Micro irrigation for Orchards and Vineyards
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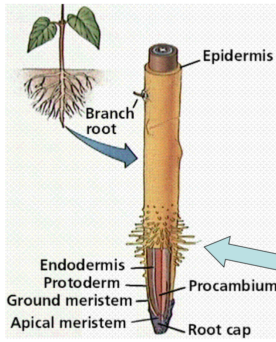
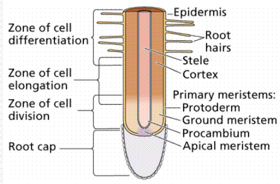
MSU

- Water relations for fruit tree crops
- Irrigation Scheduling for fruit trees
- Irrigation Systems for fruit

Water uptake by roots



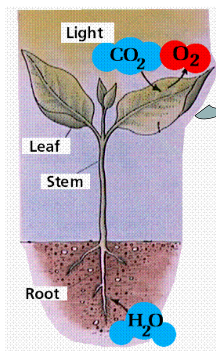


Active zone of water uptake = root hairs

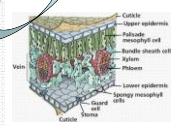
Roots will penetrate rock and crevices to develop where good soil moisture conditions exist.

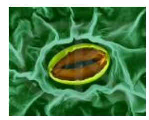
How does water move through the plant?

The driving force is transpiration !!



1. Water loss; Via Transpiration (70%) through stomata





2. Water loss; Via Evaporation (30%)

3. Therefore …. Evapotranspiration
Evapotranspiration is water loss occurring from the processes of evaporation and transpiration. Evaporation occurs when water changes to vapor on either soil or plant surfaces. Transpiration refers to the water lost through the leaves of plants.

Factors that influence Transpiration

1. Light
2. Sever water stress = Turgid guard cells
3. Humidity: if low = more stress
4. Big Crop Load = driven by Pn
5. Leaf area X Water Loss area
   - As leaf area increases, transpiration increases.

(J. Flore, MSU Hort)

When does a plant need water?

- When leaves are present
- When soil moisture is less than field capacity (June, July and August).

Flooded orchard in late February, no leaves, very little root activity

How much does a plant need?

- Enough to replace the amount evaporated through the plant or: the amount required to bring soil back to field capacity.
- Consequences of drought stress/not satisfying need.
  - Vegetative growth
  - Leaf growth is most sensitive
  - Shoot growth slows, slightly less sensitive
  - Root growth; depends on species and conditions.

(J. Flore, MSU Hort)

Consequences of drought stress

Reproductive responses

1. Fruit set not affected in Mich
2. Fruit growth, especially during final swell in stone fruit and throughout the year in pome fruit is critical….size
3. Flower Bud Initiation (FBI) mid June-July
   - Low to moderate stress ↑
   - Severe stress ↓
4. Flower Bud Development (late winter/spring)
   - Low to moderate stress = no effect
   - Severe stress = Incomplete flower development

Stressed grape vines, not watered (Notice that they were mulched on Typical sandy soil N. Mich)

Irrigation Scheduling

– Dependent on:

1. Based on soil moisture
2. Based on plant need
3. Based on weather conditions

Measuring Soil Moisture

- **Soil - Feel**

Instruments to measure soil moisture

- **Tensiometers**
- **Lysimeters**
- **Gypsum blocks**
- **Neutron probes**
- **Electrical Conductivity**
  - **Time Domain Reflectometry (TDR)**
  - **Other**
    - **SmartRain™**
    - **ThetaProbes™**
    - **Watermark ™ (Irrometer)**

Tensiometers

Tensiometers

- Only accurate to -75cb (.75 atms)
- Accurate for crops in the 20-75 cb range
- Placement is important
  - Place between source and edge of wetted zone
- Maintenance is important.
- Some have solenoid valves activated by tensiometer readings initiate irrigation.

http://www.irrometer.com/sensors.html

Recommended soil suction to start irrigation, only guidelines, depends on soil type

Crop	Suction	ASM	Depth
Apple	-0.3-0.6	50%	Root zone
Apple	-0.5-0.6	50%	24"
Peach	-0.4	50%	24-48"
Grape Early	-0.4-0.5		Root zone
Grape late	-1.0		Root zone
Strawberry	-0.2-0.3		Root zone

Watermark Soil Moisture Sensor

by Irrometer

http://www.irrometer.com/sensors.html

Watermark Sensors

- As the tension changes with water content the resistance changes as well. That resistance can be measured using the WATERMARK Sensor.
- The sensor consists of a pair of highly corrosion resistant electrodes that are imbedded within a granular matrix. A current is applied to the WATERMARK to obtain a resistance value. The WATERMARK Meter or WATERMARK Monitor correlates the resistance to Centibars (kilopascals) of soil water tension.
- The WATERMARK is designed to be a permanent sensor, placed in the soil to be monitored and "read" as often as necessary with a portable or stationary device. Internally installed gypsum, provides some buffering for the effect of salinity levels normally found in irrigated agricultural crops and landscapes.

Decagon Meters

http://www.decagon.com/products/sensors/soil-moisture-sensors/?gclid=CNvRmPGczasCFVMBQAod-BFY1w

Plant Indicators

Visual -
lose turgidity in leaves/ leaf drop

Stressed grape vines, not watered

Plant indicators

- Leaf emergence
- Shoot length
- Trunk diameter
- Fruit growth
- Xylem Water potential
- Photosynthesis
- Stomatal conductance

(J. Flore, MSU Hort)

Optimizing Irrigation Scheduling

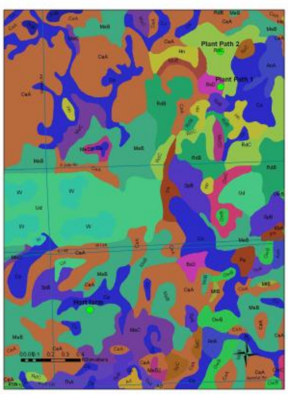
- Need to know:

1. Soil water holding capacity - how much water is available to the plant?
2. Allowable soil moisture depletion – how low can supplies get before plants are affected?
3. Evapo-transpiration - how quickly is water being lost?
   - General knowledge on soil type and moisture holding capacity.
   - Evap-transpiration is most critical

Table 2. The Relationship of Soil Type to Water Holding Capacity and Moisture Availability to Plants (From: Temperature-Zone Pomology)

Soil Type	Water Content At Field Capacity	Water Content At Permanent Wilting	Available Water
Sandy Loam	12%	4%	8%
Loam	24%	12%	12%
Adobe Clay	38%	19%	19%

From Ohio Fruit ICM News, Volume 3, No. 27, July 30, page 5



- Soils in Michigan are extremely variable as noted in the soil map here.
- Irrigation delivery systems and scheduling must account for soil types and non uniformity.
- Each of the colored areas (Polygons) represents a different soil series.

Soil Water Definitions

- Saturation.
  - All pores filled with water.
- Field Capacity.
  - As much water as the soil can hold against gravity.
  - Macropores air-filled, Micropores water-filled.
- Permanent Wilting Point.
  - Water content at which plants wilt – water not available. Easily visible in herbaceous annuals
  - In fruit… Not usually seen in woody perennial fruit plants…. If you do close to gone.

Irrigation schedule summary

- Use a combination of tools….
- Soil Sensors
- Plant indicators
- Evapotransporation

Factors to consider

A. The physiological response of the crop.
B. The water use by the plant.
   Biological factors Environmental factors
C. The amount of water in reserve. Soil water.
D. The type of irrigation system.
   – Micro irrigation systems are designed to deliver less water anyone time, but instead constant replenishment. Can't catch up and then pour large volume.

Evapotranspiration

- ET or evapotranspiration is the combined loss of water from the soil surface by evaporation and from plant tissue by transpiration.
- The process of evaporation involves a change of state of water from a liquid to a gas or vapor. The rate of E depends chiefly on the total supply of energy from radiation (direct solar and radiation which is reflected and/or re-radiated), and advective or horizontal air flow (wind), which carries the water vapor away.

(J. Flore, MSU Hort)

How is ET measured and used

- The traditional method is to make daily measurements of a "Class A" pan and the amount of water that actually evaporates each day
- Peak ET during the growing season can be used to design irrigation systems.
- Daily and /or weekly estimates of ET rates during the growing season are used to determine irrigation schedules (where and how much).

Estimating Water Use

- **Potential Evapotranspiration model (pET)**
  – Takes into account actual canopy volume coverage by fruit tree and species differential water use for different times of the growing season.
  – Must use Kc (crop coefficient from a table)
  – Must use pET found on MAWN http://www.enviro-weather.msu.edu/homeMap.php estimated with the modified Penman method according to Kincaid and Heermann (1974). Considers sun, wind, temperature, and humidity.

Weather Stations Generate Data Critical to Determining Evap

Weather station at Sparta, Kraft Orchard, 10 mile Rd.

http://www.agweather.geo.msu.edu/mawn

- Guidance in using the Enviro Weather web site.
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- When arriving at MAWN, select the site for weather records that have been archived. Press and go to that site web page.
- Go to Custom Reports and select Data Type (Daily Data).
- Check only boxes for Reference **Potential Evapotranspiration**, **Precipitation** and other variables; ex. Air temperatures - Min and Max
- In the **Function box**, select (none)
- **Display Units**… American
- **Output in CSV** (comma-delimited) for Excel spread sheet
- **Select Dates: Choose dates May 1 to Aug 15 over a selected time period for archive.**
- **For current conditions: set dates to current date to last 10 days.**
- **Generate Report**

DAILY WEATHER SUMMARY

Northwest Michigan Horticultural Research Station
Traverse City / (NWMHRS)

Date	Temperatures(F) *Air* Max	Min	*Soil* Max	Min	Total *Precip* (in)	Average *Relative Humidity* (%)	Total *Wind* (mi/day)	Total *Solar* (ly/day)	***Estimated PET*** **(in/day)**
07/01/09	62.2	50.5	69.3	59.0	0.57	89.0	31.6	346.0	**0.091**
07/02/09	59.8	52.5	63.9	60.3	0.04	91.4	48.0	155.5	**0.046**
07/03/09	67.8	53.0	74.0	60.2	--	76.5	60.4	516.3	**0.132**
07/04/09	76.2	48.2	81.3	58.5	--	61.9	29.5	699.1	**0.202**
07/05/09	77.9	52.4	83.9	63.2	--	67.1	55.4	681.2	**0.207**
07/06/09	71.0	51.5	80.5	64.0	--	70.6	63.8	553.9	**0.161**
07/07/09	64.6	51.4	79.6	64.2	--	75.2	80.8	538.4	**0.136**
07/08/09	76.7	49.4	84.3	62.9	--	74.3	34.2	670.1	**0.190**
07/09/09	82.7	54.7	87.5	65.9	--	68.8	35.4	672.6	**0.205**

·
· http://www.agweather.geo.msu.edu/mawn/report.asp?fileid=nwmd

Warning...
Date Selected: 20120518:2400
Last Entry In Datebase: 20120517:2400
...Resetting Date Selected To: 20120517:2400
msuhtrc
daily summary

date	pcpn	rpet
5/7/2012	0.12	0.068
5/8/2012		0.156
5/9/2012	0.02	0.114
5/10/2012		0.181
5/11/2012		0.198
5/12/2012	0.32	0.055
5/13/2012	0.14	0.144
5/14/2012		0.196
5/15/2012	0.03	0.217
5/16/2012	0.05	0.184
5/17/2012		0.176

Variable Ids:
pcpn: Precipitation (in)
rpet: Reference Potential Evapotranspiration (in/hr)

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Data provided by the Michigan Automated Weather Network (MAWN)
and Enviro-weather Program.

Please direct bug re comments and suggestions to the following
email address: agwxinfo@www.agweather.geo.msu.edu

Estimating water use for a mature orchard using the pET formula

- Water use = **Epan** x **K_c** x area covered (fraction)
- Example water use in gal =
- pET (.25 inches) x **Kc (.8)** x area covered (.75).
- I acre inch = 27,154 gallons
- Water use = .25 x .8 x .75 x 27,154
- = 4,073 gal

Crop coefficients (K_c)

- Crop coefficients relate the actual rate of crop water use, Et_c to potential ET (ET_r or ET_o)
- $ET_c=K_c$ x potential ET
- Where values of K_c are determined experimentally and reflect the physiology of the crop, the degree of crop cover, the location where data are collected and the reference crop used to determine potential ET

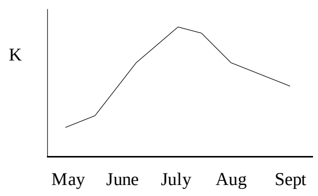
(J. Flore, MSU Hort)

Monthly Kc for orchard crops (Kc -Pan)

Month	Apple + cover	Apple - cover	Stone fruit + cover
April	.36	.32	.36
May	.68	.48	.64
June	.92	.68	.84
July	1.0	.80	.92

(J. Flore, MSU Hort)

Crop Coefficients are dependent on time period in the growing season…example the crop coefficient for peach



K factor for peach under Michigan conditions

(J. Flore, MSU Hort)

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Area Covered

- This is the area covered by vegetation which includes the ground cover, sod alleyway (rows between tree rows) and the tree/vine canopies themselves.
- The best way to estimate is think of looking down on the site from top view and estimating land surface covered by vegetation.
- Less covered in new orchards than older

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How much water needed per tree/vine?

- If you have 580 trees per acre
  - 43560 sq ft in acre / Tree Spacing
  - 43560 / 5 X 15 = 580 Trees / Acre
- and you need to replace 4,073 gallons per day
- Then 4,073/580 = 7.0 gallons per tree per day.

How do you deliver needed water?

- Micro irrigation system
- Calc pumping or source capacity in GPM (wells, etc.)
- Blocking strategies
  - Orchard/vineyard blocks considering capacity and delivery needs.
  - Micro system delivery rates

Example scenario

- 1 gal / hour emitters
- 7 gallons takes 7 hours system is on
- Or 21 hours every 3 days depending on pumping capacity… example
- 10 acre orchard, 100 gpm well and need 4000 gal / acre / day = 40,000 gals / day.
- Pump capacity 6,000 gph = run pump 6.6 hours

Distribution Uniformity

- Distribution Uniformity or DU in irrigation is a measure of how uniformly water is applied to the area being watered, expressed as a percentage.
- DU is the Low Quarter DU, which is a measure of the average of the lowest quarter of samples, divided by the average of all samples. The higher the DU, the better the performance of the system. If all samples are equal, the DU is 100%. If a proportion of the area greater than 25% receives zero application the DU will be 0%. There is no universal value of DU for satisfactory system performance but generally a value >80% is considered acceptable.
- Distribution uniformity is useful when determining the total watering requirement during irrigation scheduling. For example, an irrigator might want to apply not less than one inch of water to the area being watered. If the DU were 75%, then the total amount to be applied would be the desired amount of water, divided by the DU.
- DU = Low Quarter Samples / Avg of samples

Types of Micro Irrigation Systems for Delivering Water

Low Volume Systems that require 40-50 lbs PSI to deliver and less than 15 gals per hour delivered by each unit

Low volume permanent set or hose-pull sprinkler system

Microjet or Microsprinkler systems

Trickle/Drip Systems

Many today or
Pressure Compensating

* In-line emitters are gaining popularity

Filter and Injector systems for in incorporating nutrients in water