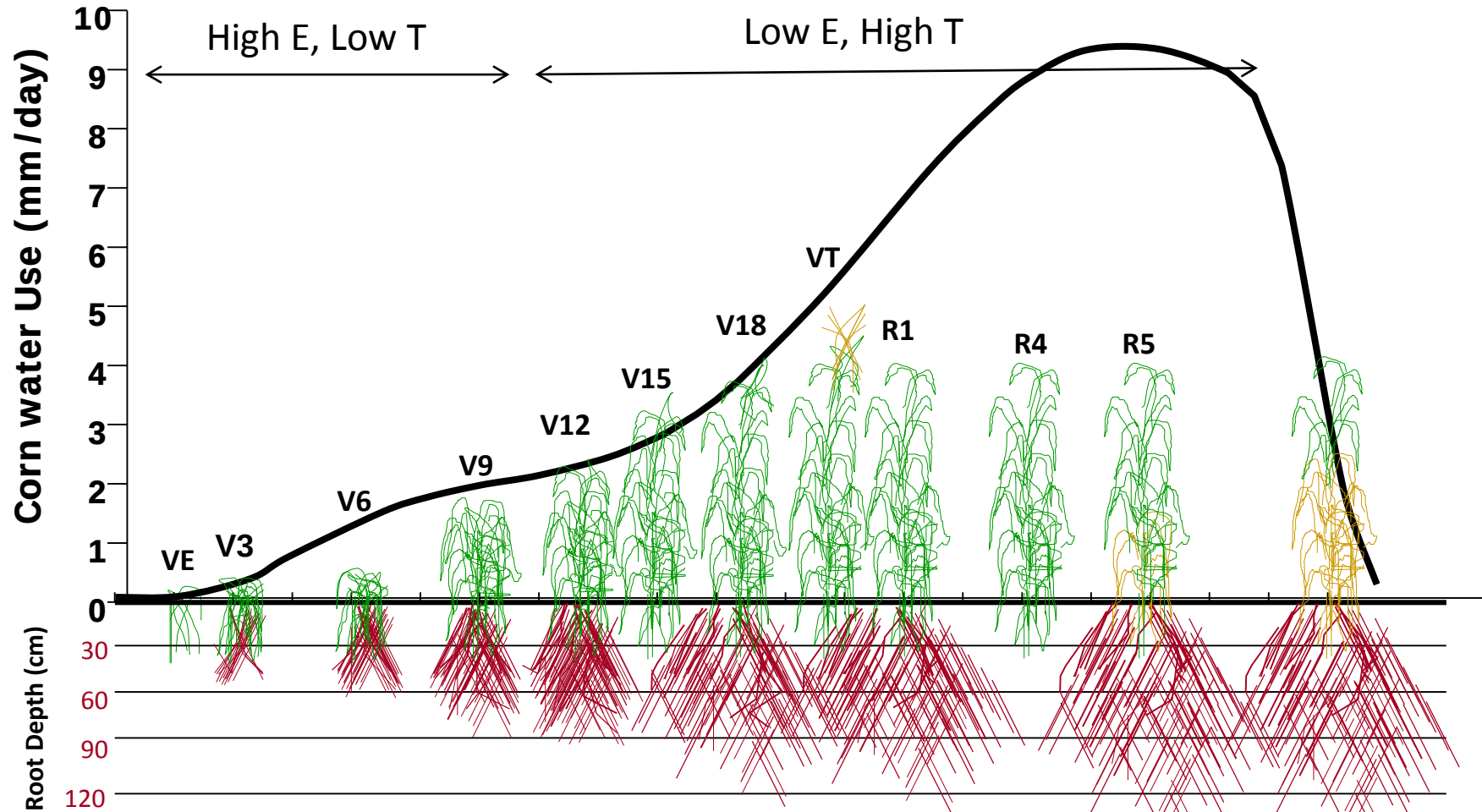
$$ET = K_c * ET_{\text{ref}}$$

2) This is the classic Checkbook method.

3) This method is also referred to as ET-based or climate-based irrigation scheduling.



Typical Corn Evapotranspiration (ET) (Crop water use)



Note: Root depth, root zone, and water use change over time

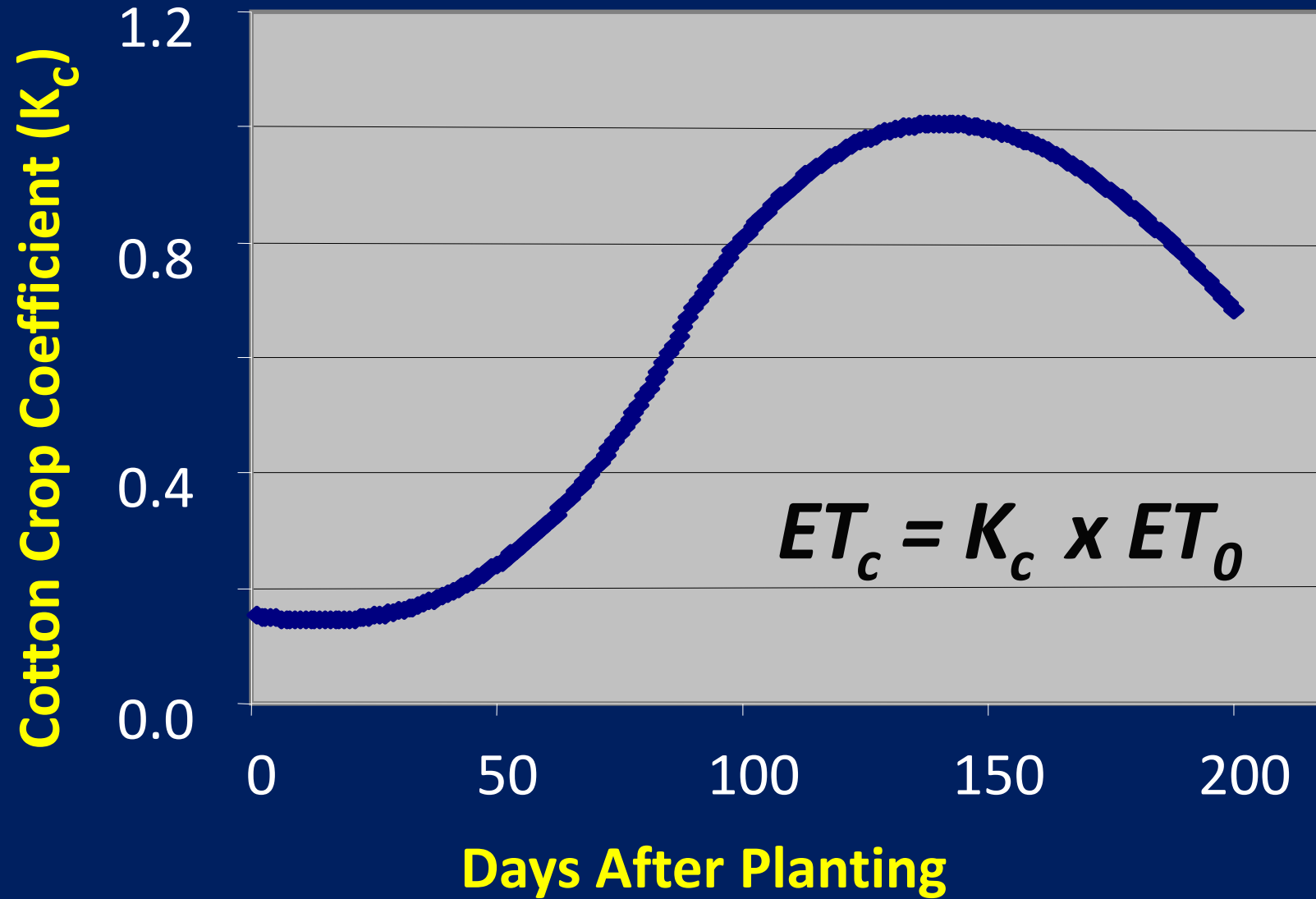
$$\text{Crop } ET = K_c \times ET_0$$

The reference evapotranspiration (ET_0) can be estimated using one of many ET equations depending on weather data availability.

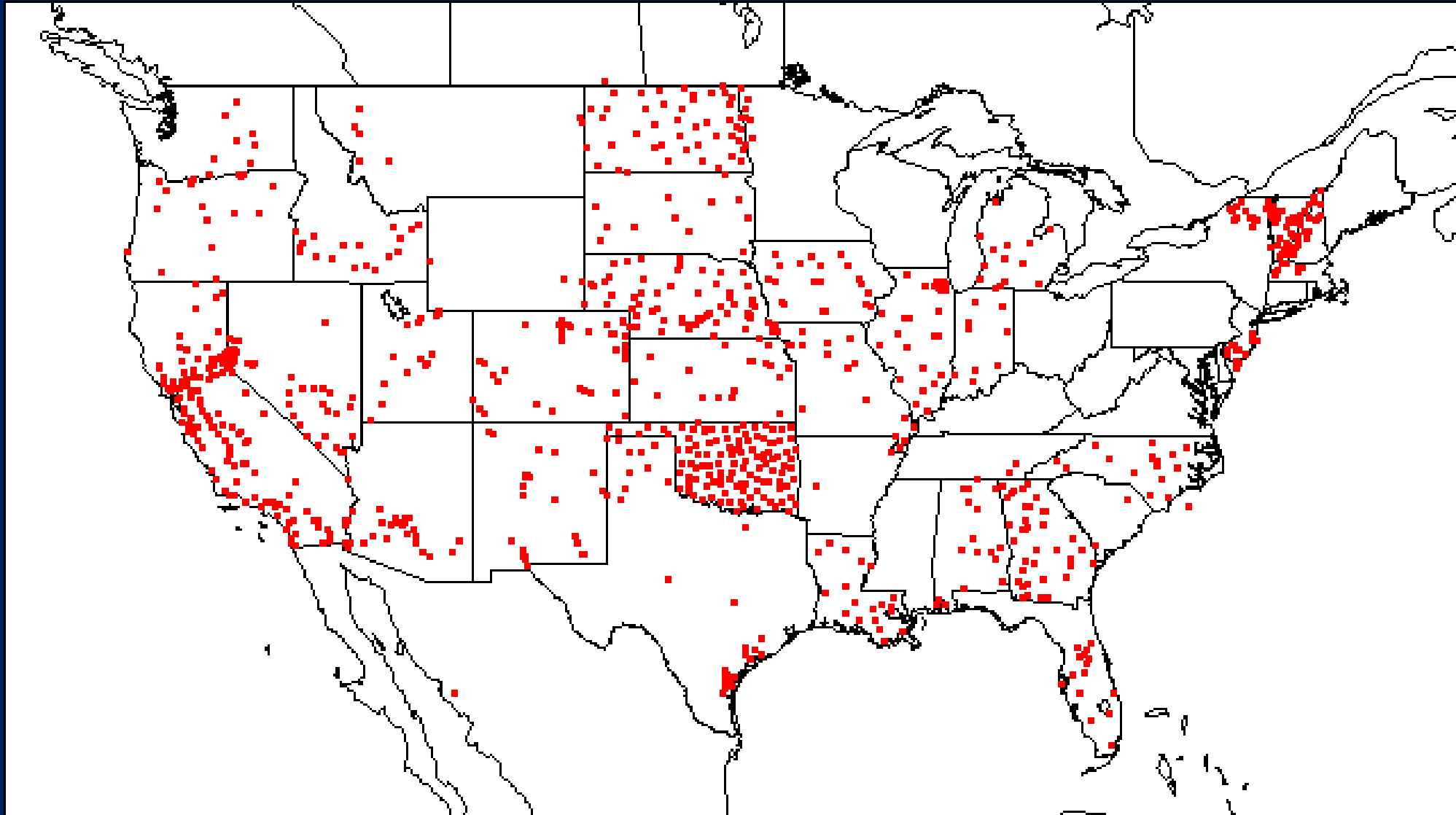
FAO-56:

The Penman Monteith Model

Crop Coefficient (K_c)



US Networks of Agricultural Meteorological Stations



The Checkbook Method

Soil Moisture Balance Worksheet

Field _____ Crop _____ Emergence date _____

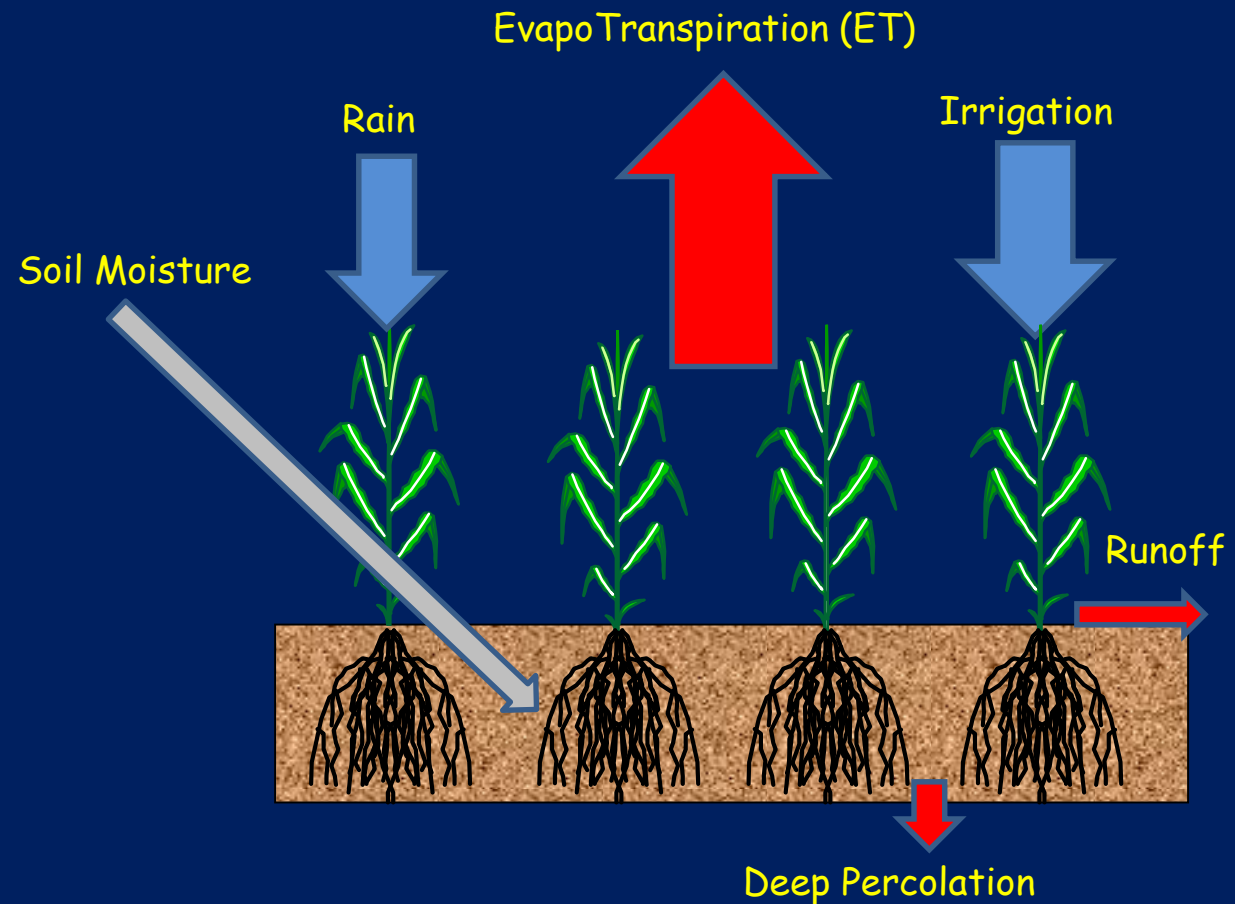
Irrigation application capacity _____ net inches/day

Growth stage	<u>Seedling</u>	<u>Vegetative</u>	<u>Critical period</u>	<u>Maturing</u>
Rooting depth	_____ inches	_____ inches	_____ inches	_____ inches
Total available soil moisture capacity	_____ inches	_____ inches	_____ inches	_____ inches
Allowable depletion	_____ %	_____ %	_____ %	_____ %
Allowable soil moisture deficit	_____ inches	_____ inches	_____ inches	_____ inches

[illegible][illegible]

Estimating versus Measuring Soil Moisture

At the end of the day, the outcome of all these is a change in soil moisture, So why not just measure it.



[illegible]

AD: Allowable Depletion
AW: Available Water

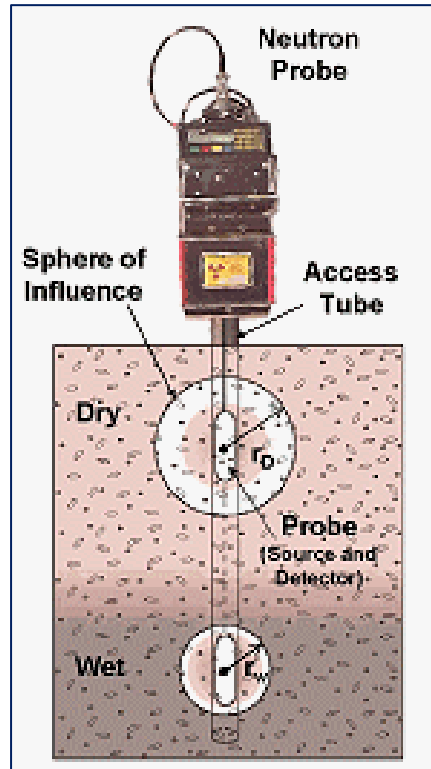
Soil Moisture Measurements

- Feel and appearance method
- Neutron scattering
- Tensiometers & Electrical resistance blocks
- New electronic sensors
(TDR, TDT, FDR and Capacitance based probes
based on soil dielectric properties)

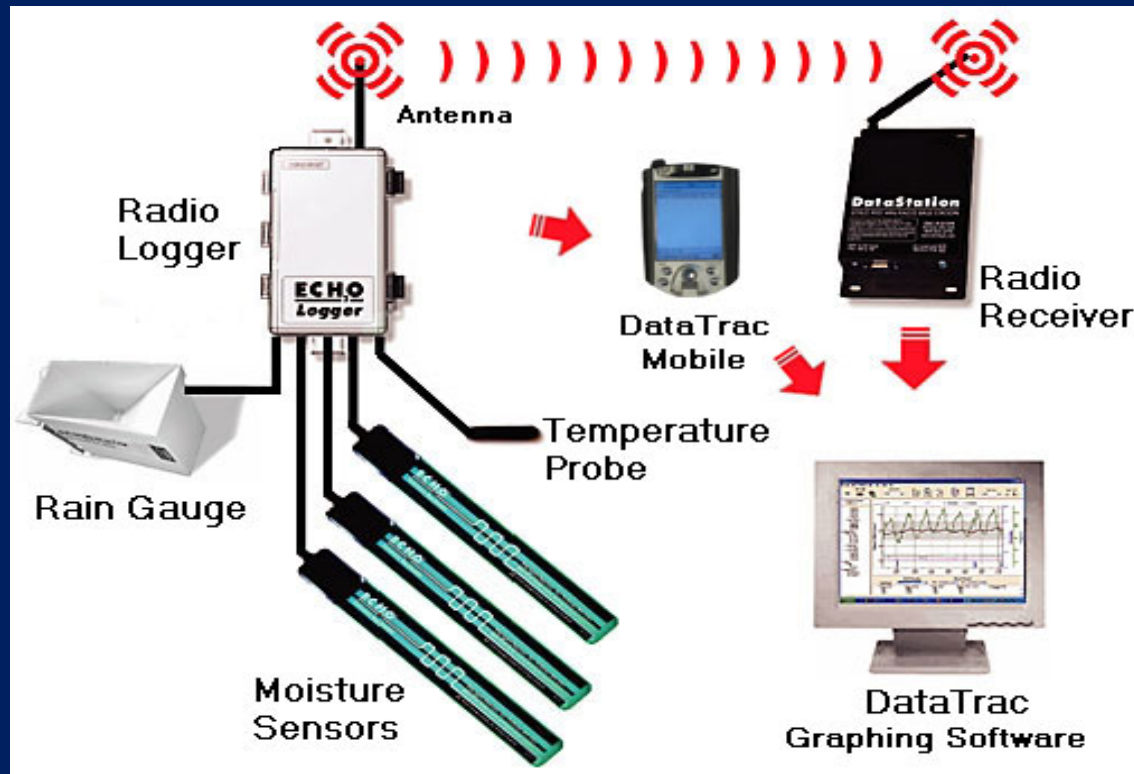
Soil moisture measurement technologies

Innovations:

- Mobile Apps
- Networks
- Automation
- Subscription services



Complete Systems - Remote Data Access

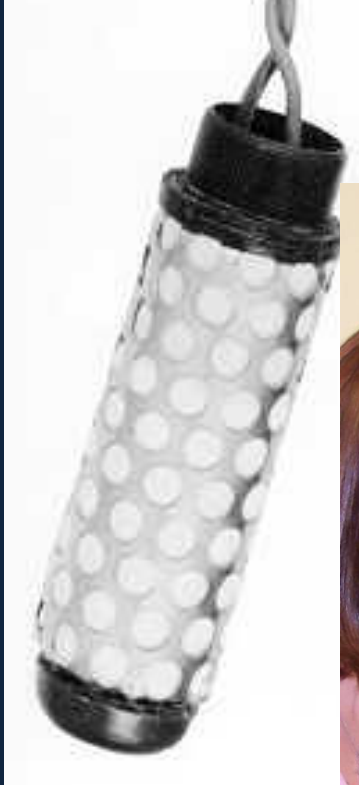


Local and cell phone web-based reporting systems

Dealing with Soil Moisture Sensors

- Calibration
- Installation
- Field Location
- Data Retrieval
- Data Interpretation
- Maintenance
- Cost

Prepare your sensors



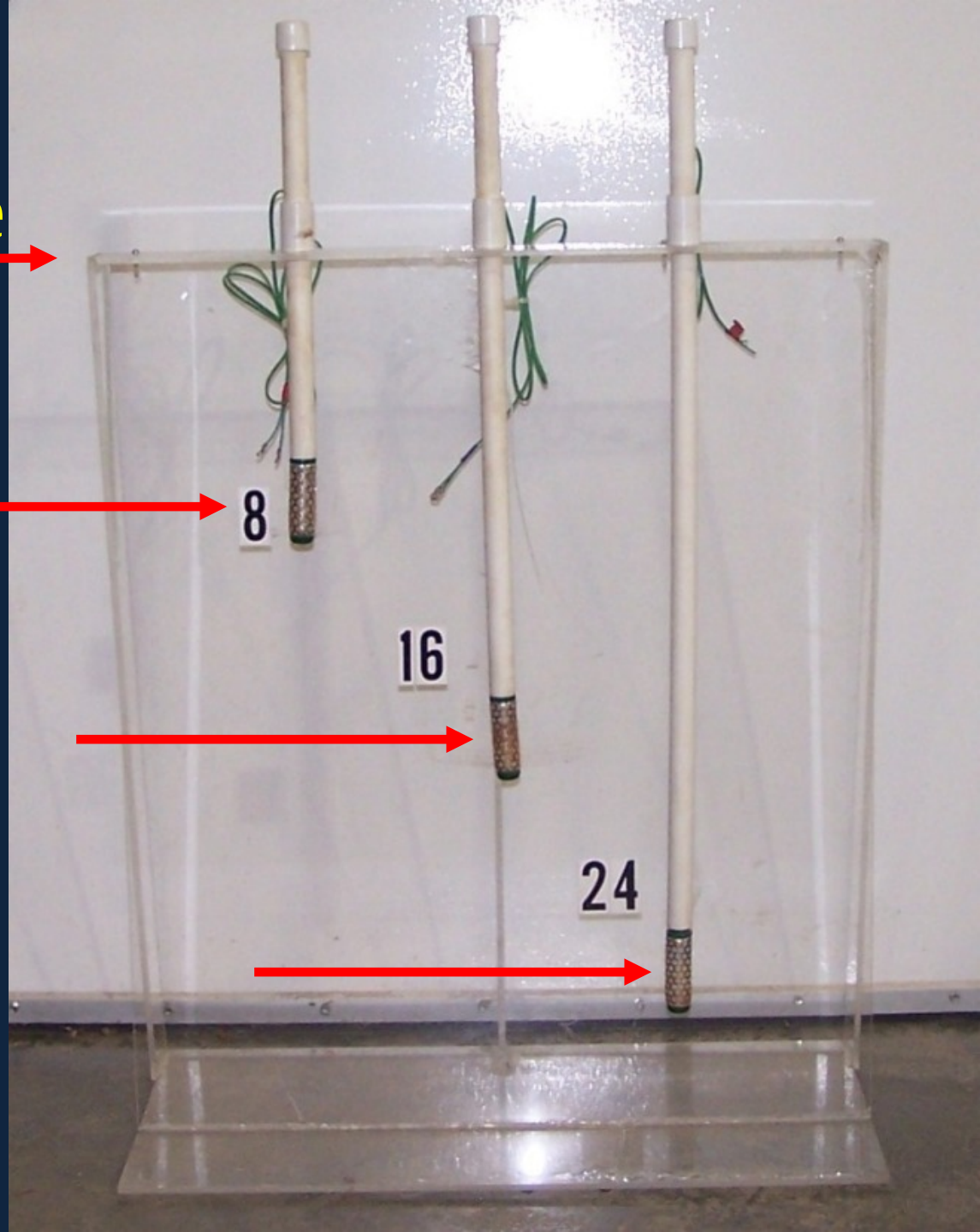
Soil Surface

8 in

16 in

24 in

Watermark Sensors



Install your sensors





Multisensor Capacitance Probes



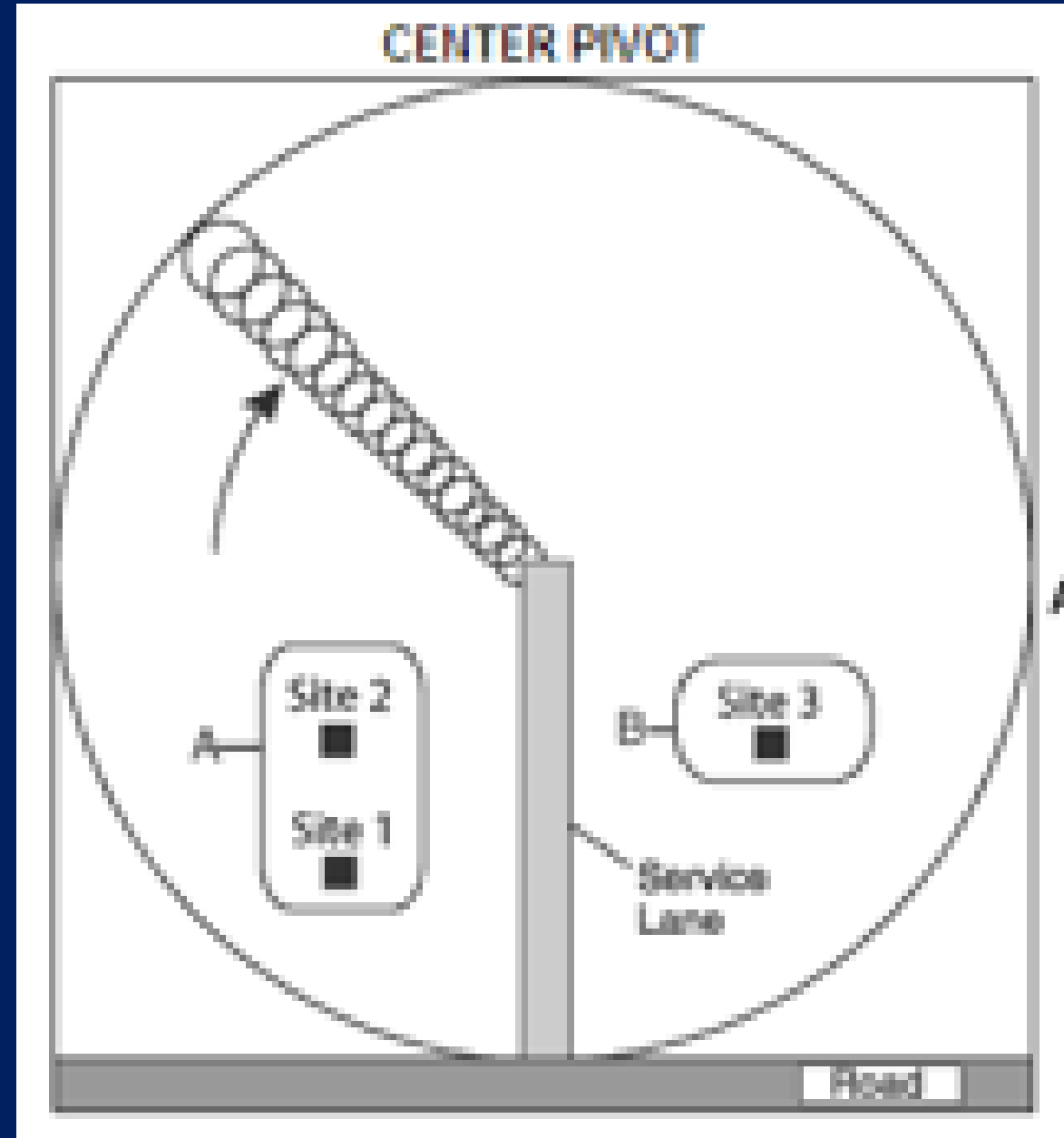
Sentek



AquaSpy

Sensor Location

- 💧 Within the root zone
- 💧 Within the wetted pattern
- 💧 Across the field



EasyAg Probe (Sentek)

Readings at 10, 20, 30, 40, 50 cm depths



Placement in Different Irrigation Systems

Surface (gravity): Low-Medium Efficiency



Sub-irrigation (water table control)



Sprinkler: Medium-High Efficiency



Micro (drip, trickle): High Efficiency





Take readings and make data entry



Automatic Data Collection



TDT Sensor



**Trend: Continuous Monitoring and Web
Deployment of Soil Moisture**

Sensor-based Agriculture

Wireless Capable & Internet Deployable



NRCS IWM Resources

- NEH - Irrigation Guide (Part 652, 1997); Chapters 4 & 9
- NEH - Section 15 - Irrigation (Part 623, 1991); Chapters 2 & 9
- Irrigation Water Management - CPS 449
- NRCS Irrigation Training Toolbox
<http://irrigationtoolbox.com/WebPages/Chapter%207.html>
- NRCS Science & Technology Training Library
<http://conservationwebinars.net/>
- Irrigation Supplements from States
- NRCS Irrigation Water Requirements (IWRpm) Software Model



hamid.farahani@gnb.usda.gov
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