Trickle Irrigation Primer

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What Do Plants Need? How Do They Get It?

- **Water**
- **Light Energy**
- **Air (CO_2 & O_2)**
- **Temperature**
- **Absence of toxins**
- **Nutrients**

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Precipitation
- NE WI 30-32" / year

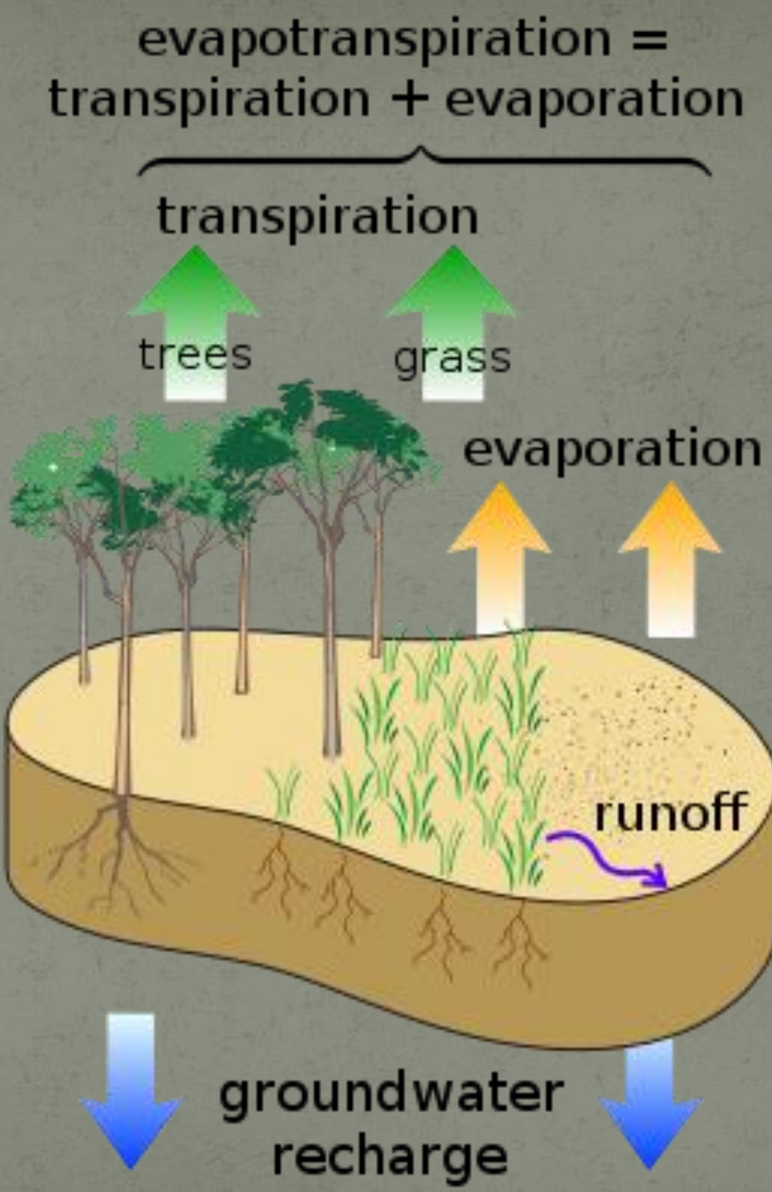
Conservation
- Weed control
- Mulching

Irrigation
- Supplemental

Water Cycle

Soil
Plant
Environmental
Management

all contribute to amount of moisture available for plant use



http://upload.wikimedia.org/wikipedia/commons/thumb/8/80/Surface_water_cycle.svg/260px-

Factors Limiting Moisture Supply

- Soil Type
- Root Distribution
- External Stress
  - Wind
  - Humidity
  - Temperature
  - Precipitation Frequency
- Irrigation Amount & Frequency

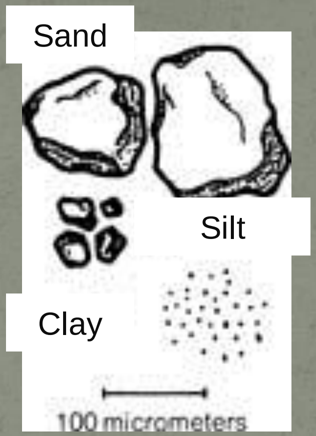
Soil Type

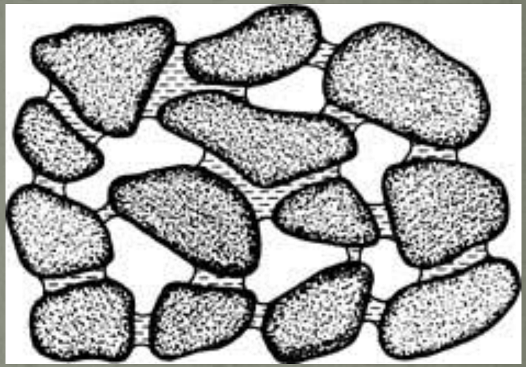
Texture

- Sand .05-1 mm
- Silt .002-.05 mm
- Clay <.002 mm

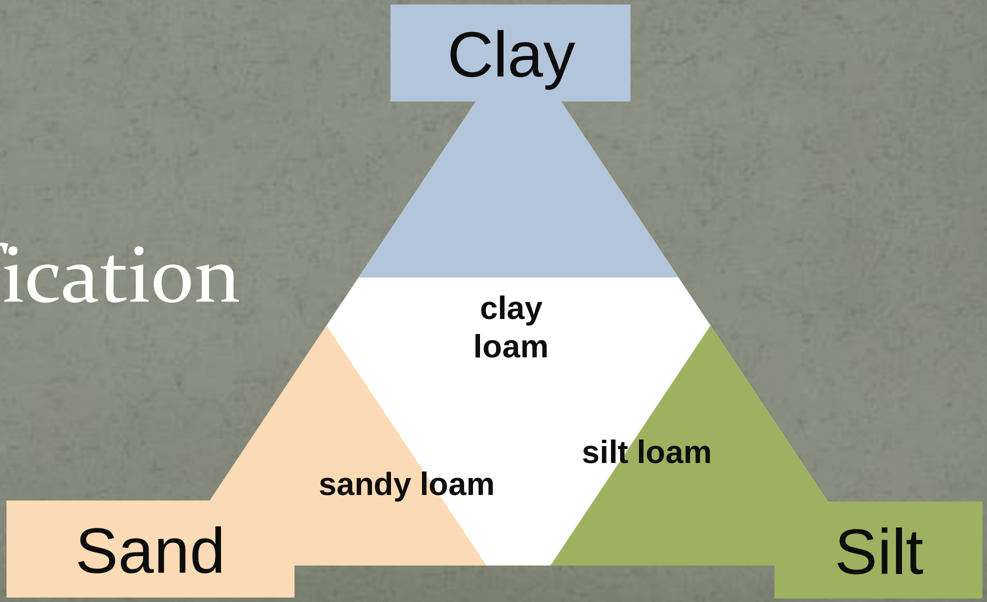
Micro-particles

Micropores



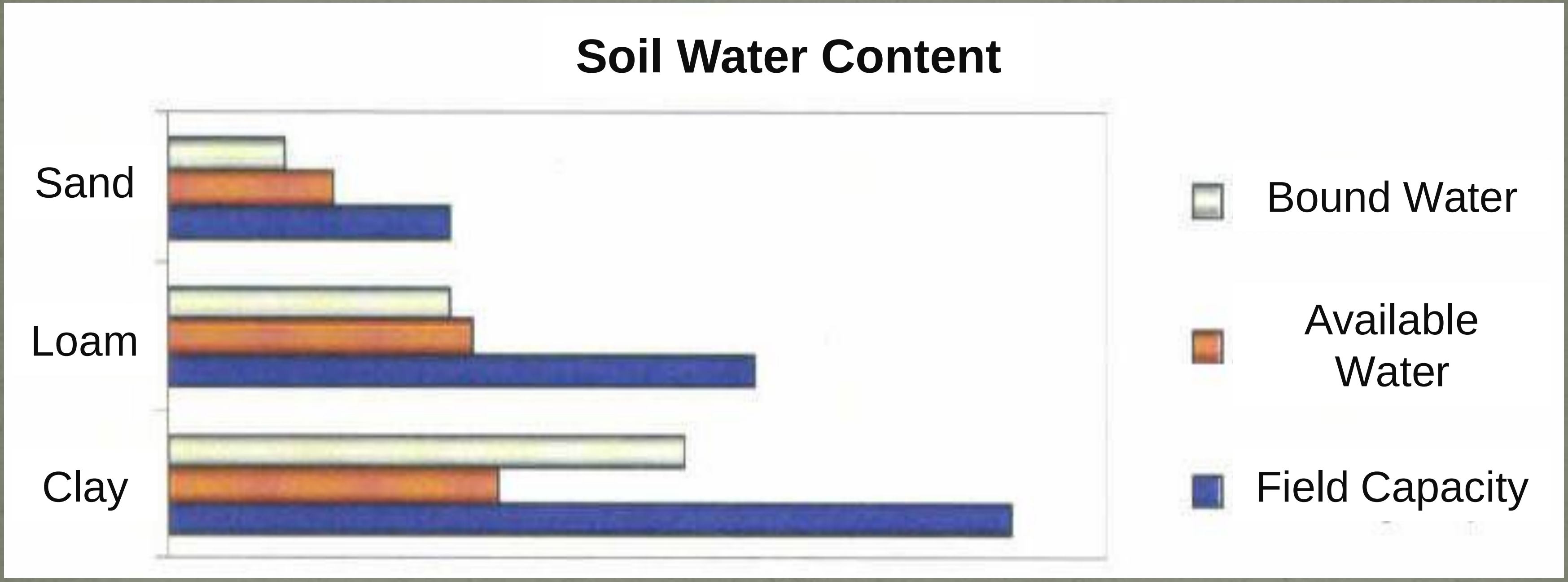


Soil Classification



Soil Type

Water Availability



The role of organic matter

Physical & chemical process bind clay-silt-sand together.

Organic matter and soil structure

- Soil flora and fauna activity dependant on organic matter.
- Bacteria, fungi, algae, earthworms, beetles, etc.
- Fungal threads, gums fats & waxes bind particles together.

Macro-particles and macropores

Soil clods & granuales

Soil aeration and permeability

Surface vegetation or mulch

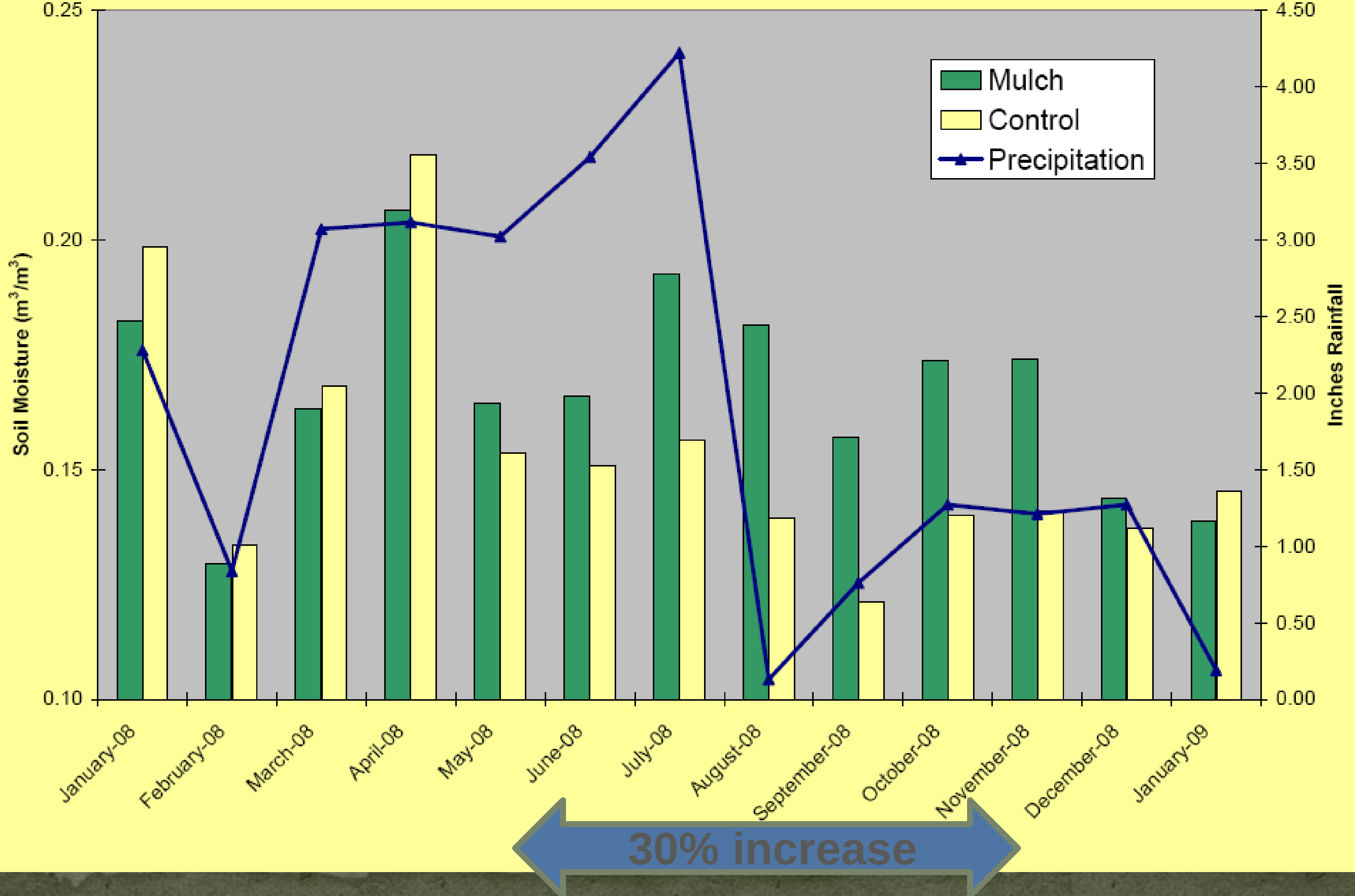
Mulching

Mulching

Improvement in surface water infiltration after two season of 'mow and throw'.

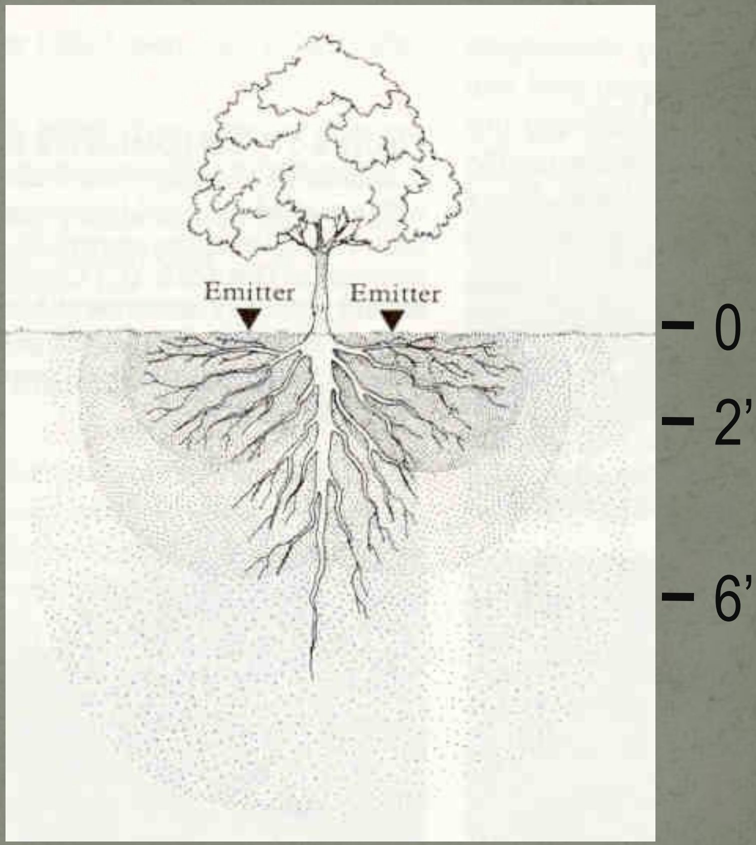
	Infiltration Rates (seconds/inch)	
	2007	2008
Control	**7.4**	**13.1**
MULCH	**8.9**	**5.9**

Soil Moisture in Herbicide Strip With and Without Side Delivered Mulch



Root Distribution

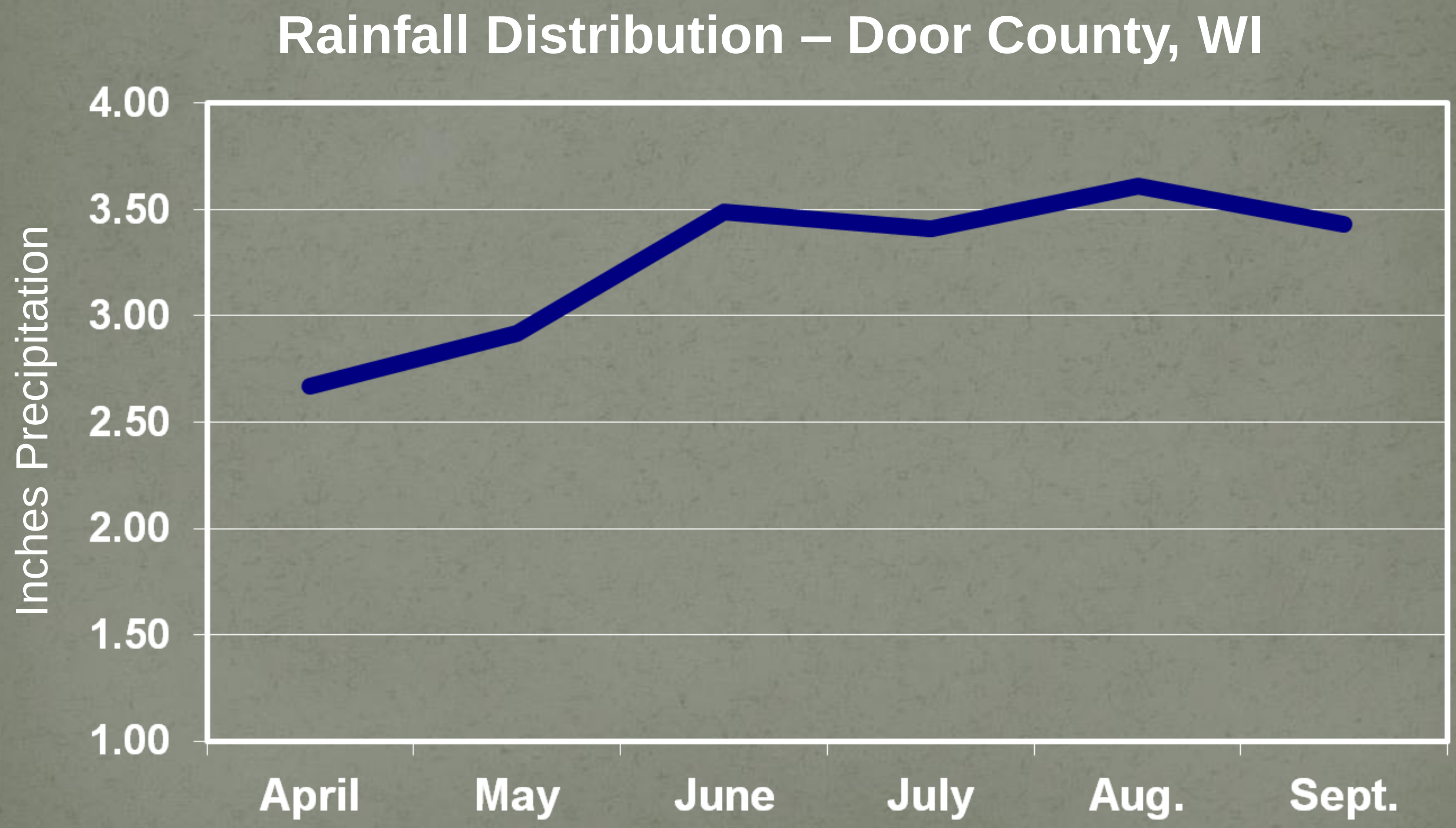
- Natural Distribution
- Soil Type
  - Poor distribution in heavy (clay) soils.
  - More extensive in coarse soils.
- Physical Limitations
  - Hard pans
  - Bedrock
- Plant Species & Cultivar



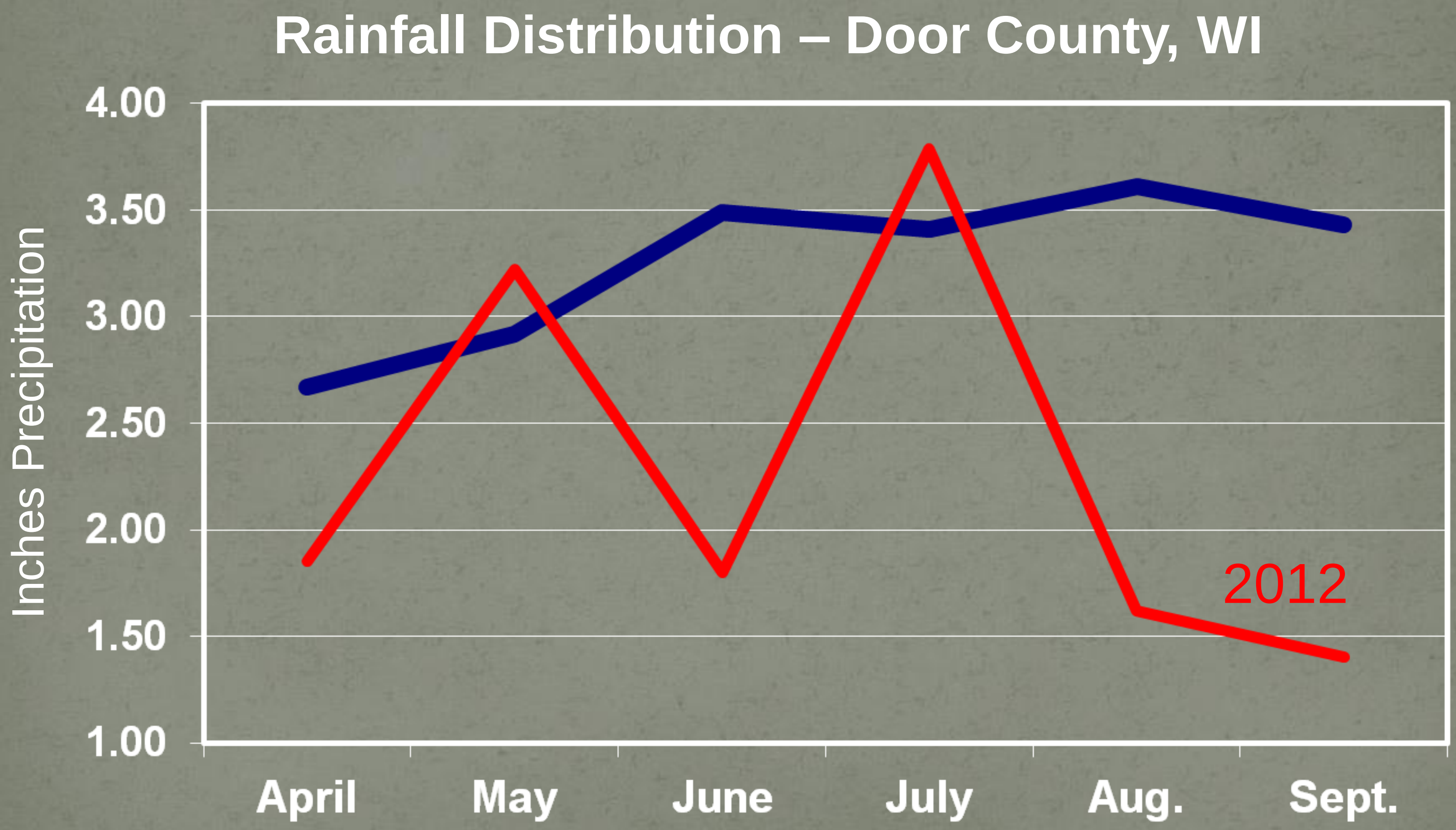
External Stress -

- Wind
- Humidity
- Temperature
- Precipitation Frequency

External Stress -



External Stress -



Irrigation Amount & Frequency

	Acre-inches		*Actual irrigation required due to inefficiencies*	
	Consumptive Use	Irrigation Requirement	Furrow (50% loss)	Sprinkler (25% loss)
April	0.81	-	-	-
May	3.33	1.28	2.56	1.71
June	4.56	3.19	6.38	4.25
July	5.32	4.97	9.94	6.63
August	4.39	3.91	7.82	5.21
Sept	2.07	0.52	1.04	0.69
October	0.54	-	-	-
Total	**21.02**	**13.87**	**27.74**	**18.49**

Average consumptive use and net irrigation requirement for orchards in the Willamette Valley in acre-inches. OSU Agricultural Experiment Station Circular 628

'Drip' Advantages & Disadvantages

- Lower water usage
  50% less that sprinkler
- Lower energy requirement
  Operating pressure and volume
- Efficiency - only what 'crop' needs
- Less potential for disease damage
- Reduced weed pressure & mowing costs
- More readily adaptable to hilly terrain

'Drip' Advantages & Disadvantages

- Management, initial investment & operating costs
- Only what ‘crop’ needs
  - Limited application volume can also be a negative
- No frost protection
- Clogging
  - Particulates, algae, mineral precipitates

Irrigation Amount & Frequency

How much?

- Species & cultivar
- Plant age

When?

- Critical periods
- Timing

Where?

- Placement

Supplemental Irrigation in a Humid Climate

How much?

Differences between species

- Annual crop – apple - hop
- Roots spread & depth
  - Down to to 15 ft
  - 3-6' beyond drip line

Vine age



How much?

	PLANT AGE					
	1	**2**	**3**	**4**	**5**	**6-20**
CROP	GAL/PLANT/DAY					
Hop	**1**	**2.5**	**3 - 4?**	**3 - 4?**	**3 - 4?**	**3 - 4?**
Dwarf Apple	**1**	**2**	**1.5**	**1.5**	**2**	**3**
Grape	**1**	**2**	**3**	**5**	**8**	**15**
Melons	**3**	**-**	**-**	**-**	**-**	**-**

How much?

Newly planted vines 7 gallons of water/week.

Best to split into 2 applications.

'Rule of Thumb'.

Increase volume by 50% each year.

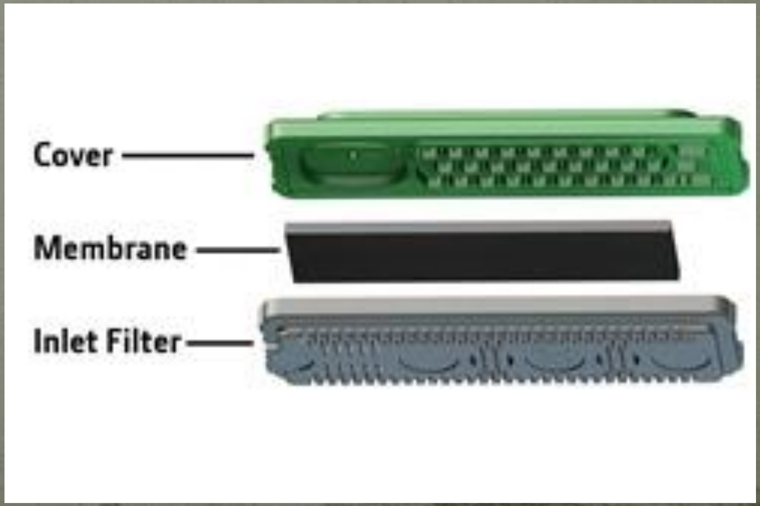
(more vigorous, greater increase)

Amount needed for vines varies with age.

Distribution System

Emitters

- Point source
  - Historically used in low density crops (1-2 gph)
- Inline
  - T-tape, 'drip-in'
  - Increased use in high density orchards (0.2-0.3 gph per foot)



Emitter Placement

Need to supply 25% root volume

- Young vines.
  - 1-2 feet from the crown.
  - 3-4 feet of slack at installation.
- Mature vines .
  - Maintain distance from crown to avoid root rot.
  - Additional emitters or lines may be required.

Application Interval

	TREE AGE					
	1	2	3	4	5	6-20
CROP	GAL/PLANT/DAY					
Hop	1	2.5	3 - 4?	3 - 4?	3 - 4?	3 - 4?
Dwarf Apple		2	1.5	1.5	2	
Grape		2	3	5	8	
Melons		-	-	-	-	

Application Interval

1st year

Hops

888 vines/acre

(3.5x14’ spacing)

Need to supply:

1 gal/vine/day = 7 gal/week

Using:

1 gph emitter per vine

point source emitters

Application Interval

1st year

Hops
888 vines/acre
(3.5x14' spacing)

Need to supply:

1 gal/vine/day = 7 gal/week

Using:

1 gph emitter per vine

point source emitters

$$\frac{7\ \text{g/wk}}{1\ \text{gph}} = \textbf{7 hr/week}$$

3-4 hrs at 2x per week

Application Interval

1st year

Hops

888 vines/acre

(3.5x14' spacing)

Need to supply:

1 gal/vine/day = 7 gal/week

Using:

0.735 gph per vine

(3.5/2*.42)

In-line emitters

2' spacing, 0.42 gph

Application Interval

1st year

In-line emitters

2' spacing, 0.42 gph

Hops

888 vines/acre

(3.5x14' spacing)

Need to supply:

1 gal/vine/day = 7 gal/week

Using:

0.735 gph per vine

(3.5/2*.42)

$$\frac{7\ g/wk}{.735\ gph} = \mathbf{9.5\ hr/week}$$

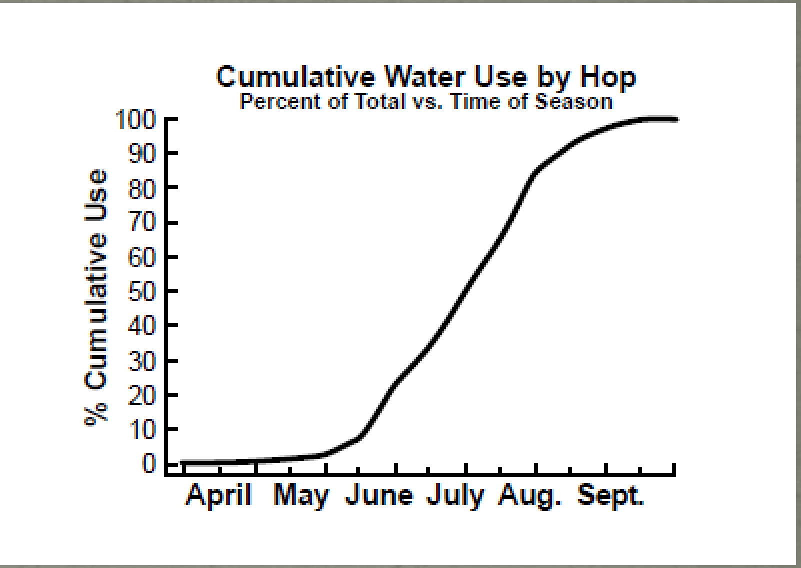
5 hrs at 2x per week

When?

Critical Periods

- Young plants
- Flowering

- Avoid water logging



In Midwest - typically June through early September

When?

Start early before soil dries

- Increase lateral spread
- Avoid 'catch up'

Timing

Pan evaporation

Tensiometers

Electrical resistance

Dry Soil > Resistance

Water Availability

Scheduling with pan evaporation

Evaporation/week		2.2 inches
Rainfall/week	-	0.7 inches
Net water loss/week		1.5 inches

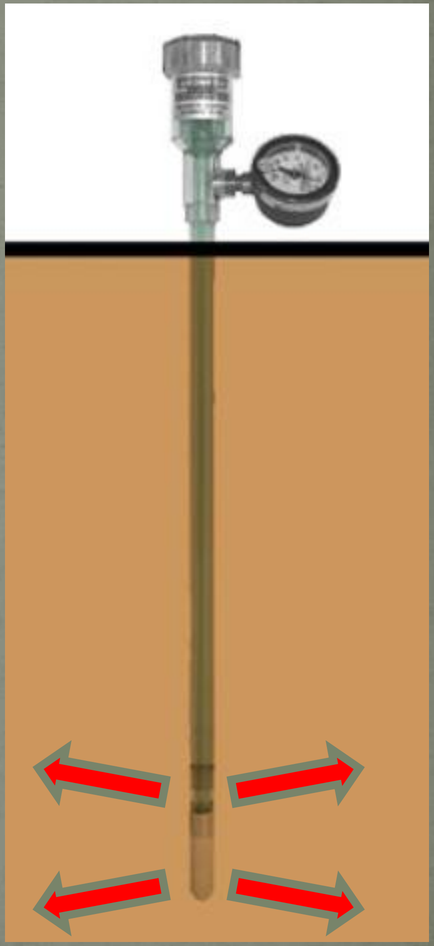
75- 100% replacement depending on crop

Best in arid climates and coarse (sandy soils)

Monitoring & Scheduling

Tensiometers

- Measure energy status of soil water.
- 'Soil Moisture Tension' (negative pressure).
- Expressed as bars or centibars.



Water Availability

	Tension (Bars)		% H_2O Filled Space
Oven Dry	10,000	Unavailable	~0
Wilt Point	15		~25
Field Capacity	.33	Available	~50
		Lost to Drainage	
Saturation	0		100

1 Bar (kPa) = -.15psi → 15 Bars = -2 psi → 10,000 Bars = -1450 psi

Water Availability

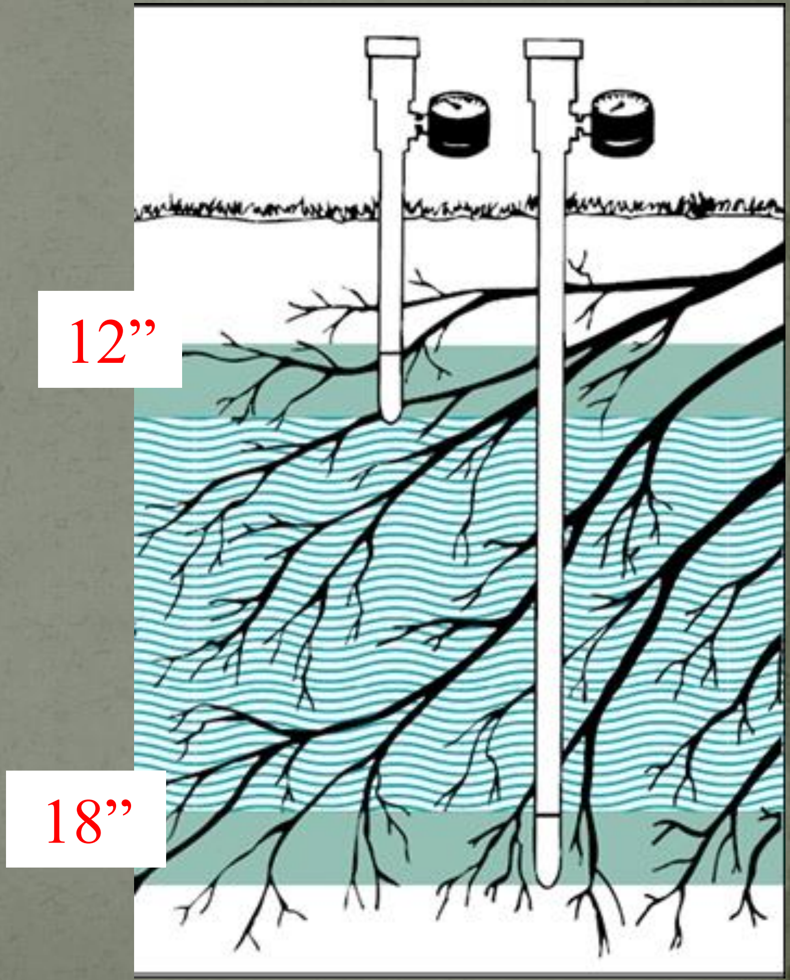
- Monitor with tensiometers
  - Place 1/3 & 2/3 root depth
- Sprinkler
  - Begin 40-50 cb
- Drip
  - Maintain between 10-50 cb

Wet - Dry

Sand 10-40

Loam 20-80

Clay 30-100



Water Source

Well, stream or pond?

- Particulates
  - Less likely with well water
- pH, dissolved solids & elements
  - Calcium, Magnesium & Iron
- All water sources contain bacteria or elements that support bacterial growth
  - Can lead to ‘bacterial slime’
- Algae from surface water

Water Source

Filters needed depend on water source

- Coarse screen filters
  - Protect pumps from surface water trash
- Fine mesh screen filters
  - Slotted plastic, perforated/mesh stainless, or nylon

Water Source

Filters needed depend on water source

Sand filters for surface water - high ‘organic’ matter

Prevention of Clogging

Table 2. Drip irrigation emitter clogging potential

Water Criteria	Clogging Potential: slight	moderate	severe
	— — — — concentration (ppm) — — — —		
Physical			
suspended solids	< 50	50 to 100	> 100
Chemical			
pH	< 7.0	7.0 to 7.5	> 7.5
dissolved solids	< 500	500 to 2,000	> 2,000
manganese	< 0.1	0.1 to 1.5	> 1.5
iron	< 0.1	0.1 to 1.5	> 1.5
hardness, as $CaCO_3$	< 150	150 to 300	> 300
Biological			
bacteria (plate count/ml)	< 10,000	10,000 to 50,000	> 50,000

Using Irrigation Water Tests to Predict and Prevent Clogging of Drip Irrigation Systems. Storlie, C. 1995. Rutgers Cooperative Research and Extension Fact Sheet, FS793.

Prevention of Clogging

Calcite (scale) formation

Soluble

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$

Calcium carbonate

Weak acid

Calcium bicarbonate

pH and temperature dependant

Precipitate

Prevention of Clogging

Acid treatment

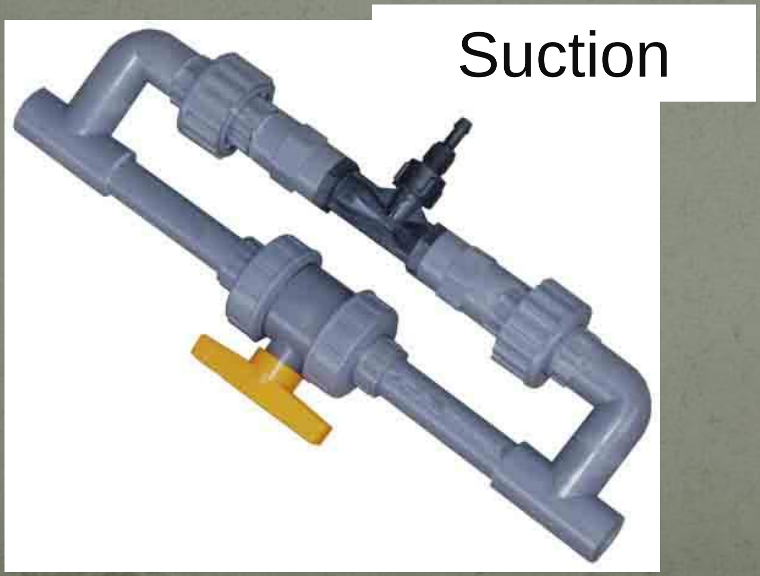
- Citric, phosphoric, sulfuric, hydrochloric
- Prevention of Mg & Ca scaling, bacterial slime (Fe)
  - – Continuous injection to lower pH to just below 7.0.
- Scale removal
  - – 'Slug' injection with pH 3.0-4.0.
  - – Flush after sitting in line 1-2 hours.

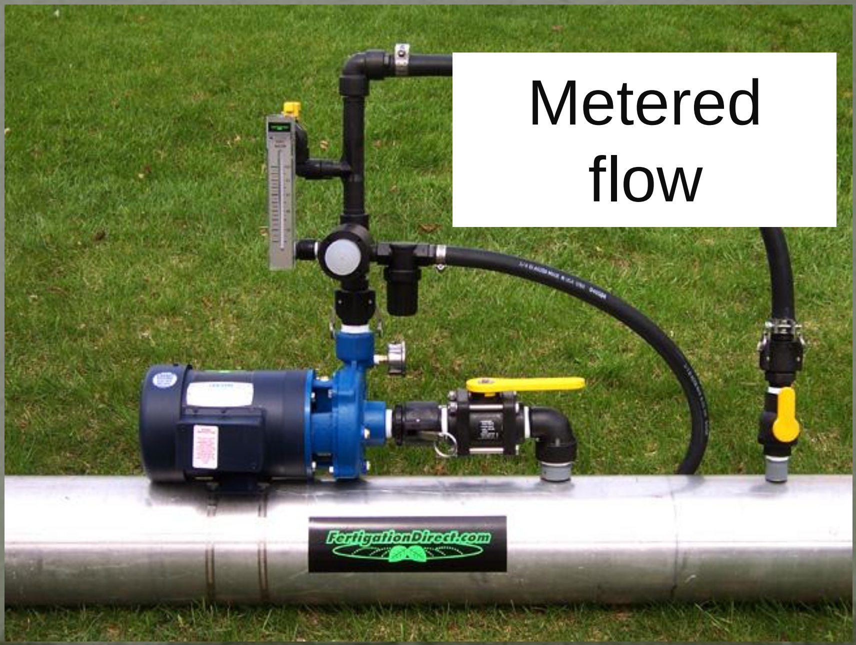
Chlorine injection

- Algae, bacterial slime (Fe)
  - – Continuous injection to maintain 1-2ppm.

Injectors

- Chemical injection to reduce algae and precipitates.
- Type – venturi, metering, proportioner
- Fertilizer use can be cut by 50%.
- All require backflow prevention to protect water source.





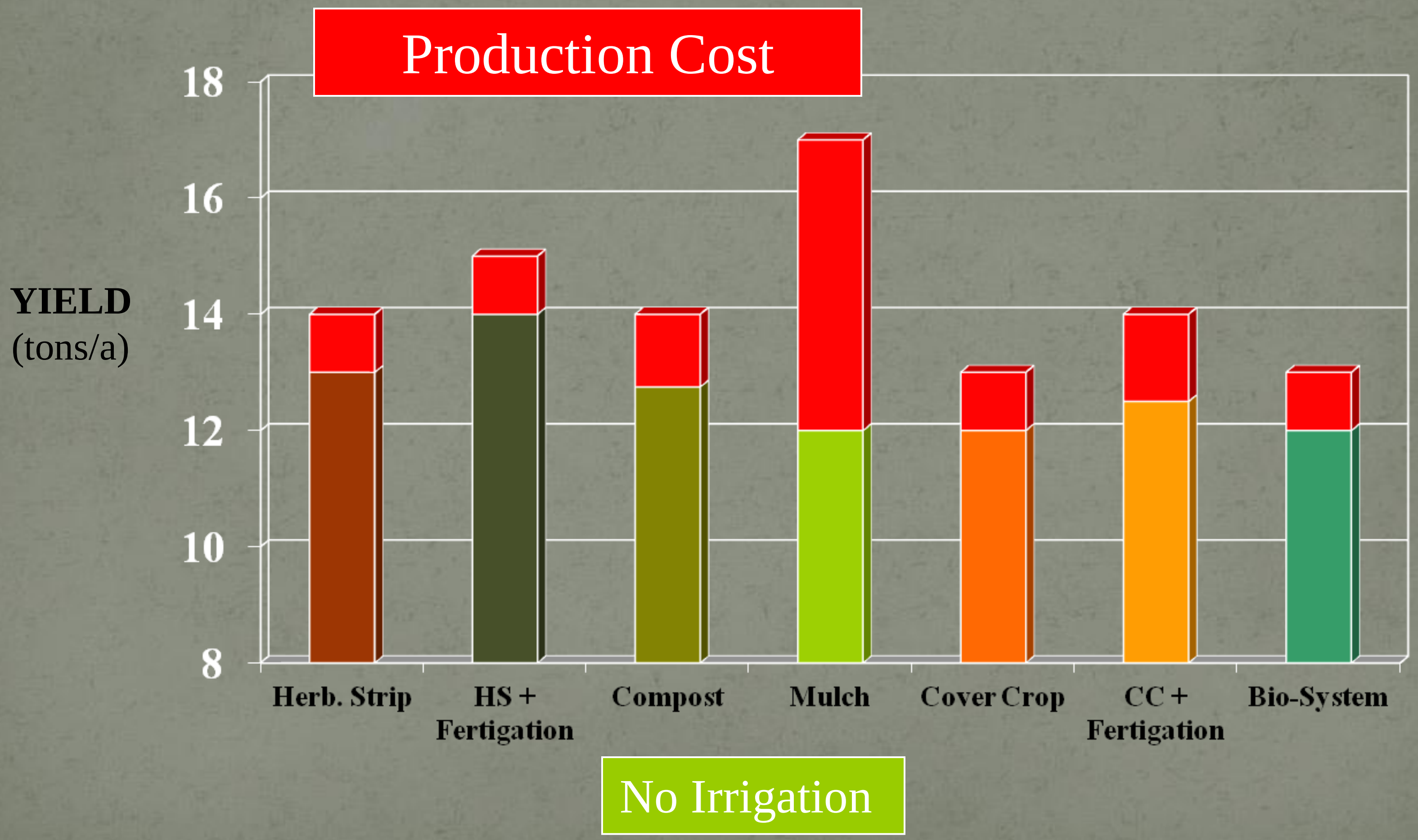
Fertigation?

Nitrogen, potassium, magnesium, boron, and zinc can be effectively supplied through fertigation

Benefits over broadcast fertilizing include:

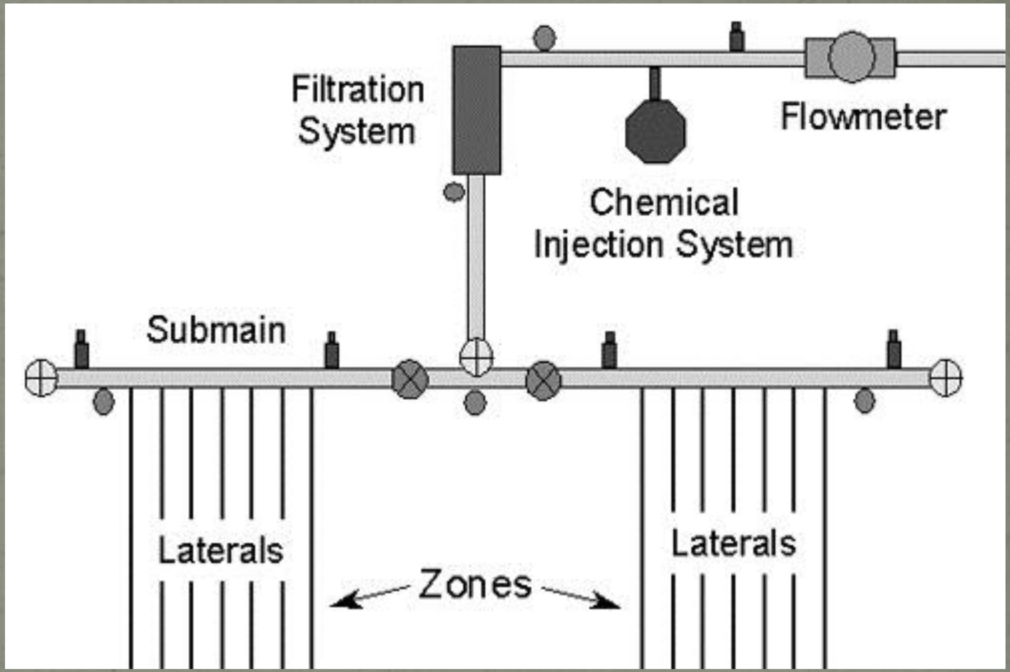
- Increased nutrient absorption
- Reduced fertilizer need
- Reduced leaching
- Reduction in water usage due to the plant's resulting increased root mass's ability to trap and hold water
- Precise timing and application rates

Average Yields from Seven Tart Cherry Orchard Floor Systems, 1995-2000



Design Considerations

- Field layout
  - Mainline
    - Supply to fields
  - Submain (header)
    - Within field
  - Laterals
    - To the tree
  - Emitters



Flow Rate

Flow Rate Determination - per acre

	TREE AGE					
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CROP	GAL/PLANT/DAY					
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Dwarf Apple	1	2	1.5	1.5	2	
Grape	1	2	3	5	8	
Melons	3	-	-	-	-	

Flow Rate Determination - per acre

Mature

Hop
888 vines/acre
(3.5x14' spacing)

Need to supply:

3 gal/vine/day = 21 gal/week

Using:

1 gph emitter per vine

888 vines/acre x 1 gph =
888 gallons per hour

Flow Rate Supply

Required main and submain size for various flow rates.	
Pipe Flow Rate (gpm)	**Minimum Pipe Size (inches)**
1. 0 - 4	1/2
8 - 12	1
22 - 30	1 ½
30 - 50	2
70 - 110	3
110 - 190	4
190 - 450	6

Sufficient flow?

888 vines/acre x 1 gph =
888 gallons per hour

14.8gal/min.
1 ACRE

7.4gal/min.
1/2 ACRE

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Sufficient flow?

888 vines/acre x 1 gph =
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Water Source

Pump requirements

Needs to be sufficient to bring water to the surface and move against gravity and friction.

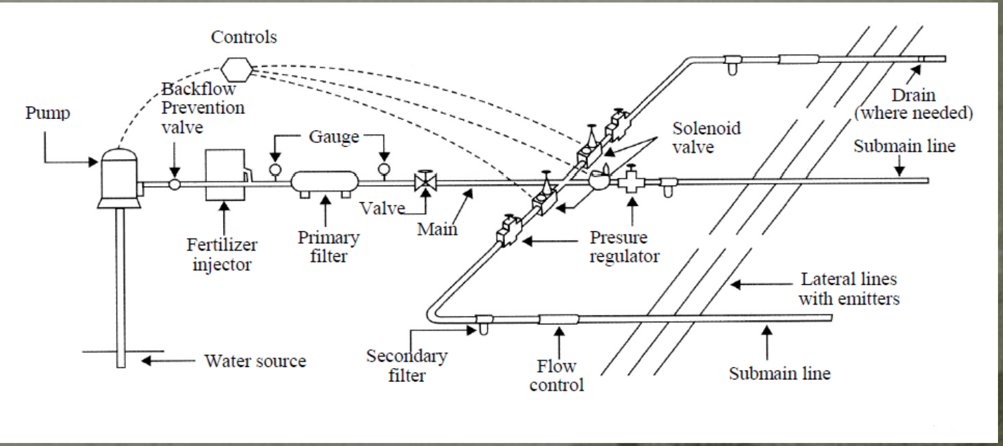
Combination of-

- Flow rate
  - Gallons per minute each section to be irrigated.
- ‘Head’ - total energy needed supply emitters
  - Elevation – water source to highest lateral.
  - Friction – supply lines, valves, filters, etc.

Final Thoughts - Design Considerations

Professional Design Engineer

- Water source – well, pond, existing pumps, etc.
- Electrical supply – voltage, etc.
- Total flow rate
- Vine age & cultivar
- Row and plant spacing
- Field dimensions – row lengths
- Terrain
- Automation
- Chemical injection



Suppliers

Roberts Irrigation Company, Inc.
1500 Post Rd
P.O. Box 490
Plover, WI 54467
Ph: 800-434-5224
www.robertsirrigation.net

Trickl-eez Company
4266 Hollywood Rd.
St. Joseph, MI 49085
Ph: 800-874-2553
www.trickl-eez.com

Spring Brook Supply
11291 Lakewood Blvd.
Holland, MI 49424
Ph: 616-396-1956
www.springbrookirrigation.com

Further Information

Designing A Drip/Trickle Irrigation System: Part 1&2 — Water Needs, Emitters, and Management. Albert R. Jarrett Professor of Agricultural Engineering
http://pubs.cas.psu.edu/freepubs/pdfs/F180.pdf
http://pubs.cas.psu.edu/freepubs/pdfs/F181.pdf

Fertigation of Apple Trees in Humid Climates. Terence Robinson and Warren Stiles. 2004. New York Fruit Quarterly. Vol.12 No.1.
http://www.nyshs.org/pdf/fq/2004-Volume-12/Vol-12-No-1/Fertigation-of-Apple-Trees-in-Humid-Climates.pdf

Using Irrigation Water Tests to Predict and Prevent Clogging of Drip Irrigation Systems. Storlie, C. 1995. Rutgers Cooperative Research and Extension Fact Sheet, FS793.
http://njaes.rutgers.edu/pubs/publication.asp?pid=FS793

Treating Drip Irrigation Systems with Chlorine. Storlie, C. 1997. Rutgers Cooperative Research and Extension Fact Sheet, FS795.
http://njaes.rutgers.edu/pubs/publication.asp?pid=FS795

How to Reduce Clogging Problems in Fertigation. Guodong Liu and Gene McAvoy. 2012. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, HS1202
http://edis.ifas.ufl.edu/hs1202