Irrigation Water Management and Scheduling

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UW – Extension
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BSE Boot Camp Training
November 3rd, 2017





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.

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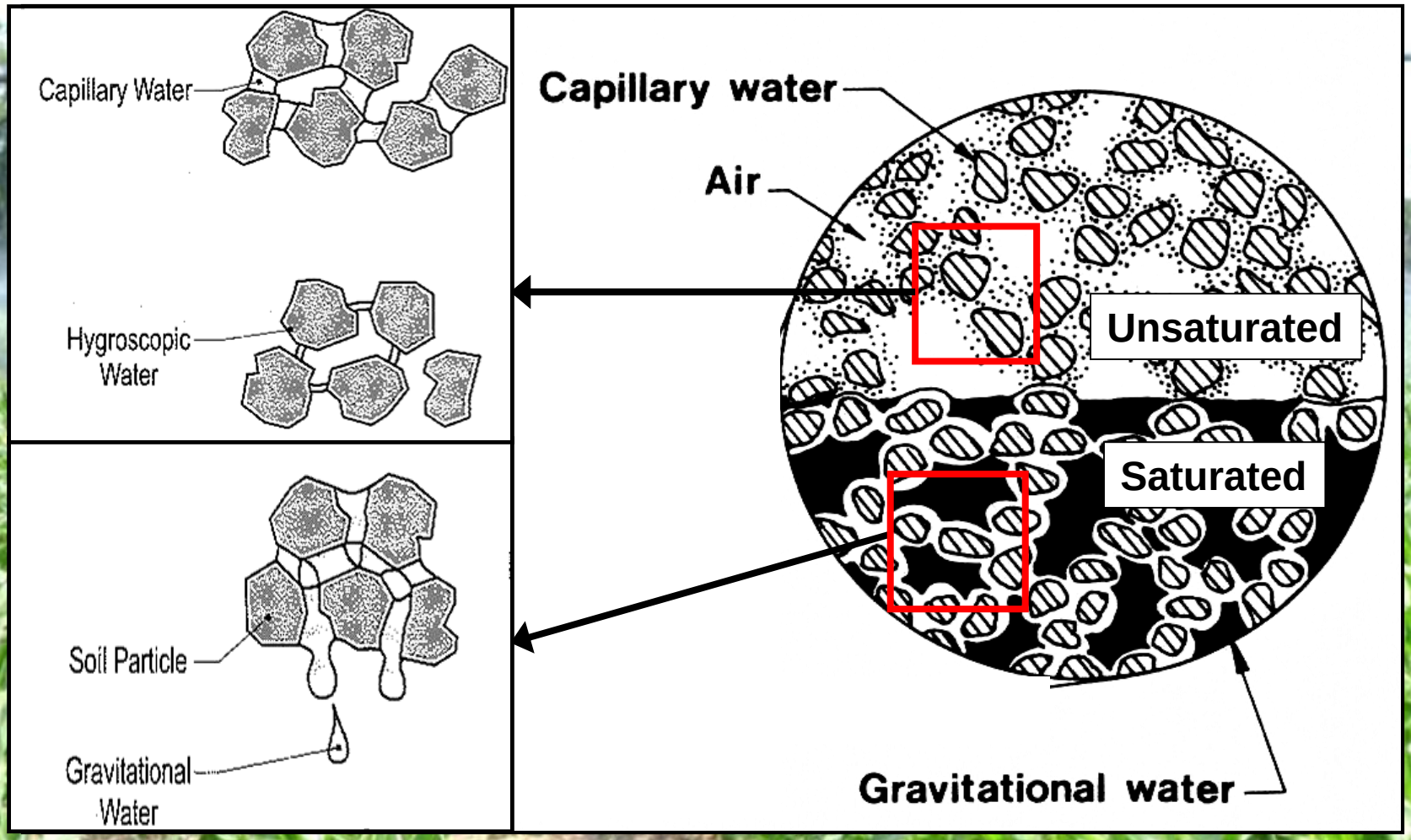
Water in the Soil Profile



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

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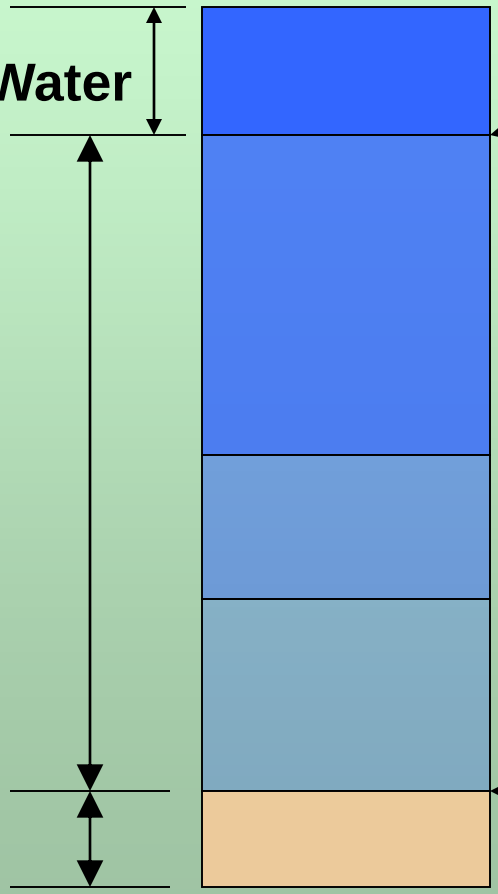
Definitions

- ***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 (Fc - PWP).
- ***Management Allowed Depletion*** (MAD) – portion of water easily extracted by plant without limiting growth.
- **Readily Available Water** (RAW) = TAW x MAD

Soil Moisture Primer



Saturation

Field Capacity

Gravitational Water

Management Allowed Depletion

(MAD ~ 0.5 TAW)

Plant water stress begins

Total Available Water

Plant water stress increases

Unavailable water

Permanent wilting point (about 100 centibars)

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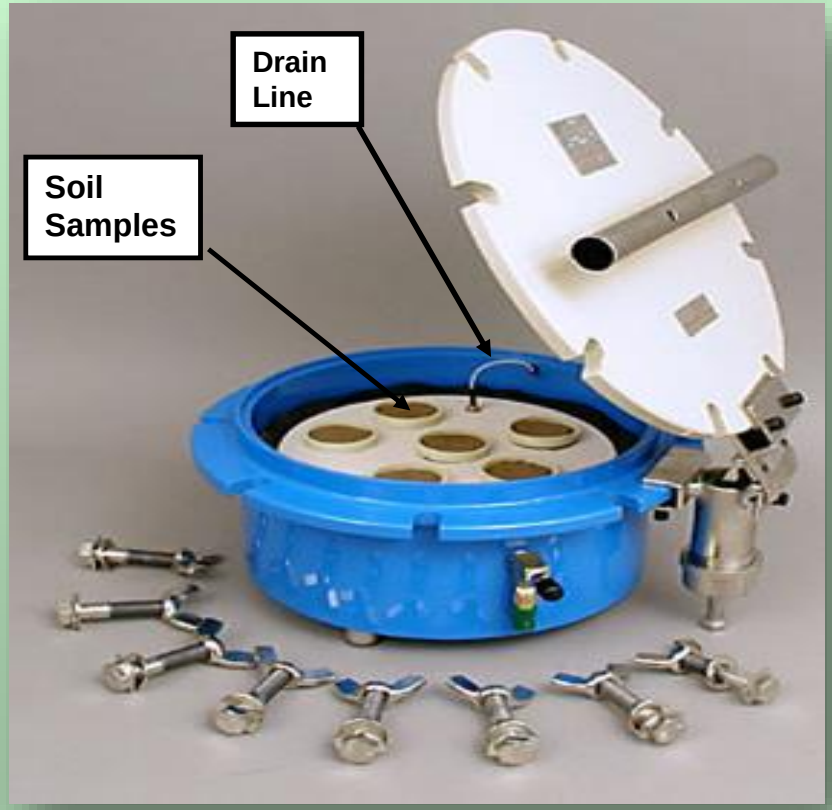
Soil Water Pressure Plate Extraction Device



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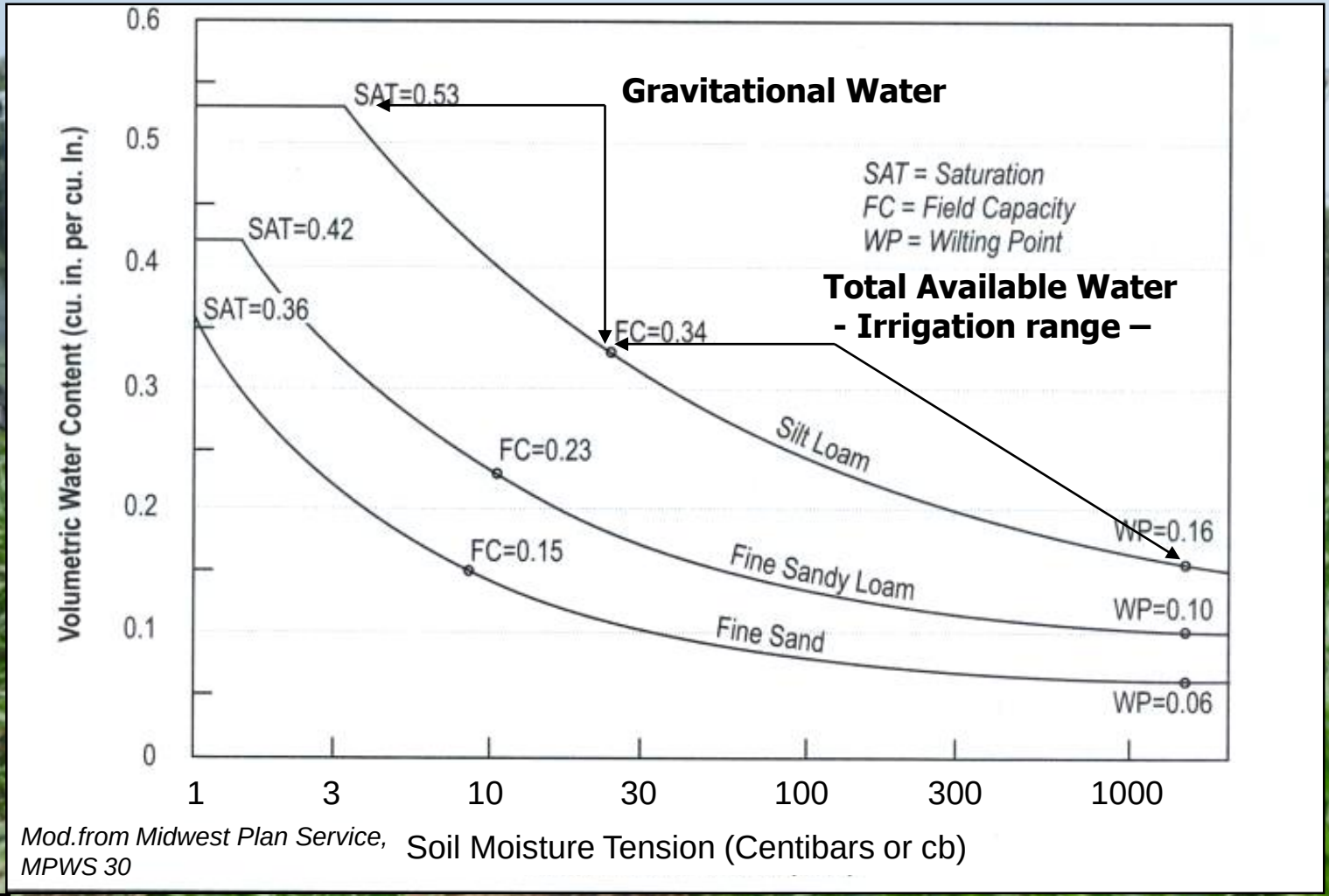
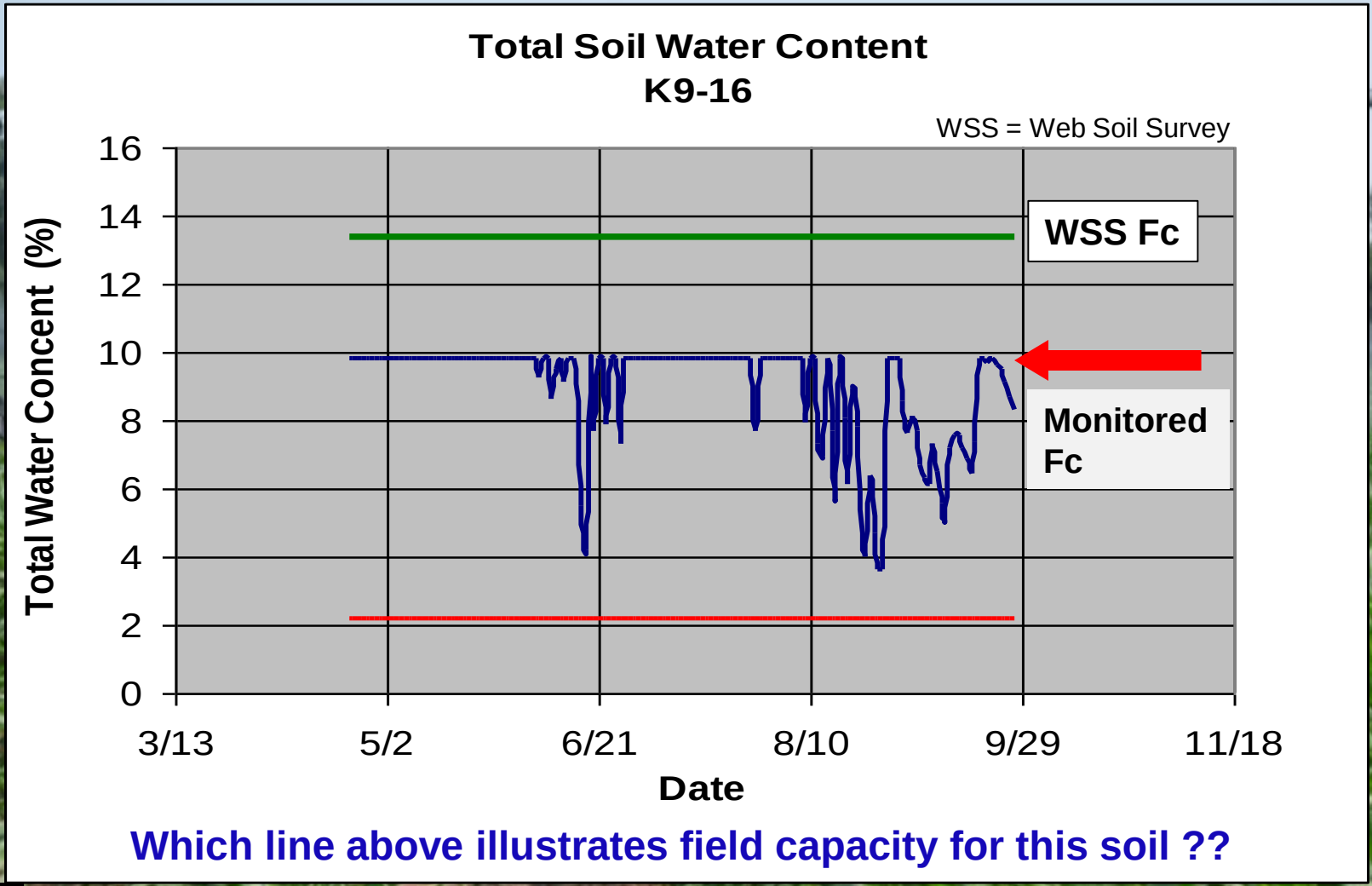
Soil- Water Release Curves



Mod.from Midwest Plan Service, MPWS 30

Soil Moisture Monitoring



Which line above illustrates field capacity for this soil ??

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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

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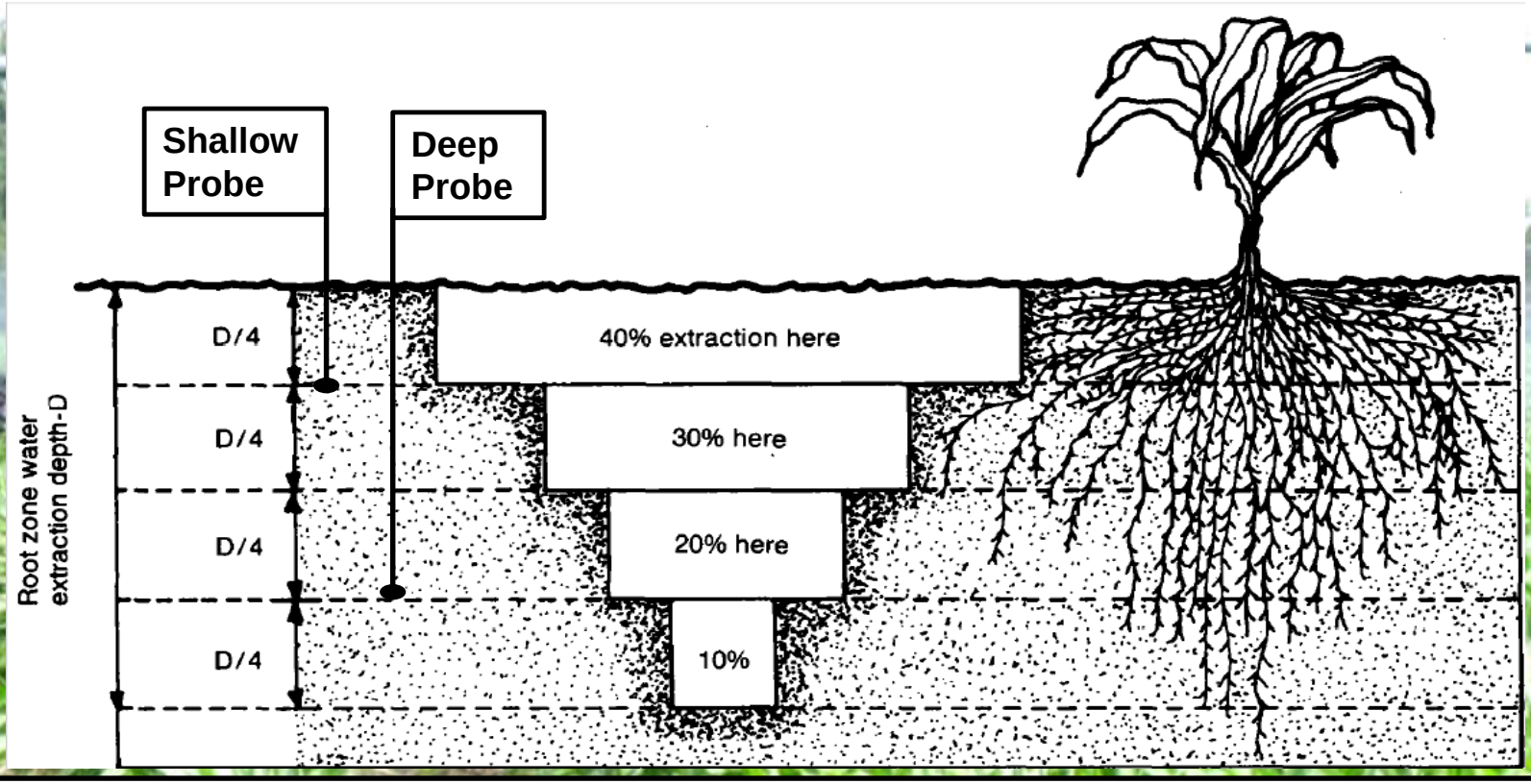
Plant Water Removal Pattern

- 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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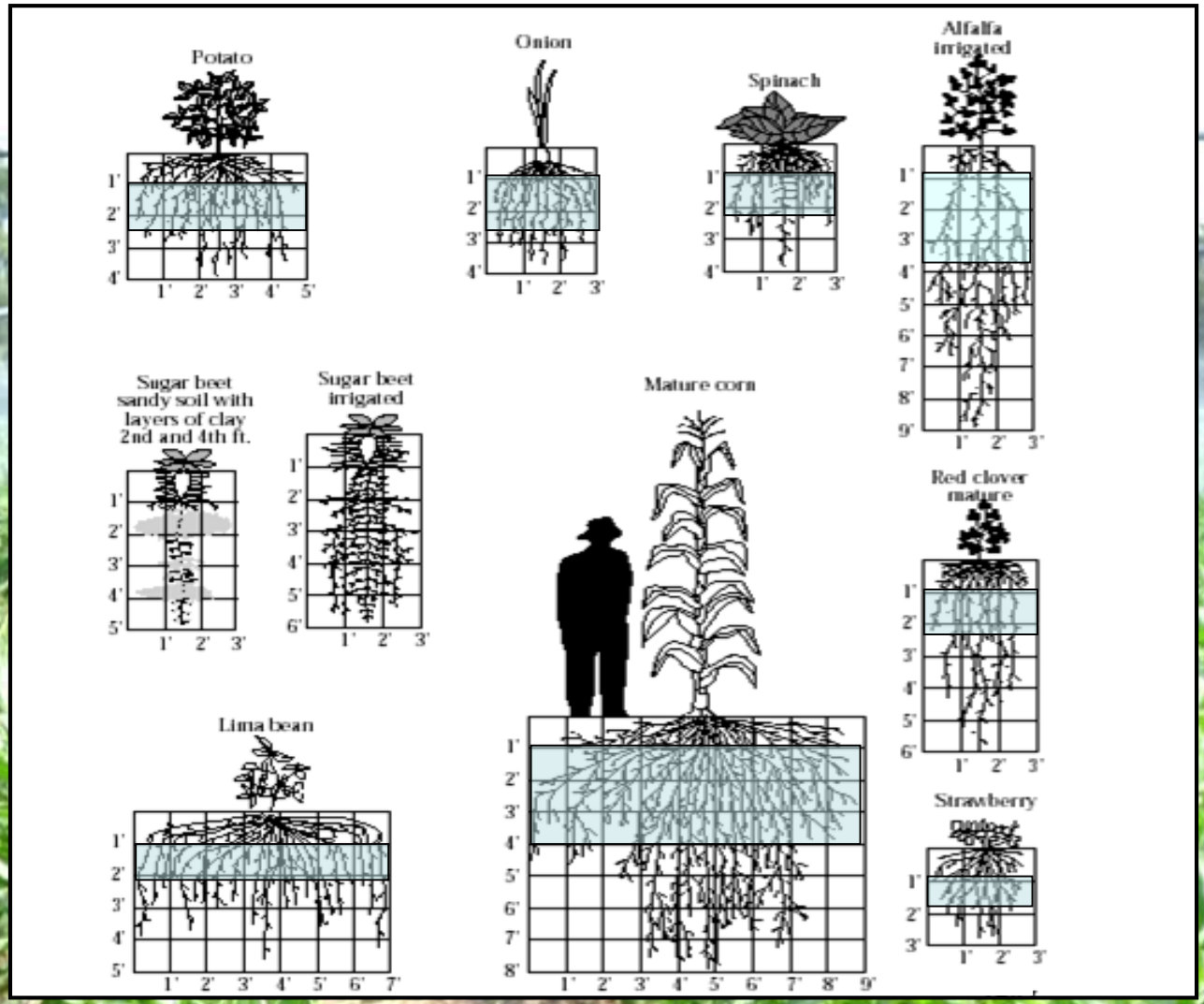
Irrigation Management Depth

- Determined by Crop and Soil Properties -



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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 ?
- Watch for leaching events

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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	24
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**

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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

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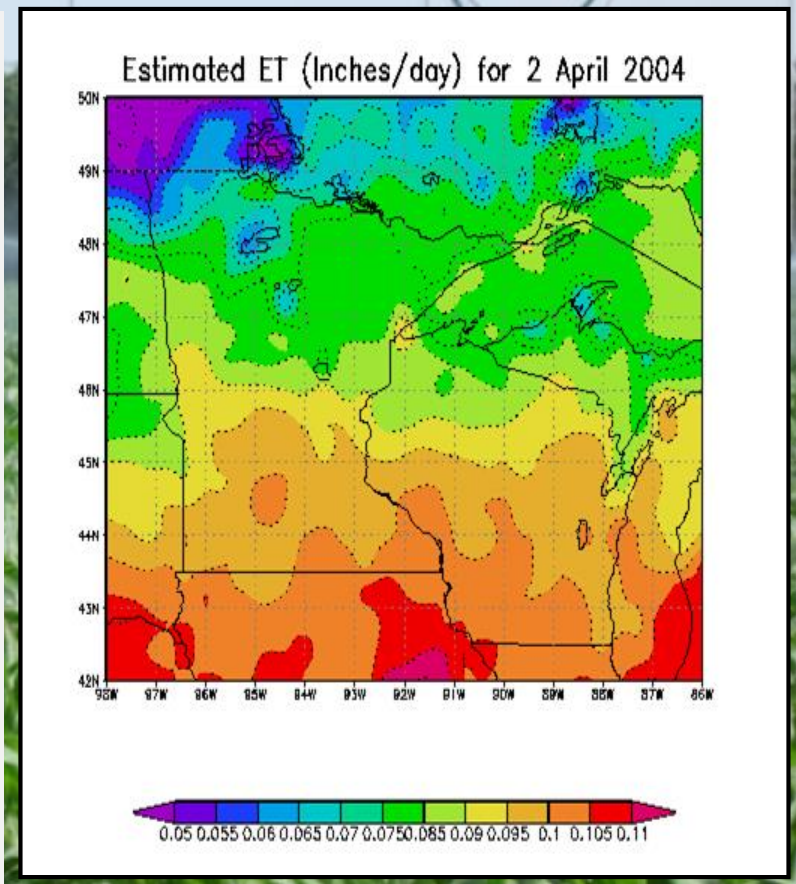
How much water is the crop using ?

- WI ET Estimates -

Example: Crop ET values from the UW AGWX site

agweather.cals.wisc.edu/sun_water

- Based on Priestley - Taylor equation (Potential ET)
- Adjusted by canopy cover (%)
- Referenced by latitude and longitude
- Inputs = Solar radiation, air temperature, soil heat flux
  Accuracy : +/- 15 - 20%



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Precipitation Inputs

- Rain Gages -

- Accurate measurements of field conditions
- Three gages in every field is preferred
  - Records rain and irrigation
- Low evaporation rates
  - < 1% per week



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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 Program or Manual System (Paper)

- Manually track daily rainfall, irrigation and ET
- Use a irrigation scheduling software package

  WI Irrigation Scheduling Program (WISP)

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How often should I Irrigate ?

- Irrigation Strategy -

Full Irrigation Strategy

A full irrigation strategy fills the soil profile is back to field capacity

Partial Irrigation Strategy

A partial strategy does not fill the root zone to Fc with each irrigation, but makes unfilled soil water storage capacity available for natural rainfall

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Irrigation Water Management Tools

- Web-based Scheduler WISP 2012 - Version 2.0 -

WISP: Wisconsin Irrigation Scheduling Program 2012 Version 2.0.0

WISP Home
Farm Status
Pivots, Fields, and Crops
Field Status
Field Groups
Multi-Edit Daily Data
User's Guide
Latest Info (updated 13 Dec 2014)

Sign up Sign in

REMINDER
WISP user input data will be purged on Feb. 15th each year. To save current year data use the Create Report in CSV Form on the Field Status page prior to 2/15!

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).

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

...ganization

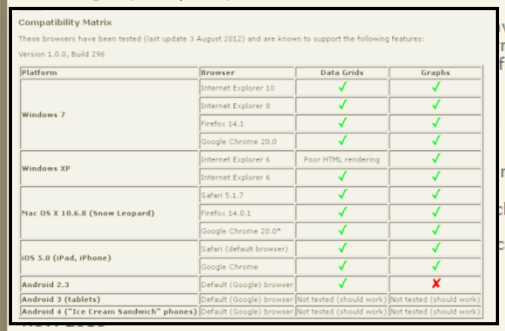
...SP accommodates multiple Farms, Pivots, Fields and Crops with a hierarchy:

... chooses (e.g. common ownership, location or management).
...wing different crops.
...mmon physical or management characteristics (e.g., crop type, soil water holding capacity or irrigation ...d characteristics can change from year to year.
...fy an emergence date and depth of the managed root zone. WISP's default initial soil moisture content is field ... a measured value.

... same for multiple fields, **field groups** are provided. Fields can be associated with a field group; daily data entered ...) are automatically copied to all associated fields. The groupings can be changed at any time.

Getting Started

Secure access to your WISP data is provided using a service called OpenID (OID). When you start WISP you are directed to a login page where you enter your email address and password. **A Gmail account is no longer required, you can use any valid email you can access.** If this is your first time using WISP, select Sign Up to create your user account. That's all there is to it!


Compatibility Matrix

These browsers have been tested (last update 3 August 2012) and are known to support the following features:

Version 1.0.0, Build 296

Platform	Browser	Data Grids	Graphs
Windows 7	Internet Explorer 10	✓	✓
	Internet Explorer 8	✓	✓
	Firefox 14.1	✓	✓
	Google Chrome 20.0	✓	✓
Windows XP	Internet Explorer 6	Poor HTML rendering	✓
	Internet Explorer 6	✓	✓
Mac OS X 10.6.8 (Snow Leopard)	Safari 5.1.7	✓	✓
	Firefox 14.0.1	✓	✓
	Google Chrome 20.0*	✓	✓
iOS 5.0 (iPad, iPhone)	Safari (default browser)	✓	✓
	Google Chrome	✓	✓
Android 2.3	Default (Google) browser	✓	✗
Android 3 (tablets)	Default (Google) browser	Not tested (should work)	Not tested (should work)
Android 4 ("Ice Cream Sandwich" phones)	Default (Google) browser	Not tested (should work)	Not tested (should work)

...vigation bar on the left side of the screen. You will be asked to enter your login credentials.
...m Status screen.
...field, and crop are created for you, along with weather/irrigation records for the season. You can edit

... the "Farm Status" page. Pivots, the fields they serve, and crop in the field are managed from the

...nd use the "Add Pivots" button to add pivots for the farm.

...h you would like to combine data entry, create a field group and use "Multi-Edit Daily Data" feature.

...cation guidance.

wisp.cals.wisc.edu/

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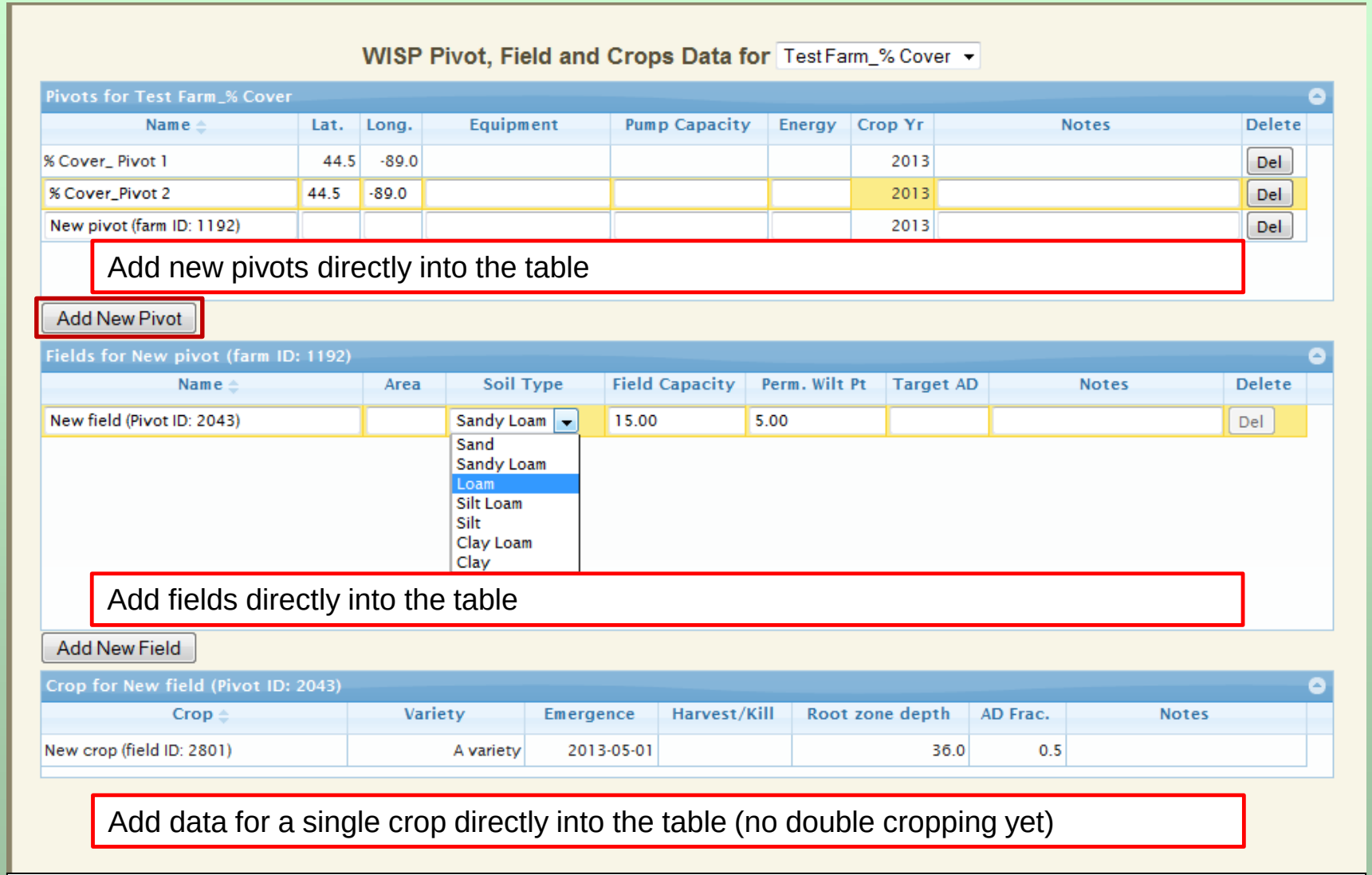
The Pivot, Field and Crops Screen



When selecting a pivot, the fields and crops for the selected field appear below.

Field Status Screen

WISP Field Status

Test Farm_% Cover | % Cover_Pivot 2 | % Cover, Pv 1, Field 1 | 2013-07-28

Field Data

Farm: Test Farm_% Cover
Pivot: % Cover_Pivot 2
Field/soil: % Cover, Pv 1, Field 1
Crop: Sweet Corn A variety

Root zone depth: 24.0 in
Emergence Date: 05/01/13
AD at field capacity: 1.32 in.
Initial soil moisture: 15 %
Target 70 % (0.92 in.)
Update Target

Edit Observed Values Below

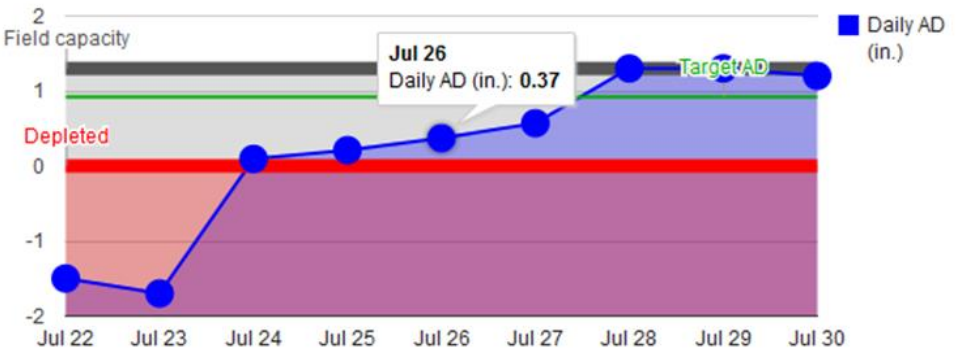
Date	Poten. ET	Rainfall	Irrigation	% Moisture	% Cover	Adj. ET	AD	Deep Drainage
2013-07-22	0.23	0.00	0.00	3.17898	87	0.23	-1.52	
2013-07-23	0.21	0.00	0.00	2.30815	89	0.21	-1.73	
2013-07-24	0.18	2.00	0.00	9.89148	90	0.18	0.09	
2013-07-25	0.18	0.00	0.30	10.3915	92	0.18	0.21	
2013-07-26	0.14	0.00	0.30	11.0581	94	0.14	0.37	
2013-07-27	0.10	0.00	0.30	11.8915	95	0.10	0.57	
2013-07-28	0.11	1.00	0.60	15.0	97	0.11	1.32	0.74

Seasonal Totals
2013-05-01 to 2013-10-31

Report in CSV Format

Rainfall: 11.90 in.
Irrigation: 3.00 in.
ET: 24.33 in.
Drainage: 3.64 in.

Calculated Allowable Depletion (inches)



Graph background color changes when RAW is depleted

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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 scheduling can not . . .

- Change the total plant consumptive water use

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Irrigation Water Management Tools

- Irrigation Scheduling Publication -

Updated in 2015



UNDERSTANDING CROP IRRIGATION

Irrigation Management in Wisconsin

The Wisconsin Irrigation Scheduling Program (WISP)

Scott Sanford and John Panuska

Most of the areas in Wisconsin that are under sprinkler irrigation have sandy soils and groundwater that is close to the surface.

Growers in Wisconsin irrigate about 473,000 acres of potato, vegetable, field, fruit, turf and nursery crops each year (2013 NASS) to ensure profitable crop production. Irrigation improves both crop yield and quality. Yield responses are due to increased dry matter production, more plants per acre and increased numbers of vegetative parts (tubers, roots, stems, leaves) or reproductive parts (flowers, pods, fruits).

Irrigation enhances the quality of many crops by reducing moisture stress. A lack of moisture in a crop can produce misshapen fruit and tubers, poorly filled bean pods or ears of corn, and low protein content in forages. Moisture stress can deter uniform crop maturity, which is important for efficient harvesting of processing vegetables.

Successful irrigation management uses a combination of rainfall and applied water to conserve energy, reduce cost and protect groundwater. Most of the areas in Wisconsin that are under sprinkler irrigation have sandy soils and groundwater that is close to the surface, so the potential for groundwater contamination by nitrates and pesticides is high. Over-irrigation and excessive or untimely rains can add more water than crops can use or soils can store. The excess water moves past the root zone (leaches), carrying nitrates and pesticides into groundwater.

Sprinkler irrigation

Sprinkler irrigation is the most common type of irrigation in Wisconsin (98%). Drip irrigation is another type. Sprinkler irrigation waters crops through a pressurized system of pipes and spray or impact nozzles. The objective is to apply the right amount of water at the right time.

Overhead sprinkler irrigation can do more than water crops. Properly designed and managed sprinkler systems can regulate soil moisture and temperature, apply fertilizers and pesticides, provide frost protection and apply liquid waste and separated liquid manure.

Center pivot sprinkler system.

Sprinkler irrigation of large crop acreages requires large volumes of water. On the average summer day in central and southern Wisconsin an average crop plant will use approximately 0.25 inches in evapotranspiration, which is the combination of *evaporation* from soil and plant surfaces and *transpiration* or the amount of water that plants use to grow. On a per-acre basis, 0.25 inches amounts to 6,789 gallons of water (27,154 gallons per acre-inch x 0.25 inch = 6,789 gallons). However, irrigation systems

Revised – January, 2015

LOW PRESSURE CENTER PIVOT: Average nozzle pressure 20 psi, nozzle diameter 9/32 inch			
Air Temperature	% Relative Humidity	Wind Speed (mph)	% Evaporation Loss
70 F	70%	7 mph	1.5 %
70 F	30%	7 mph	2 %
90 F	70%	7 mph	1.8 %
70 F	70%	15 mph	2.2 %
90 F	30%	15 mph	4.5 %
STANDARD PRESSURE CENTER PIVOT: Average nozzle pressure 55 psi, nozzle diameter 7/32 inch			
Air Temperature	% Relative Humidity	Wind Speed (mph)	% Evaporation Loss
70 F	70%	7 mph	4.7 %
70 F	30%	7 mph	6.1 %
90 F	70%	7 mph	5.5 %
70 F	70%	15 mph	7.5 %
90 F	30%	15 mph	16 %

There is also a publication on drip irrigation currently under development

Also available at :

Learningstore.uwex.edu/

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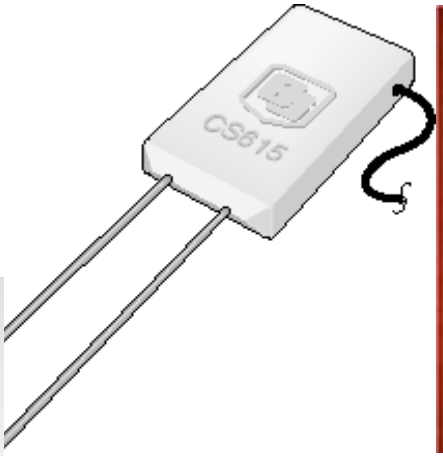
Measuring Soil Moisture



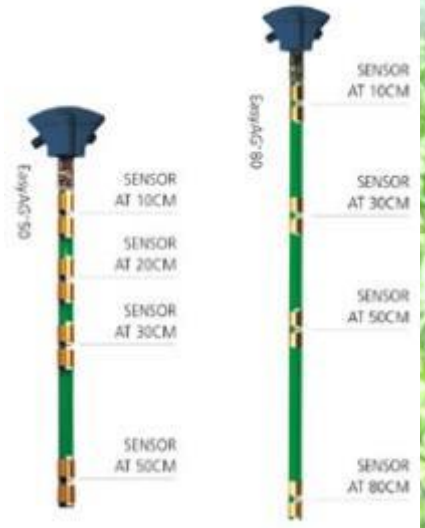












The Hand Feel Method

- Estimate only
- Quantitative accuracy not possible
- Investment is only a soil probe or shovel
- It is best to have accurate soil moistures to perfect your judgment

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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)



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Tensiometer (Cont.)

- Installed for growing season
- Maintenance may be required – refill w/distilled water, color 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

Remember for soil tension, higher = dryer

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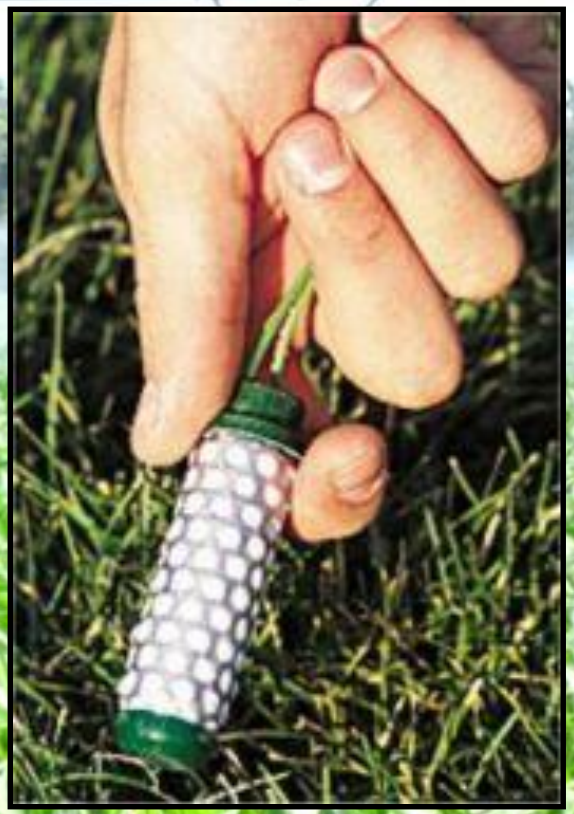
Electrical Resistance Block

- 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



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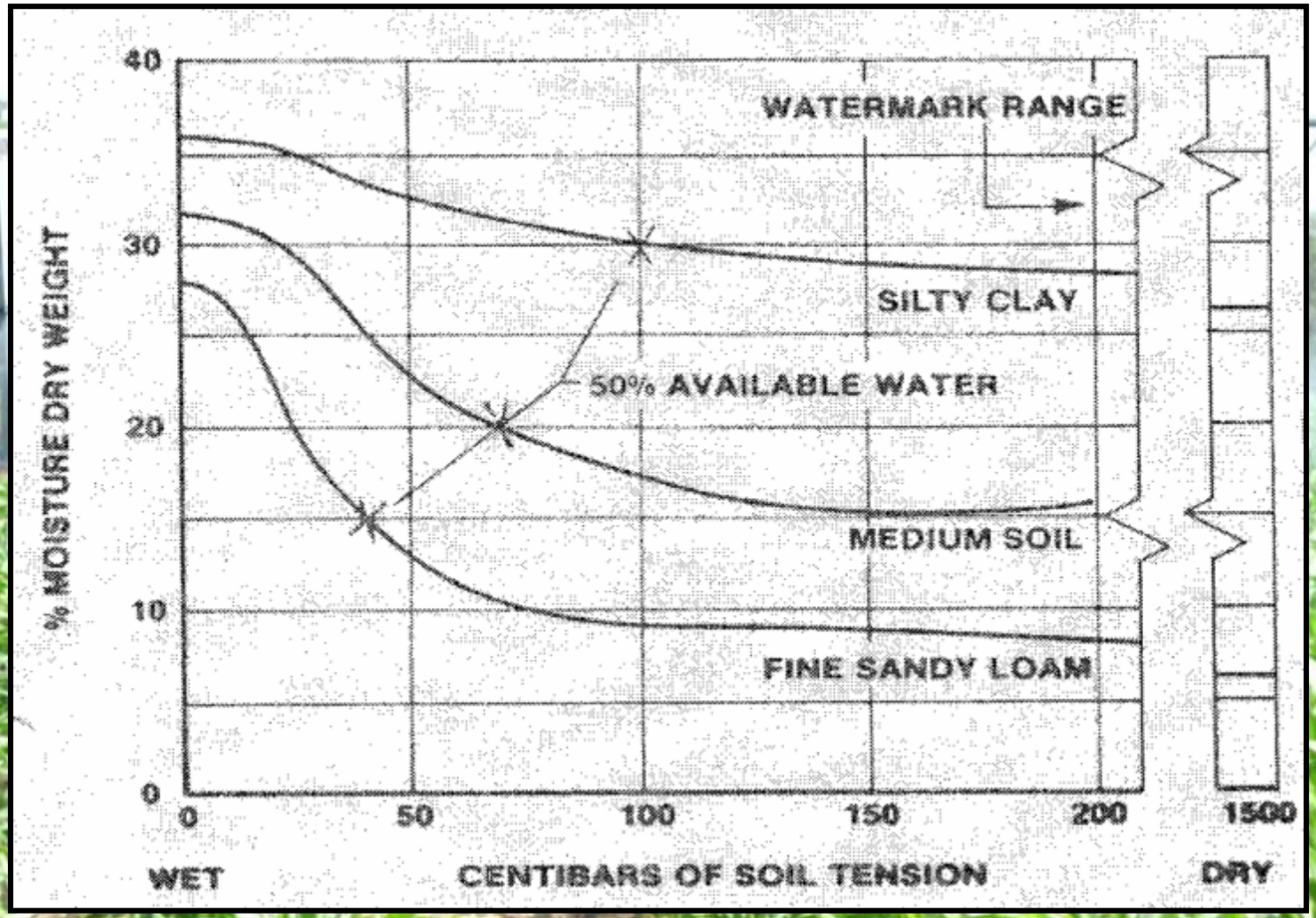
Watermark Calibration Curves



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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







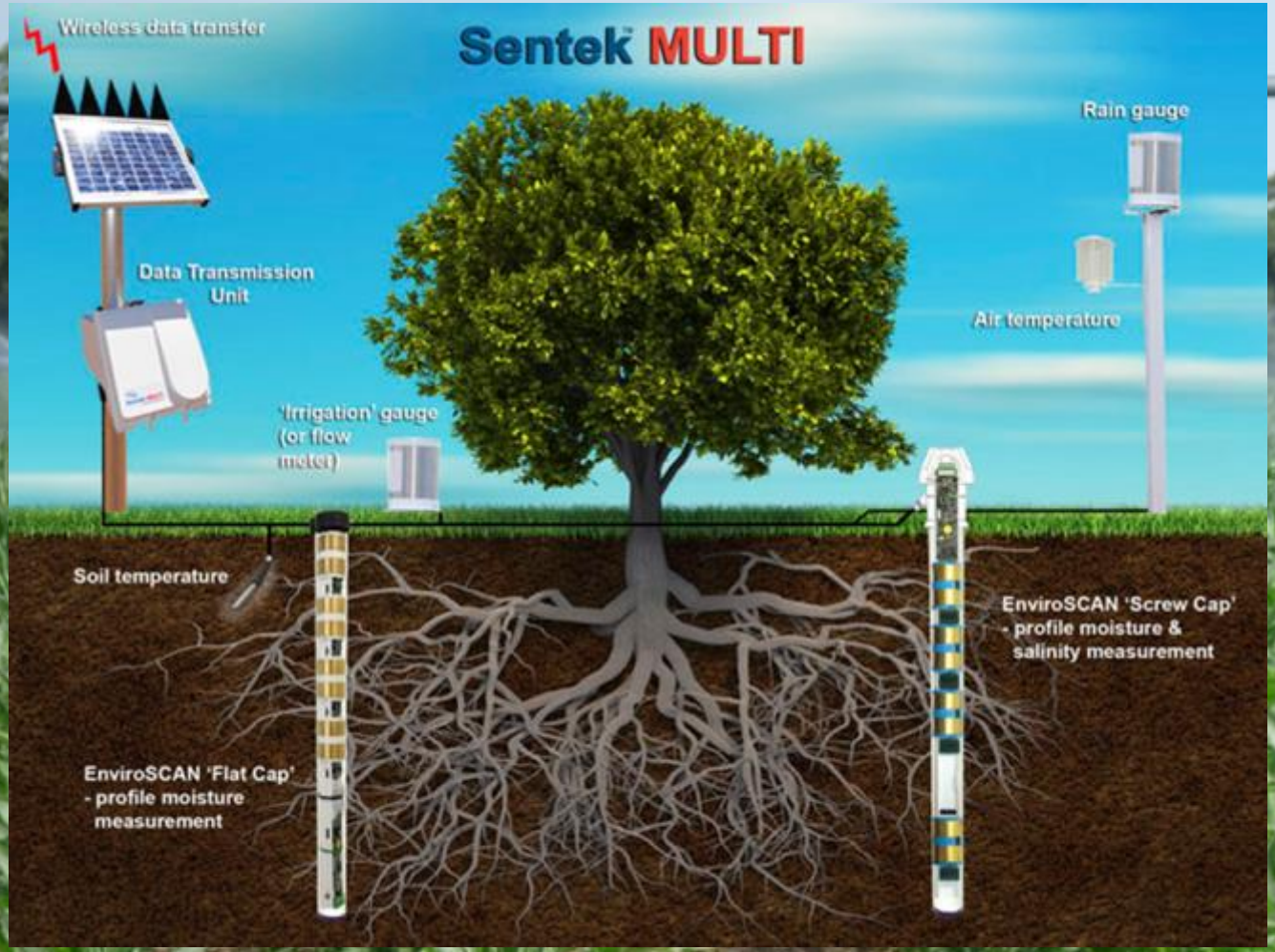
Capacitance Sensor

- Cost:
  - Sensor ~ $110
  - Hand held meter ~ $200, 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





Multi-Depth Stationary Systems



- Measure at multiple depths at once
- Uploads data in real time (web, local)
- Often linked with VRI software
- Most costly system $2,500 and up .

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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

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Simple Data Logger

- Monitoring over time
  - Typically readings every 15 to 60 minutes
- Display data or download to computer
- Two sensor system: $329



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Irrigation Water Management Tools

- Irrigation Water Management Publication -



UNDERSTANDING CROP IRRIGATION

Methods to Monitor Soil Moisture

John Panuska, Scott Sanford and Astrid Newenhouse

Advancements in soil moisture monitoring technology make it a cost-effective risk management tool.

A major challenge facing Wisconsin growers is the need to conserve and protect natural resources amid increasing food demand, rising production costs and climate extremes. Growers need to use every opportunity possible to optimize production efficiency to address these and other challenges and maintain yields. Water stress is one of several factors that can reduce crop yield and quality. Keeping the proper amount of water available in the root zone is essential to any successful crop production operation.

Irrigation has become an increasingly important risk management tool for growers. An understanding of soil moisture management is key for growers to make irrigation management decisions. The recommended approach for optimal root zone soil water management includes irrigation water management (scheduling) and soil moisture monitoring. Recent advancements in soil moisture monitoring technology make it a cost effective risk management tool.

Types of equipment

There are several aspects of soil moisture monitoring equipment: configuration, measurement science, and data management. The advantages and limitations along with specific equipment examples of each aspect are presented and discussed in this publication.

Figure 1
Portable soil moisture sensor

Spectrum Fieldscout™ TDR 300

Figure 2
Stationary moisture sensors

Sensors installed at several depths.

Sensor configuration

Soil moisture sensors measure the amount of water in the soil. They are either stationary at fixed locations and depths or portable as handheld probes. With a portable sensor (Figure 1) you can take measurements at several locations but you may need to dig a hole to get readings deeper in the soil profile. Stationary sensors (Figure 2) are placed at several predetermined locations and depths. These locations should have soil water holding characteristics that represent the whole field or to be more conservative, use the soil with the lowest water holding capacity. The primary drivers of soil water holding capacity are soil texture and soil organic matter content. Both can

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UWEX Crop Irrigation Web Site

Your First Stop for Irrigation Information



Understanding Crop Irrigation

Cooperative Extension

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About | Irrigation 101 | Educational Training | Soil Moisture Management | Sprinkler Irrigation | Irrigation System Testing | Irrigation Scheduling & Evapotranspiration Data | Drip Irrigation | Drip Irrigation Water Quality Issues | Subsurface Drip Irrigation (SDI) | Equipment Suppliers | Other Resources | Contacts | News and Events

Welcome to the University of Wisconsin-Extension Crop Irrigation Website.

This website has resources that can help growers better understand crop irrigation.

Growers in Wisconsin irrigate about 473,000 acres of potato, vegetable, field, fruit, turf and nursery crops each year to ensure profitable crop production. Irrigation improves both crop yield and quality. Successful irrigation management uses a combination of rainfall and applied water to conserve energy, reduce cost and protect groundwater. Most of the areas in Wisconsin that are under sprinkler irrigation have sandy soils and groundwater that is close to the surface, so the potential for groundwater contamination by nitrates and pesticides is high. Over-irrigation and excessive or untimely rains can add more water than crops can use or soil can store. The excess water moves past the root zone (leaches) carrying nitrates and pesticides into groundwater.

Find resources about crop irrigation on this website.

fyi.uwex.edu/cropirrigation

Photo credit: USDA NRCS.

TOPICS

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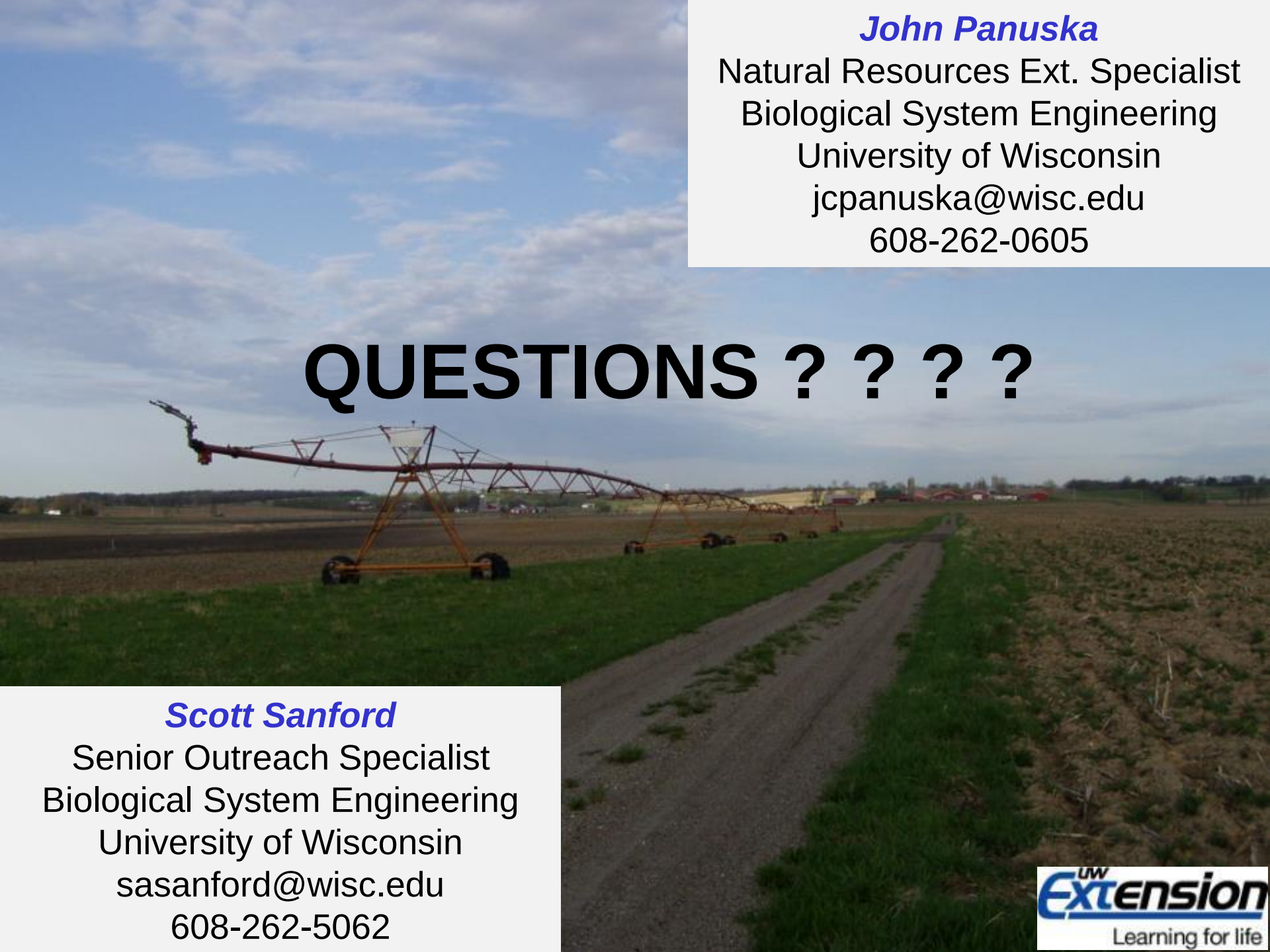

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