Irrigation Water Management and Scheduling

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BIOLOGICAL SYSTEMS ENGINEERING
University of Wisconsin - Madison
College of Agricultural and Life Sciences

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Irrigation Water Management

So you want to irrigate …….

some questions you might ask:

- **How often should I irrigate ?**
- **How much water should I apply ?**
- **How do I measure my soil moisture ?**

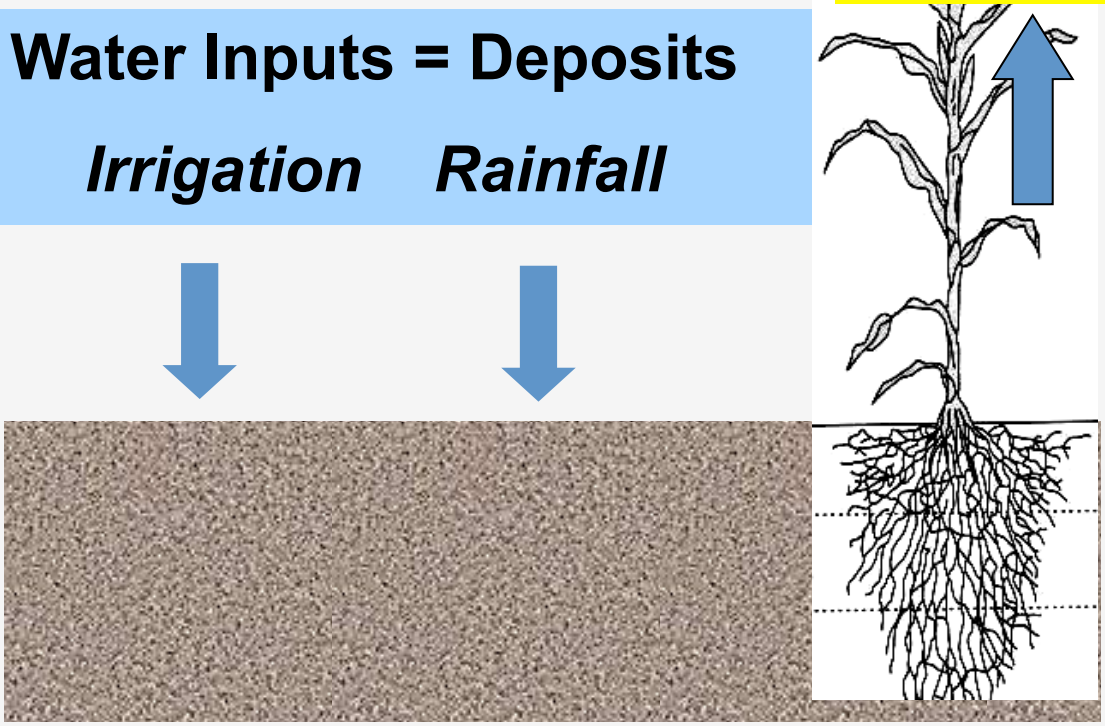
These are a few of the questions that will be discussed today.

Root Zone Soil / Water Balance

Evapotranspiration **(ET) = Withdrawal**

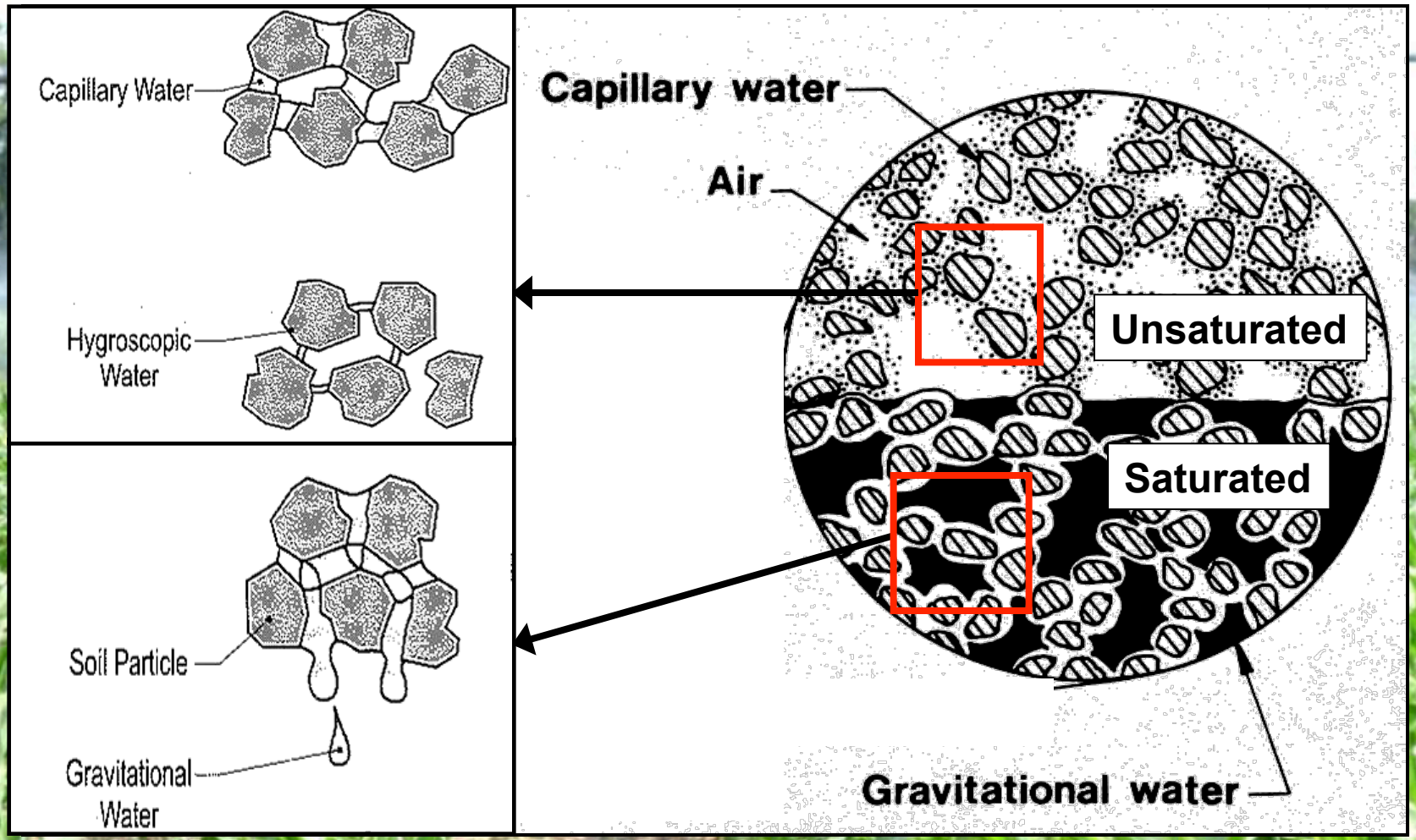
Water Inputs = Deposits

Irrigation ***Rainfall***



Deep Drainage **= Withdrawal**

Water in the Soil Profile

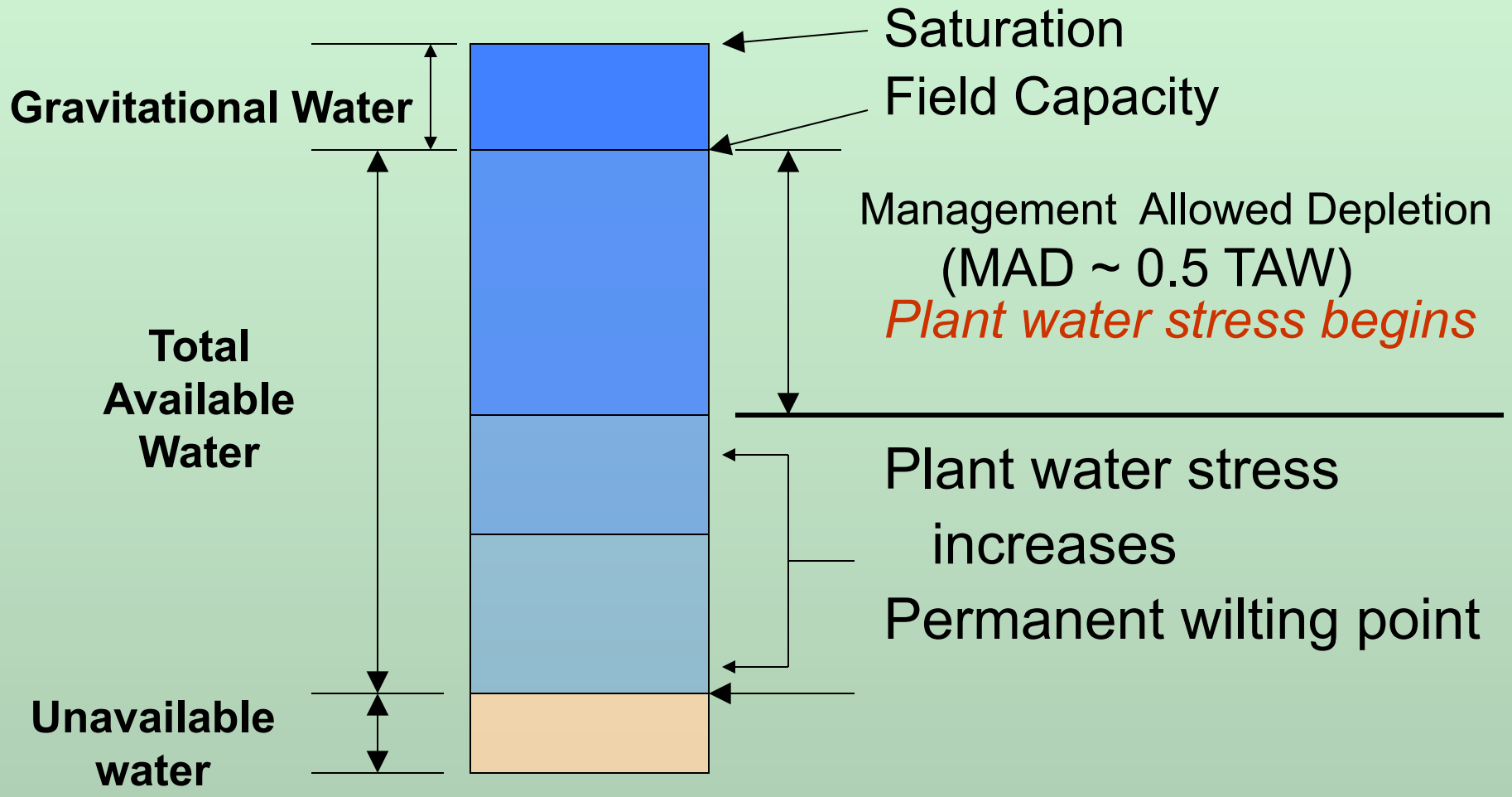


Source: Sprinkler Irrigation Systems, Midwest Plan Service, MWPS – 30, 1999

Definitions

- ***Field Capacity*** (Fc) – soil moisture content after gravity drainage of water.
- ***Permanent Wilting Point*** (PWP) – moisture exiting plant is greater than water intake. Plant can no longer extract soil water.
- ***Total Available Water*** (TAW) – amount of water held in soil between field capacity and wilting point.
- ***Management Allowed Depletion*** (MAD) – portion of water relatively easily extracted by plant without limiting growth.
- **Readily Available Water** (RAW) = TAW x AD

Soil Moisture Primer



Average Soil Water Properties

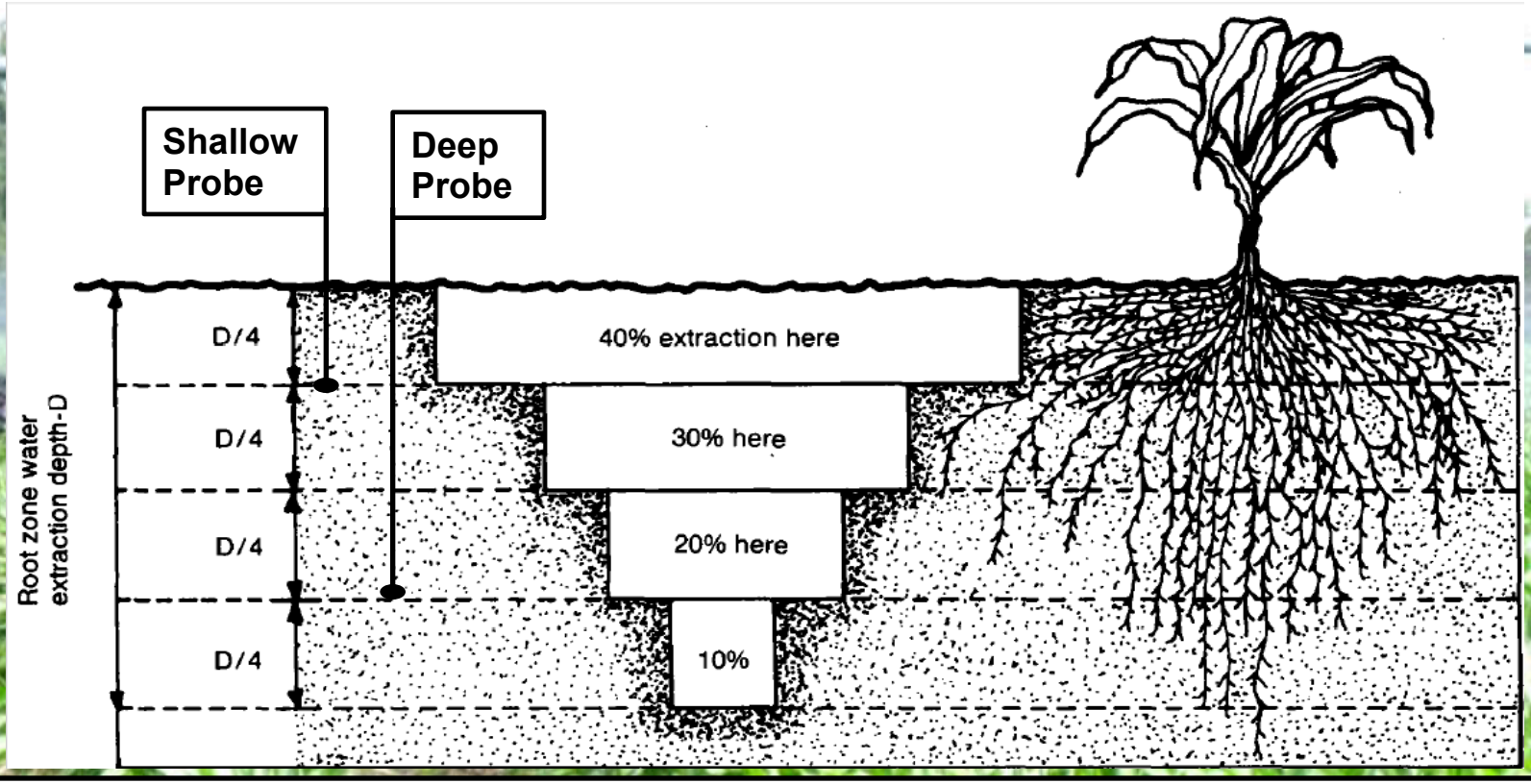
- By Textural Class -

Soil Texture	Total Pore Space (% by volume)	Field Capacity (% by volume)	Permanent Wilting Point (% by volume)	Total Available Water (% by volume)
Sandy	38	15	7	8
Sandy Loam	43	21	9	12
Loam	47	31	14	17
Clay loam	49	36	18	18
Silty clay	51	40	20	20
Clay	53	44	21	23

Source: James, L.G. Principals of Farm Irrigation System Design

Plant Water Removal Pattern

- Uniform Soil Profile -



The effective root depth is that portion of the root zone where the crop extracts the majority of its water

Source: NRCS National Engineering Handbook Section 15, Irrigation

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Sensor Location

Shallow Location

- ~ 25 - 30% of root zone depth
- Used to know when to start irrigation

Deep Location

- ~ 65 - 80% of root zone depth
- Used to know amount of irrigation
- Penetration – is the irrigation water reaching lower roots ?
- Leaching events

Irrigation Water Management Depth

Crop	Max Root Depth (in)[1]	Irrigation Water Mgt. Depth (in) [2]	Shallow Sensor (in) [3]	Deep Sensor (in) [3]
Broccoli & cauliflower	24	12 - 18	12	20 - 24
Strawberry	12 - 24	12 - 18	6	12
Potatoes	24 - 36	12 - 18	8 -10	18
Tomato & cantaloupe	36	12 - 24	18	36
Bush bean	24 - 36	18 - 24	10	18
Soybeans	48 - 60	30 - 36	12 - 18	30 - 36
Small grains	48	30 - 36	12	24
Sweet corn	24 - 36	24 - 36	12	24 - 30
Field Corn	48	30 - 36	12 -18	30 - 36
Pumpkins / Winter Squash	36 - 48	30 - 36	18	36
Established alfalfa	60	36 - 48	18	36

1. **USDA – NRCS Part 652 - Irrigation Guide, 1997, Chapter 3, Table 3-4**
2. **Depth at which the soil water content should be managed for optimum crop production.**
3. **Soil Moisture Basics, Irrometer Company, http://www.irrometer.com/basics.html**

Soil Moisture Management

	Managed Root Zone	Mgmt. Allowed Depletion	Critical Period
Potatoes	12 - 16”	35% - 50% 50%@ vine kill	Flowering and tuber formation to harvest
Peas	24”	50%	Start of flowering and when pods are swelling
Green Beans	24”	40%	Blossom through Harvest
Sweet Corn	24”	50% @ establish 40% until harvest	Tasseling thru silk stage until kernels are firm
Grain Corn	36 - 48”	50%	Tasseling thru silk stage until kernels are firm

How much water is the crop using ?

- Evapotranspiration -

Crop ET is typically calculated from crop and climate data

$$ET = (K_c)(ET_0)$$

where ET_0 = potential ET **or** reference crop ET and K_c is the crop coefficient that corrects for crop type and canopy development.

Reference crop = well watered (not stressed) alfalfa or grass

Potential ET = maximum rate of water removal from soil and plant surfaces with no plant water stress

In Wisconsin we have statewide potential ET data available

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How much water is the crop using ?

- WI & MN ET Estimates -

Crop ET values from UW Soil Science AG WX site

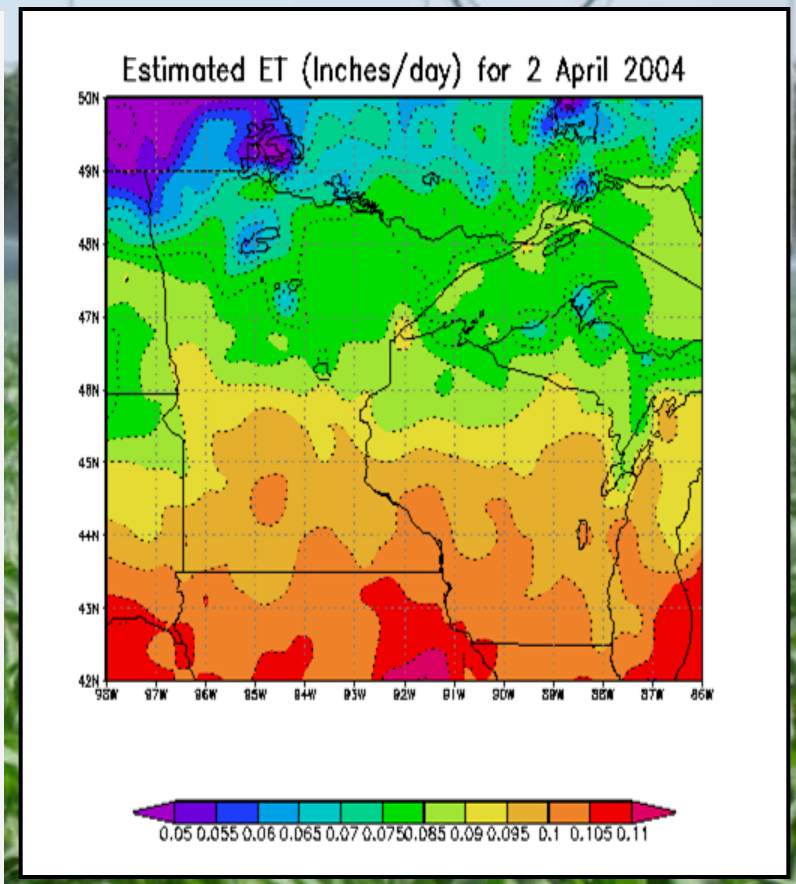
www.soils.wisc.edu/wimnext/water.html

- Based on Priestley - Taylor equation (P-T Potential ET)

- Referenced by latitude and longitude

- Inputs = Solar radiation, temperature, soil heat flux
  Accuracy : +/- 15 - 20%

- Can be emailed to you daily



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Precipitation Inputs

- Rain Gages -

- Accurate measurements of field conditions
- Three gages in every field is preferred
  - Records rain and irrigation
- Read gage soon after event to minimize evaporation
- Cost < $50.00

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How often should I Irrigate ?

- Irrigation Scheduling -

Check Book Method

- ❑ Tracks daily soil water inputs (rain, irrigation), outputs (deep drainage, ET) and change in storage
- ❑ Only water when necessary
- ❑ Use enough to grow a high quality crop

Computer Software or Manual System (Paper)

- ❑ Manually track daily rainfall, irrigation and ET (UWEX A3600)
- ❑ Use an irrigation scheduling software package

How often should I Irrigate ?

- Irrigation Scheduling -

Irrigation scheduling can . . .

- Reduce the chance of over irrigating
- Reduce the likelihood of N loss through leaching
- Help to provide more consistent root zone moisture throughout the growing season
- May reduce irrigation cost by taking better advantage of natural rainfall

Irrigation Water Management Tools

- Web-based Scheduler WISP 2012 -

WISP: Wisconsin Irrigation Scheduling Program 2012 Version 1.0.1

WISP Home
Farm Status
Pivots, Fields, and Crops
Field Status
Weather Stations
Multi-Edit Daily Data
User's Guide
Latest Info (updated 22 May 2013)

WISP Home

About WISP

The Wisconsin Irrigation Scheduling Program (WISP), is an irrigation water management tool developed by the Departments of Soil Science and Biological Systems Engineering at the Wisconsin-Madison. WISP is designed to help growers optimize crop water use efficiency by tracking the root zone water inputs and outputs (water balance).

Using WISP's water balance predictions, along with root zone soil moisture monitoring, a grower can plan irrigation timing and amount to take maximum advantage of natural rainfall while minimizing over-application of water resulting in leaching.

Organization

WISP accommodates multiple Farms, Pivots, Fields and Crops with a hierarchy:

-- A **farm** can be any set of pivots the user chooses (e.g. common ownership, location or management).
-- A **pivot** can have one or more fields growing different crops.
hysical or management characteristics (e.g., crop type, soil water holding capacity or irrigation
cteristics can change from year to year and have multiple crops per year.
an emergence date, starting soil moisture, depth of the managed root zone, and AD fraction.

r multiple fields, **weather stations** are provided. A weather station is associated with a pivot; daily data
igation) are automatically propagated to all the fields under that pivot.

a service called OpenID (OID). Google is the OID provider currently used by WISP, so you will need a
cted to a login page where you enter your email address and password. That's all there is to it!

ady have one.
nk in the navigation bar on the left side of the screen. Your login credentials will be requested, and you will

SP farm screen
pivot, field, and crop are created for you, along with weather/irrigation records for the season.
s" page; pivots, the fields they serve, and crops in the field are managed from the "Pivots, Fields, and

bar, and use the "Add Pivots" button to add pivots for the farm.
otes".
or which you would like to combine data entry, create a weather station and use "Multi-Edit Daily Data" to

The User Guide provides additional model input and application guidance.

About WISP
Version: 1.0.0
Build Number: 296

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Irrigation Water Management Tools

- Web-based Scheduler WISP 2012 -

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Latest Info (updated 18 August 2014)

Logout jcpanuska@wisc.edu

WISP Field Status

2014 % Cover | Test Pivot 1 | Test Field 1 | 2014-7-13

Field Data

Farm: 2014 % Cover
Pivot: Test Pivot 1
Field/soil: Test Field 1
Crop: New crop (field ID: 3895) A v...

Root zone depth: 36.0 in
Emergence Date: 05/01/14
AD at field capacity: 2.52 in.
Initial soil moisture: 30 %
Target 70 % (1.76 in.)
Update Target

Edit Observed Values Below

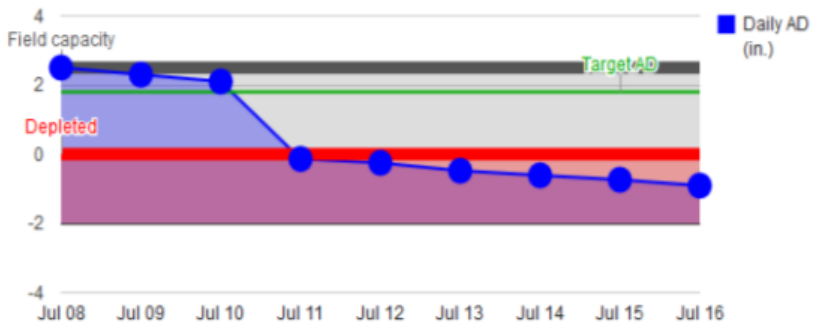
Date	Poten. ET	Rainfall	Irrigation	% Moisture	% Cover	Adj. ET	AD	Deep Drainage
2014-07-08	0.13	2.80	0.00	30.0	80	0.13	2.52	0.79
2014-07-09	0.18	0.00	0.00	29.4917	80	0.18	2.34	
2014-07-10	0.22	0.00	0.00	28.8806	80	0.22	2.12	
2014-07-11	0.15	0.00	0.00	22.6	80	0.15	-0.14	
2014-07-12	0.11	0.00	0.00	22.2972	80	0.11	-0.25	
2014-07-13	0.23	0.00	0.00	21.6639	80	0.23	-0.48	
2014-07-14	0.13	0.00	0.00	21.3167	80	0.13	-0.61	

Seasonal Totals
2014-05-01 to 2014-10-18

Report in CSV Format

Rainfall: 9.90 in.
Irrigation: 0.00 in.
ET: 14.76 in.
Drainage: 0.79 in.

Calculated Allowable Depletion (inches)



Source: WISP. CALS. WISC. EDU

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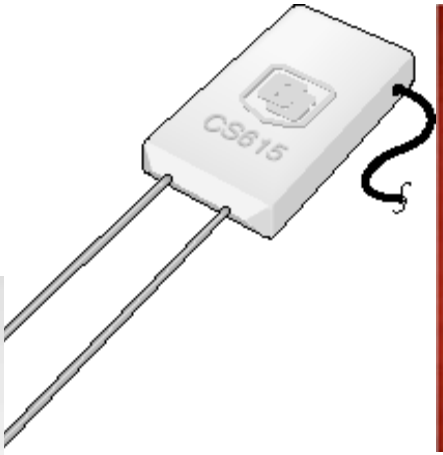
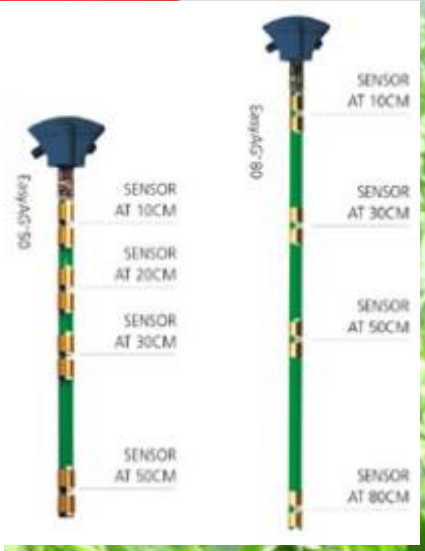
Measuring Soil Moisture





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The Hand Feel Method

- Estimate only
- Accuracy not possible
- Investment is only a soil probe
- Need accurate soil moistures to perfect your judgment
- See NRCS Publication Estimating Soil Moisture by Feel and Appearance

Tensiometer

- Works like a mechanical root
- Readings in centibars of vacuum
- Indication of water extraction rate
- Water equilibrates with soil moisture
- Accurate up to 85 centibars (~12 psi)

Tensiometer (Cont.)

- Installed for growing season
- Maintenance required – refill w/distilled water, anti-bacterial agent
- Different lengths
- Cost $82 - 92/each

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Interpreting Soil Tension Readings

Soil Tension (Vacuum) Readings

0 -10 centibar *	**Saturated soils**
10 - 20 centibar	**Field capacity**
30 - 60 centibar	**Usual range for to start irrigation**
70 -100 centibar	**Heavy soils and crops requiring dry down between irrigations.**
100 - 200 centibar	**DRY!!**

* Centibar = 0.01 bar = 0.145 psi

Electrical Resistance Block

- Solid state
- Good soil contact important
- Cost
  - Sensor: $35 - 45
  - Meter: $300
- Temperature sensitive
- Sensitive to high saline or acid soils
- Withstands freezing, can be re-use

Time Domain Reflectivity (TDR)

- Measures dielectric constant of soil
- Comes from technology was used to find breaks in underground phone cables
- Available as hand probe and buried sensor
- Reads directly in percent moisture
- Cost: $800 - 1200 – Theta Probe

Capacitance Sensor

- Cost:
  - Sensor ~ $110
  - ProCheck logger ~ $300, Five channel data logger ~ $400
- Measures volumetric soil moisture to ± 3% for all mineral soils.
- Low sensitivity to salinity and temperature
- The sensor can be left in over the winter

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Multi-Depth Monitoring Systems

AquaSpy System

- Measure at multiple depths at once
- Uploads data in real time to web
- Often linked with VRI software
- Most costly system $2,000 and up .

Photos by Precision Water Works Plainfield, WI

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Moisture Measurement Methods

Sensor Configuration Options

Portable Hand-held Probe (Capacitance, TDR)

- Very portable, can cover a lot of area
- A little more difficult to track subsurface moisture over time (need to dig a hole)

In-place Sensor (tensiometer, resistance blocks)

- Good to monitor moisture at several depths simultaneously
- Limited to a single location

Variable Rate Irrigation (VRI)

What is VRI ??

VRI allows varying rates of irrigation water application based on the individual field management zones.

Where is VRI useful ??

Overlap areas

Boggy or extra dry areas

Varying soil types

Non-croped areas

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