Scheduling Irrigation for Horticultural Crops

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Outline

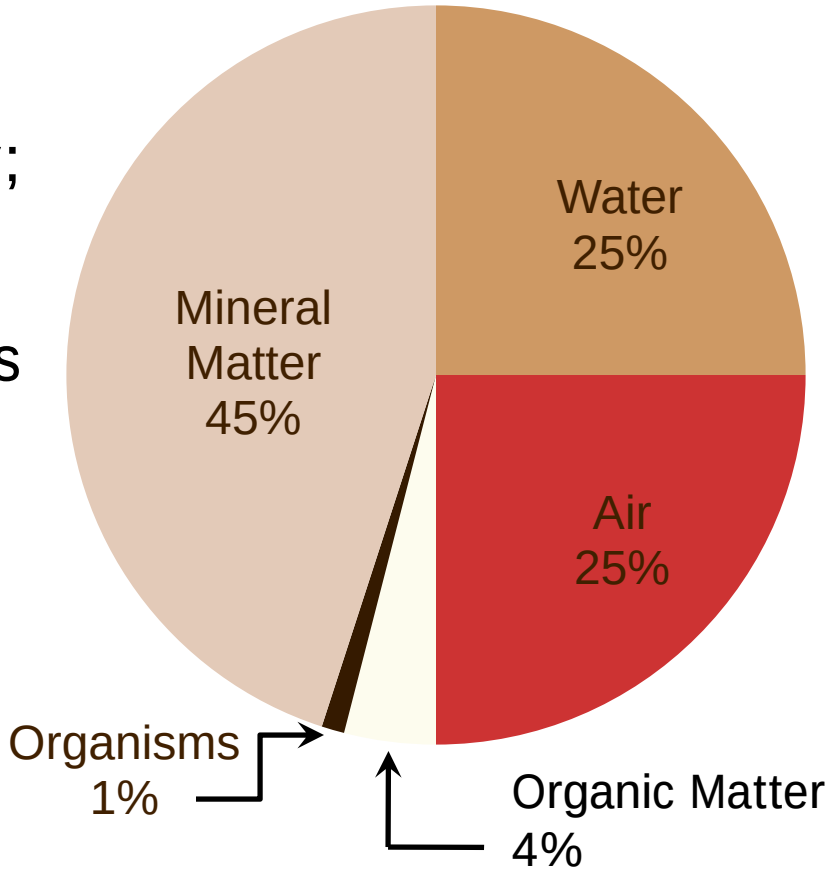
- Soil characteristics
- Soil water characteristics
- Basic watering facts
- Scheduling irrigation

What is Soil?

- **Soil is a media for plant growth**
- **Soil is complex natural material derived from disintegrated and decomposed rocks and organic materials**
- **Soil provides for plants**
  - **nutrients**
  - **anchorage**
  - **moisture**

Soil Composition

- Solids
  - Mineral matter - sand, silt, and clay; nutrients
  - Organic matter - residue from plants and animals
- Water
- Air
- Soil Organisms



Soil Texture

- **Refers to percentage of sand (2.0 - 0.05 mm), silt (0.05 - 0.002 mm) and clay particles (<.002 mm) that make up the mineral potion of the soil.**
- **Sands add porosity. Clay adds chemical and physical properties. Silt adds body to the soil.**

Soil Texture

- **Soil texture influences: water holding capacity, nutrient holding capacity, erodibility, workability, root penetration and porosity**
- **Terms describing textural classes: Sand, Silt, Clay and Loam**

Determining Soil Texture

- By feel
  - Gritty, smooth, sticky
- Check your soil survey
- Check your soil test

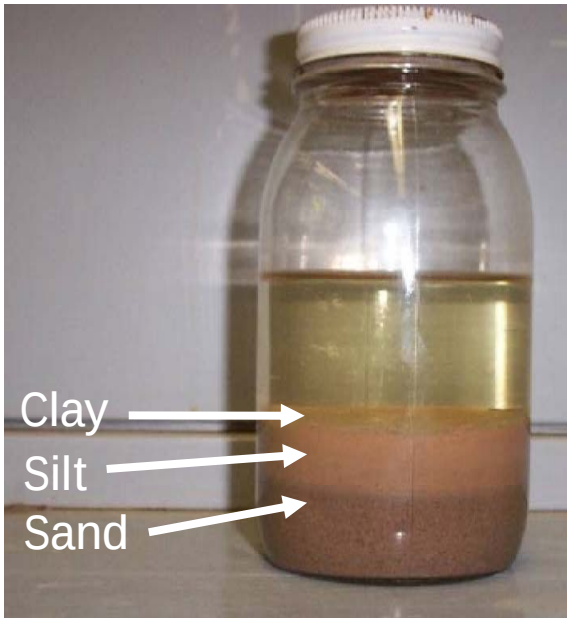
Determining Soil Texture

- The soil Cation Exchange Capacity (CEC) value is related to soil texture

Soil	CEC (meq/100 g)
Sand	2 to 5
Sandy loam	5 to 12
Loams	10 to 18
Silt and silt clay loams	15 to 30
Clay and clay loams	25 to 40

Determining Soil Texture

- Using the jar method
  - Fill a 1-quart jar ¼ full of soil
  - Fill the jar with water to ¾ full
  - Add 1 teaspoon of dishwashing detergent
  - Shake very well to suspend soil
  - Place on a flat surface and allow soil to settle for 2 days
  - Measure % thickness of each layer relative to all

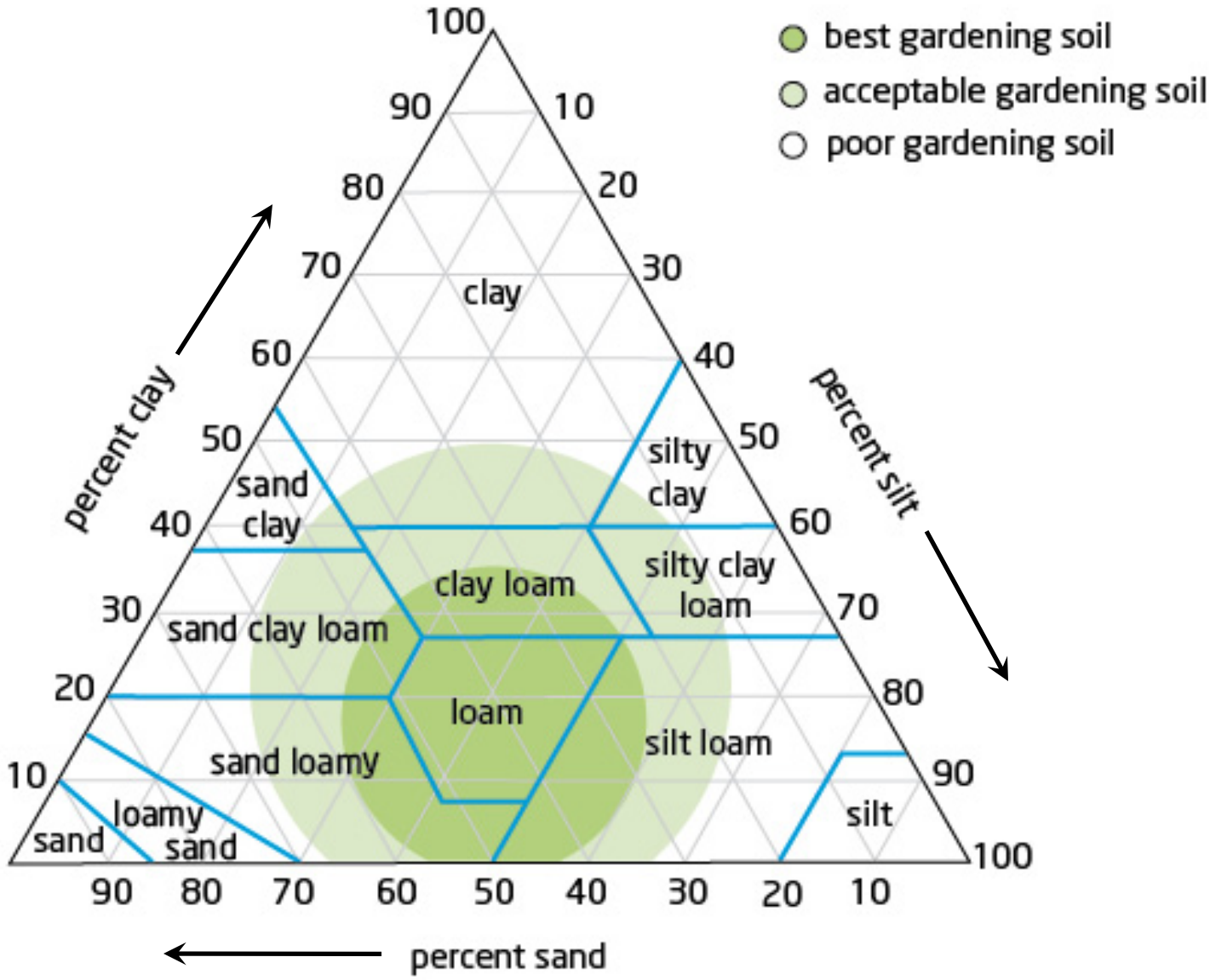


Determining Soil Texture

- Using the jar method

Soil Separate	Sample 1	Sample 2
Sand	56%	68%
Silt	32%	29%
Clay	12%	3%
Texture	Loam	Sandy loam

Soil Texture



Plant Water Soil

- **Different soil types hold water differently**
  - **The smaller the particle size, the more water it can hold**
  - **Organic matter is important for water holding capacity**
- **Available water holding capacity**
  - **Not all the water in the soil is available for plant use**

Water Retention

- **As a soil dries, water is held more tightly by the soil particles**
  - **Plant uses water tension to pull water into the roots**
  - **When the soil has more tension than the roots, the plant is unable to take up water and meet the demand for water**
  - **The result is wilting, and loss of money!**

Saturated Soil

- **All the pore space in the soil is filled with water**
  - **Very little oxygen is available for microorganisms and plant roots**
  - **Water will drain away by gravity**

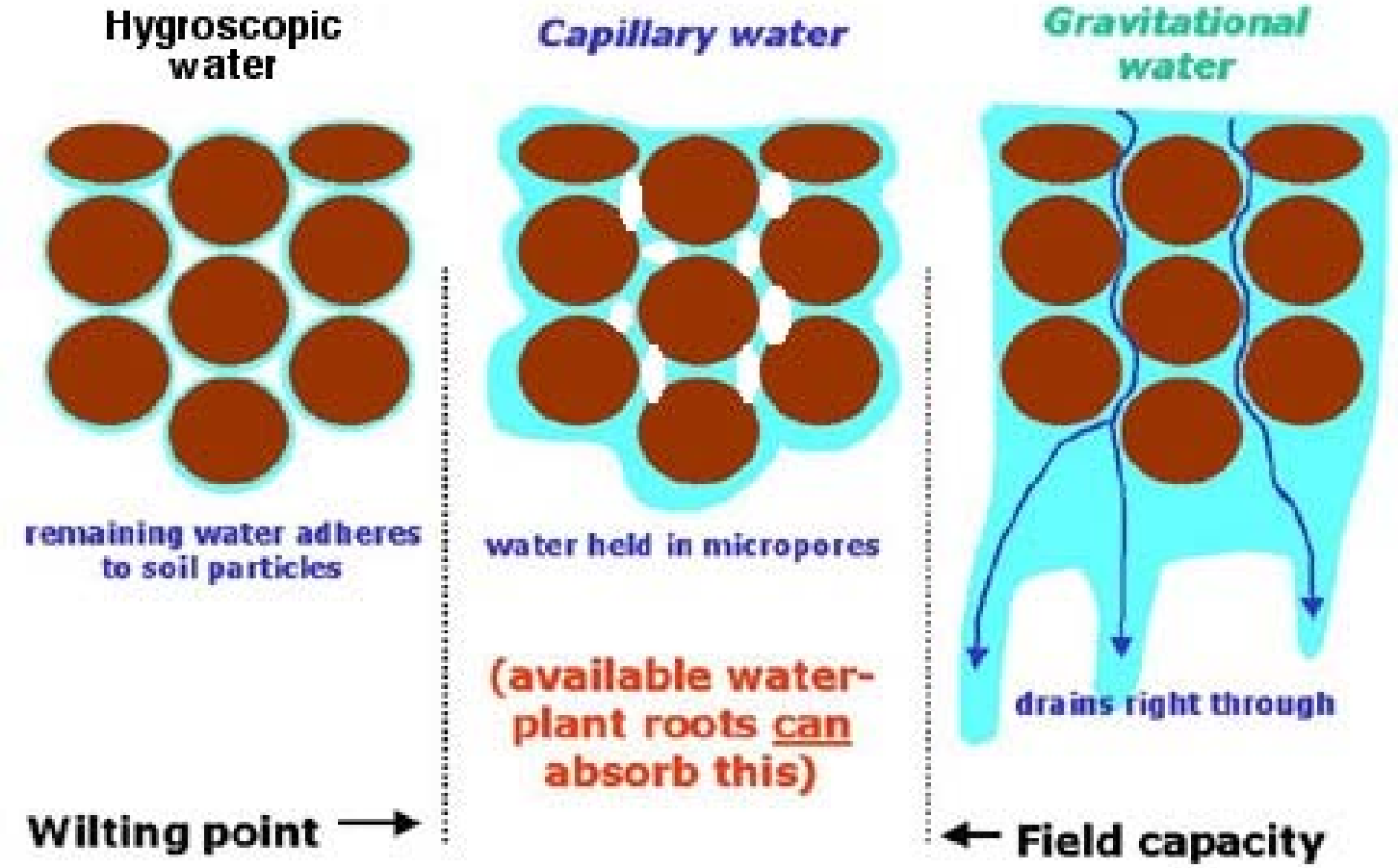
Field Capacity

- **The amount of moisture when drainage no longer occurs**
  - **Aerobic conditions for microorganisms and plant roots**
  - **About half of this moisture is available for plant use**

Wilting point

- **Particles hold moisture with greater tension**
  - **Roots cannot pull moisture from particles**
  - **Need to add water before reaching this point**

Soil Water


Hygroscopic water
Capillary water
Gravitational water
remaining water adheres to soil particles
water held in micropores
drains right through
(available water- plant roots can absorb this)
Wilting point
Field capacity

Soil Water Holding Capacity

- Soil acts as a reservoir to hold water for plant use.
- The capacity for a soil to hold water is primarily based on the soil texture but can be modified by attributes such as soil organic matter.
- Listed in inches of water per inch of soil (in/in)
- Not all water held in the soil is available for plants

Available Water

Soil Texture	Available Water	
	Range in./in.	Average in./in.
Very coarse-textured sands and fine sands	0.04-0.08	0.06
Coarse-textured loamy sands and loamy fine sands	0.06-0.10	0.08
Moderately coarse-textured sandy loams and fine sandy loams	0.10-0.15	0.13
Medium textured very fine sandy loams, loam and silt loams	0.13-0.19	0.16
Moderately fine-textured sandy clay loams, clay loams, and silty clay loams	0.15-0.21	0.18
Fine-textured sandy clays, silty clays, and clay	0.13-0.21	0.17

*

Reference: USDA, NRCS, *Engineering Field Manual*

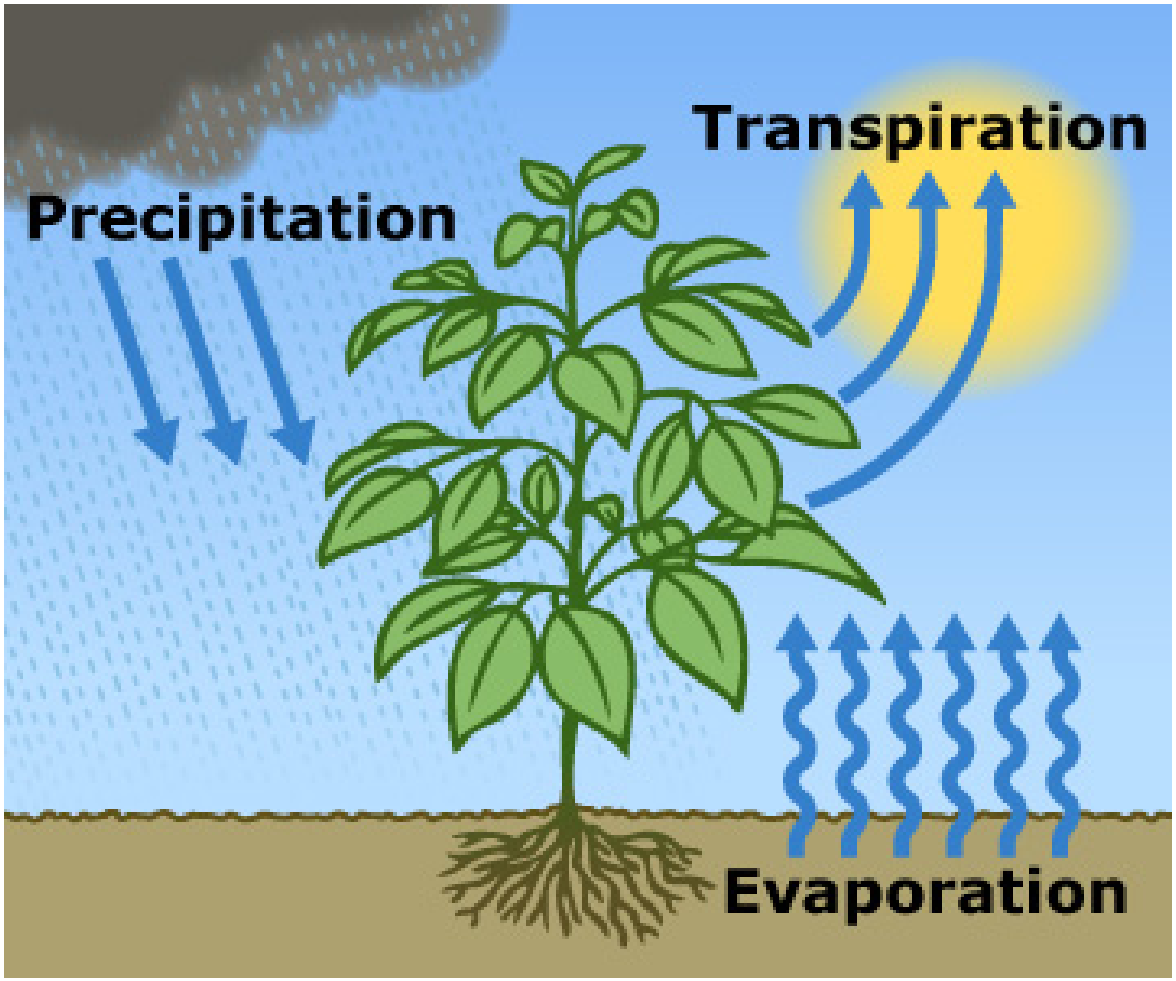
Example:

- If a clay loam soil with a water holding capacity of 0.36 in/in
  - One foot of soil can hold 4.32 inches of water
  - Assume that 50% of this water is easily available for plant use
  - Therefore, if we have a 12 inch deep root system, we have 2.2 inches of water available to the plant at field capacity

Example:

- A loamy fine sand with a water holding capacity of 0.16 in/in
  - One foot of soil can hold 1.92 inches of water
  - Assume that 50% of this water is easily available for plant use
  - Therefore, if we have a 12 inch deep root system, we have 0.96 inches of water available to the plant at field capacity

Evapotranspiration

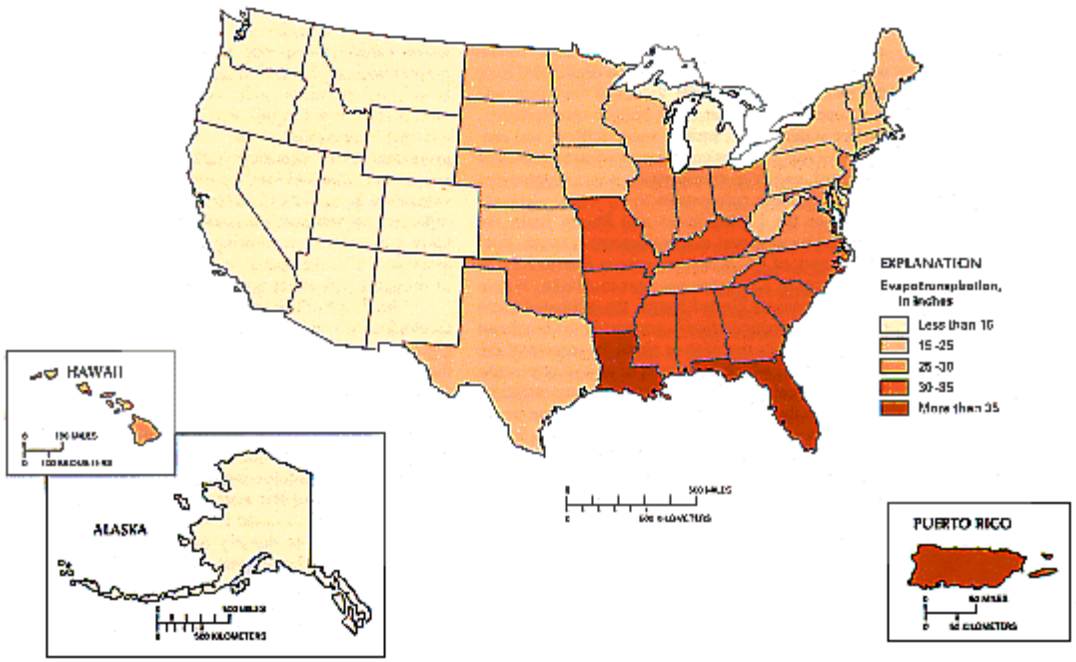


Evapotranspiration (ET)

- Rate of water loss changes as plant grows and sets fruit
- Peak water use is during bloom, fruit set, and ripening
- Factors that affect ET
  - Season
  - Temperature
  - Wind
  - Relative humidity
  - Type and amount of vegetation cover
  - Mulches and ground covers

Evapotranspiration (ET)

- Missouri – annual ET of 30-35 inches
- Maximum daily ET can exceed 0.25 inches



Source: USGS

Soil & Climate Properties

- Soils store 1.5”-2.5” of water per foot of depth (check county NRCS Soil Survey)
- Intake rate = 0.3”-2.0” per hour, rest is runoff
- Available water = 50% of total water in soil
- Summer E.T. rate is 0.25” per day
- A 12” deep rooting depth of soil holds a 4-8 day supply of moisture (most vegetables)
- SW Missouri historical weather:
  - Rainfall = 41”-42” per year
  - Evaporation = 30-35” per year
- Ozarks has 3-4 week summer dry spell

Basic Watering Facts

- Plants need 1”-1.5” of water per week
  - 624-935 gallons (83-125 cu.ft.) per 1,000 sq.ft.
- Can survive drought on half that rate
- Deep infrequent waterings are better than several light waterings
- Deeper roots require less supplemental irrigation
- Taller plants have deeper roots
  - Lowers tendency to wilt
  - Shades soil surface
  - Controls weeds by competition
  - Makes water “go farther”

Average Water Use

- Corn

Table 2. Average water use for CORN in inches/day

	Week after emergence																	
Temperature F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
50-59	.01	.02	.03	.04	.05	.06	.08	.09	.09	.10	.10	.10	.09	.07	.06	.05	.04	.03
60-69	.02	.03	.04	.06	.08	.09	.11	.12	.13	.15	.14	.14	.13	.11	.09	.07	.06	.04
70-79	.03	.04	.05	.07	.10	.12	.15	.16	.17	.19	.19	.18	.17	.14	.11	.09	.07	.05
80-89	.03	.05	.07	.09	.13	.15	.18	.20	.22	.24	.23	.22	.21	.17	.14	.11	.09	.06
90-99	.04	.06	.08	.11	.15	.18	.21	.24	.26	.28	.27	.26	.25	.20	.17	.13	.11	.07
Corn growth stages		↑ 3 leaf			↑ 8 leaf			↑ 1st tassel	↑ silk		↑ blister kernel			↑ early dent	↑ dent			

Minnesota Data

Irrigation Scheduling

- Process of maintaining an optimum water balance in the soil profile for crop growth and production

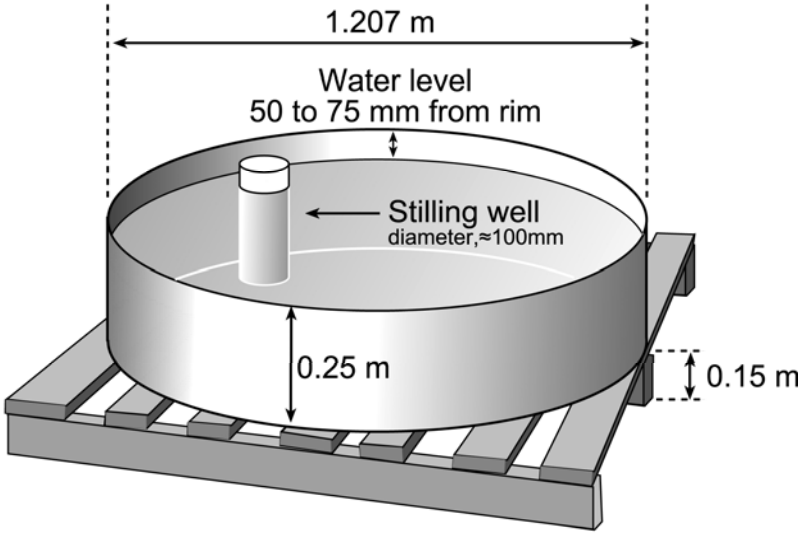
- Irrigation decisions are based on the soil water content

Soil Water Balance

- Scheduling is very much a “checkbook” type method for accounting on a daily basis the following components
  - Water withdrawals
    - Evapotranspiration
  - Water deposits
    - Rainfall
    - Irrigation

Soil Water Balance

- Measuring water withdrawals (Evapotranspiration)
  - Estimates
    - Typical values range from 0.16 to 0.33 inches per day
  - Loss of water from an open pan



Soil Water Balance

- Measuring water deposits (rainfall + irrigation)
  - Rainfall
    - Measure in each field
    - Should be read each day that a rain event occurs
    - Record time reading is taken – should be consistent
    - Rain gauges
      - Keep clean
      - Install away from obstructions
      - Basic gauges must not be allowed to freeze
  - Irrigation
    - Use cans – sprinklers
    - Calculations – trickle systems

Measuring Water Needs

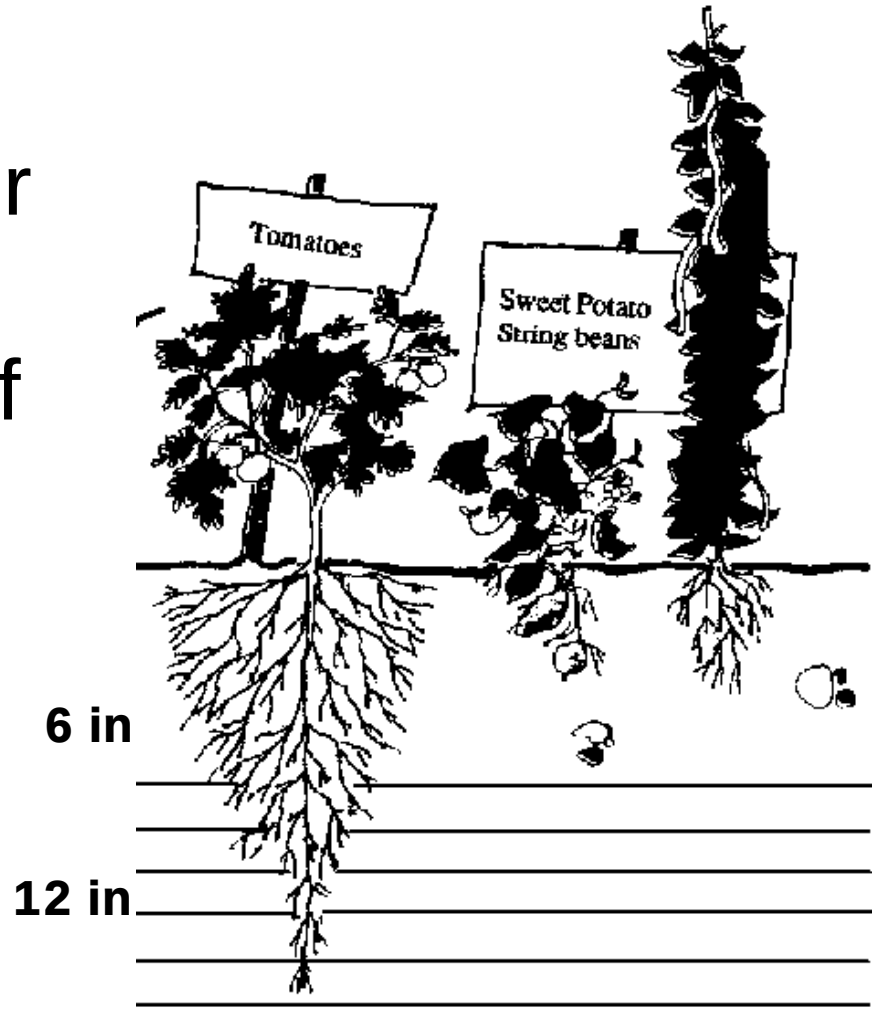
Catch cans

4-cycle timer

Rain gauge

Soil Water Balance

- Begin irrigation when the soil water balance is greater than the amount of available water storage in the soil reservoir –
- (H_2O capacity * Root Depth)



Checkbook Register

SOIL WATER BALANCE SHEET

(Make copies as needed)

Field_____Crop_____Emergence date_____
Pumping Capacity_____gpm per acre=_____net application inches per day
Available Water Capacity_____inches in root zone of_____inches

Growth Stage	Vegetative	Critical Growth	Maturing
Allowable	_____%	_____%	_____%
Soil Water Deficit	_____inches	_____inches	_____inches

Week after emergence	Date	Soil water field reading		Maximum temperature	Add	Subtract		Soil water deficit	
		A	B		Crop water use	Rainfall	Net irrigation	A	B

Soil Water Balance

- Example
  - Tomato crop, with root system in top 12 inches of soil
  - Soil – clay loam, with a water holding capacity of 0.30 in/in and available water of 1.8 in in the top 12 inches of soil
  - Midsummer - Estimated daily ET is 0.25 inches

Soil Water Balance

Day	Water Deposits (in)	Water Withdrawals (in)	Balance (in)
1	2 (rainfall)	0.0	0
2	0	0.25	-0.25
3	0	0.25	-0.50
4	0	0.25	-0.75
5	.5 (rainfall)	0.25	-0.5
6	0	0.25	-0.75
7	0	0.25	-1.0
8	0	0.25	-1.25
9	0	0.25	-1.50
10	0	0.25	-1.75
11	2 (irrigation)	0.25	0

Scheduling Irrigation

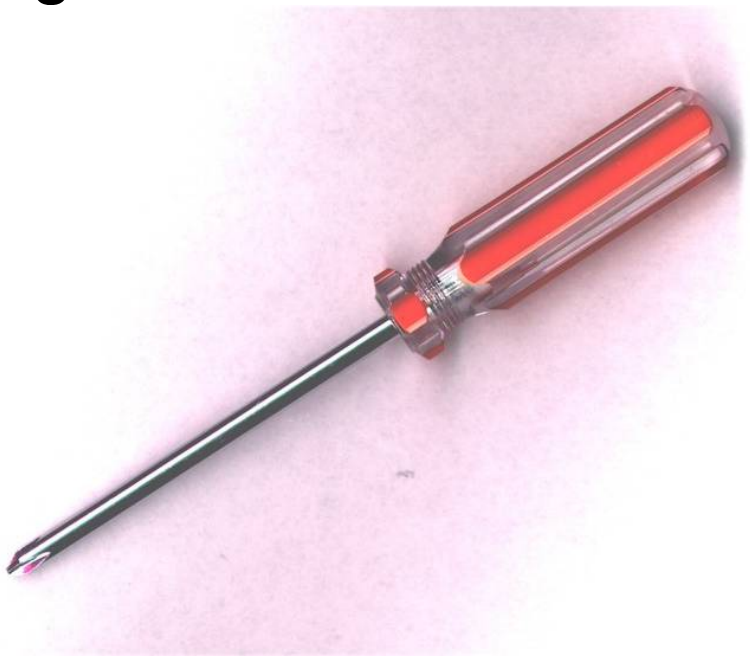
- Soil feel and appearance
  - Use a soil probe to check the soil conditions at the proper depth
- Screw driver test
- Measurements of rainfall alone
- Plant appearance
- Soil moisture estimation instruments

Table 12. Guide for judging soil water deficit based on soil feel and appearance for several soil textures.

SOIL TEXTURE CLASSIFICATION					
Moisture deficiency	Coarse (loamy sand)	Sandy (sandy loam)	Medium (loam)	Fine (clay loam)	Moisture deficiency
in./ft.					in./ft.
.0	(field capacity) Leaves wet outline on hand when squeezed.	(field capacity) Appears very dark, leaves wet outline on hand, makes a short ribbon.	(field capacity) Appears very dark, leaves wet outline on hand, will ribbon out about one inch.	(field capacity) Appears very dark, leaves slight moisture on hands when squeezed, will ribbon out about two inches.	.0
.2	Appears moist, makes a weak ball.	Quite dark color, makes a hard ball.	Dark color, forms a plastic ball, slicks when rubbed.	Dark color, will slick and ribbons easily.	.2
.4	Appears slightly moist, sticks together slightly.	Fairly dark color, makes a good ball.	Quite dark, forms a hard ball.	Quite dark, will make thick ribbon, may slick when rubbed.	.4
.6	Appears to be dry, will not form a ball under pressure.	Slightly dark color, makes a weak ball.	Fairly dark, forms a good ball.	Fairly dark, makes a good ball.	.6
.8	Dry, loose, single-grained flows through fingers. (wilting point)	Lightly colored by moisture, will not ball.	Slightly dark, forms weak ball.	Will ball, small clods will flatten out rather than crumble.	.8
1.0		Very slight color due to moisture, loose, flows through fingers. (wilting point)	Lightly colored, small clods crumble fairly easily.	Slightly dark, clods crumble.	1.0
1.2			Slight color due to moisture, powdery, dry, sometimes slightly crusted but easily broken down in powdery condition. (wilting point)	Some darkness due to unavailable moisture, hard, baked, cracked sometimes has loose crumbs on surface. (wilting point)	1.2
1.4					1.4
1.6					1.6
1.8					1.8
2.0					2.0

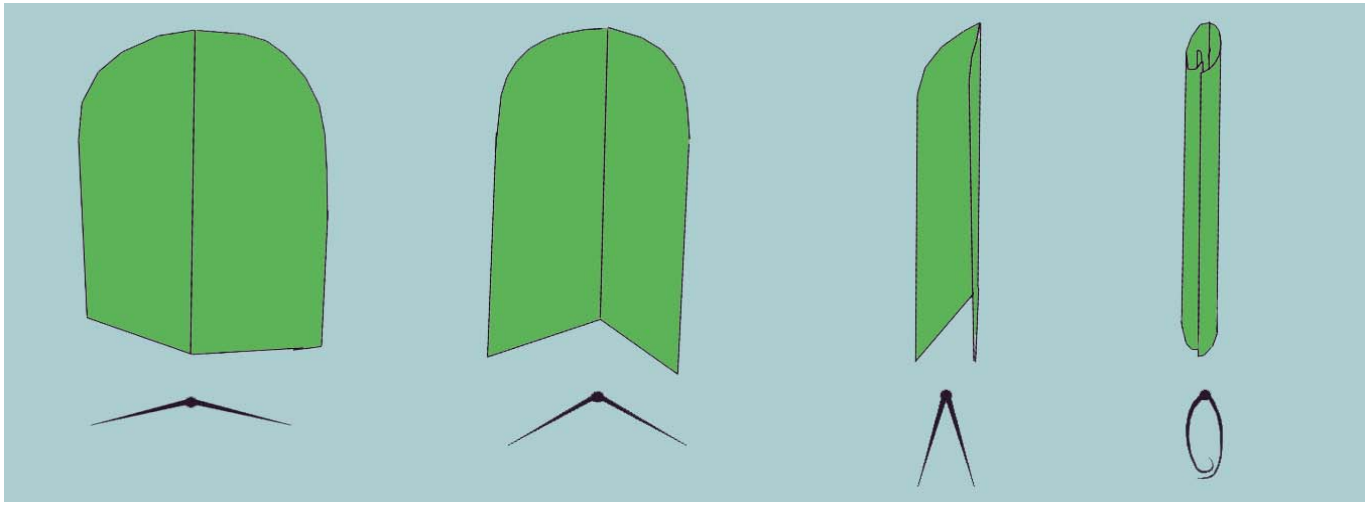
Scheduling Irrigation

- Rainfall less than 1” per week
- Check soil moisture with long screwdriver



Scheduling Irrigation

- Your plants will tell you when they need water
  - Purple-blue wilting leaves
  - Grass that leaves footprints

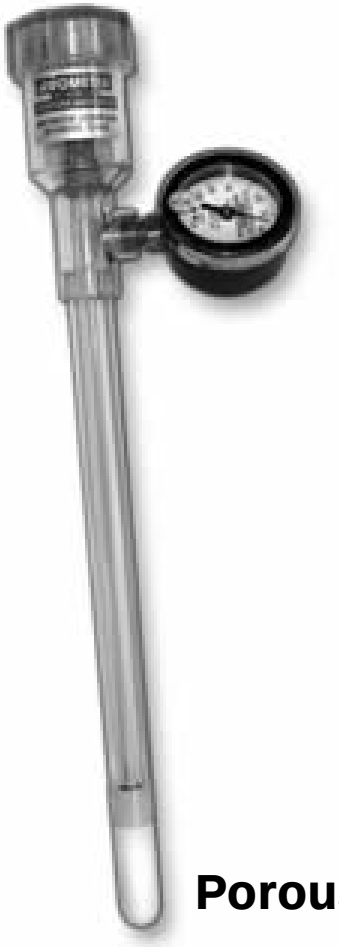


Scheduling Irrigation

- Tensiometers
  - Reading is a measure of the energy needed to extract water from the soil
  - Place at appropriate depth
  - Cost: $70-90, plus $50 for service unit

Scheduling Irrigation

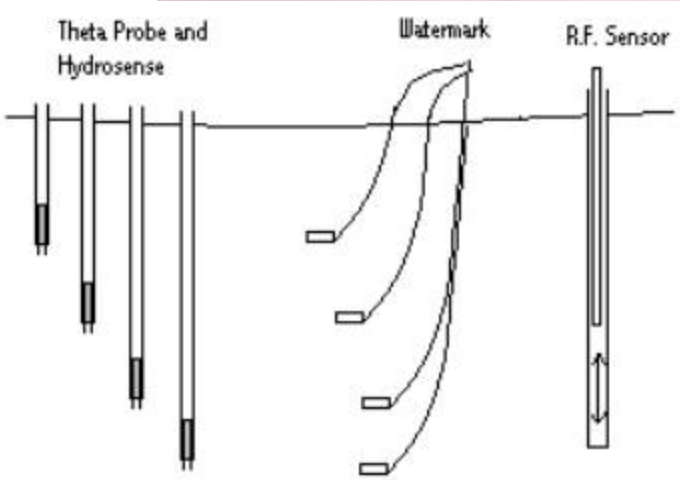
- Components



Scheduling Irrigation

- Electrical resistance sensor
  - Measures the electrical resistance between electrodes imbedded in a gypsum block
  - More or less permanent installation in the soil, at appropriate depth
  - Cost: $30-80 for sensor, $280 for meter

Scheduling Irrigation



- Electrical resistance sensors

Irrigation System Use

- Apply water at the proper rate – avoid puddling and runoff
- Turn on the system early in the morning
  - Plants dry before evening = fewer disease problems
  - Less water loss to evaporation

Plant Water Requirements 3

(Estimated design rates for southwest Missouri)

Vegetable Crop (mature)	*Gallons per 100 Feet of Row per Week*
Minimum for plant survival	100
Lettuce, spinach, onions, carrots, radishes, beets	200
Green beans, peas, kale	250
Tomatoes, cabbage, peppers, potatoes, asparagus, pole beans	300
Corn, squash, cucumbers, pumpkins, melons	400-600

Irrigation Resources on the Web

- Irrigation System Planning & Management Links
  extension.missouri.edu/webster/irrigation/

- Missouri Digital Soil Survey
  soils.missouri.edu/


The End