Tools and Techniques for Optimizing Orchard Irrigation

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Utah State University

Western Region Sustainable Agriculture Research and Education

UtahState University COOPERATIVE EXTENSION

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Overview

- Irrigation scheduling approaches
  - Weather-based
  - Soil moisture-based
  - Plant-based
- Regulated Deficit Irrigation
  - What is it?
  - Where might it be appropriate?
- Tree water status

Weather-based irrigation

Evapotranspiration (ET)

(evaporation + transpiration)

- Estimated with gauge
- Calculated based on weather
  - Temperature
  - Humidity
  - Wind speed
  - Light intensity

UTAH CLIMATE CENTER

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Payson - Allred Farm

News View All »

Forecast of First Fall Freeze Day
Latest Fall Freeze Forecast calls for warmer Sept...

March Newsletter
Featuring the perspectives on winter of 2014
Read More »

Logan, UT
Change Location

28°F
High: 40°F Low: 23°F

January 9, 2015

Exposure Time Before Frostbite:
> 30 Minutes

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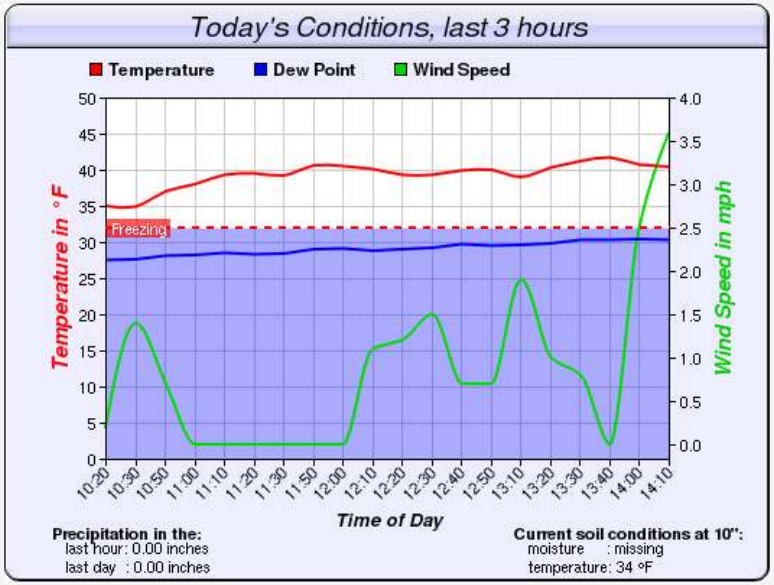

Change Station
Station List

Edit Daily/Hourly Report Range
To access historic weather data, click on the daily or hourly tab below.
POR Begins: 05-27-2004
Start Date: 12-10-2014
End Date: 01-09-2015
Submit

Last Updated: 01-09-2015 14:13:35 (Local)
Page auto refreshed every 2 minutes

Current Conditions | Daily | Hourly

Current Conditions

Date/Time	Air Temp (°F)	Dew Point (°F)	RH (%)	Solar (MJ/m²)	Wind Speed (mph)	Leaf Wetness (%)	Precipitation (in)	Leaf Temp (°F)	Bud Temp (°F)
01-09-2015 14:10	40.4	30.3	67	401	4	0	0.00	46.3	60.1
01-09-2015 14:00	40.7	30.4	67	407	3	0	0.00	46.5	60.8
01-09-2015 13:40	41.7	30.3	64	438	0	0	0.00	49.7	58.7
01-09-2015 13:30	41.2	30.3	65	452	1	0	0.00	49.8	64.7
01-09-2015 13:20	40.3	29.8	66	465	1	0	0.00	47.4	60.2
01-09-2015 13:10	39.0	29.6	69	465	2	0	0.00	48.4	52.0
01-09-2015 12:50	40.0	29.5	66	494	1	0	0.00	48.5	51.2
01-09-2015 12:40	39.9	29.7	66	417	1	0	0.00	49.1	56.7

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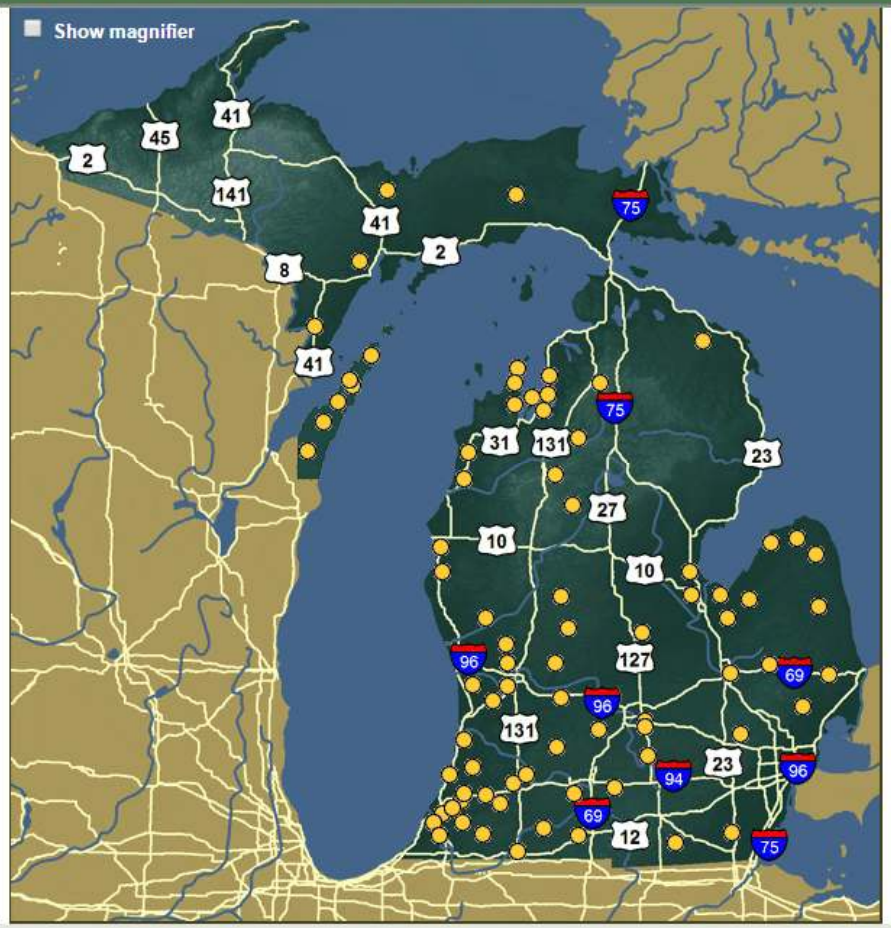
Enviro-weather

Weather-based pest, natural resources, and production management tools



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For access to specific commodity tools: Select from list above.

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Project GREEEN

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Weather-based pest, natural resources, and production management tools

National Weather Service radar and local forecast for Elk Rapids

Weather Station at Elk Rapids

Elk Rapids, Michigan

Latest observations at Elk Rapids

01/09/2015 03:00 AM (Station online). Measurements by 5-minute average or total unless otherwise indicated.

16.7 F	Air temperature
0.0 in.	Rainfall(01/09/2015)
94.9%	Relative Humidity
15.5 F	Dewpoint
WNW	Wind Direction (hourly average)
17.0 mi./hr.	Windspeed
0%	Percent of last full hour wet - leaf wetness (tripod-mount)

Weather observations and summaries

- Overnight temperatures/ hours below freezing
- Rainfall comparisons for Region
- Temperature, rainfall and degree-day summary
- Rainfall comparisons last 5 years at this station
- Soil conditions
- More weather for this station

Degree-day tools

- Current degree day maps
- Degree Day accumulations for Region
- Degree Day accumulations for Region (alfalfa and corn development)
- Average degree day summary
- Degree day comparisons: Compare 2 sensors
- Degree day comparisons: last 5 years at this station
- Degree day comparisons: last 5 years at this station (alfalfa and corn development)
- Temperature, rainfall and degree-day summary

Water-use tools

- Irrigation scheduling Excel Workbook
- Irrigation Scheduling online

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This station is hosted at Orchard View and is funded in part by:

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- Michigan State University Extension
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MAWN STATION NAME: elkrapids

DATE	ET	PCPN	TMPX	TMPN
2014-03-01	0.020	0.00	16.9	2.3
2014-03-02	0.023	0.00	11.8	-7.7
2014-03-03	0.033	0.02	17.3	-20.8
2014-03-04	0.021	0.02	21.0	-3.5
2014-03-05	0.030	0.00	16.6	-15.1
2014-03-06	0.056	0.00	33.1	-7.0
2014-03-07	0.058	0.00	45.5	14.2
2014-03-08	0.033	0.00	28.1	5.1
2014-03-09	0.048	0.00	36.9	2.9
2014-03-10	0.077	0.00	52.6	29.7
2014-03-11	0.048	0.00	42.7	27.8
2014-03-12	0.031	0.00	28.0	3.4
2014-03-13	0.034	0.00	27.7	-7.0
2014-03-14	0.043	0.15	46.5	25.6
2014-03-15	0.035	0.01	33.2	6.8
2014-03-16	0.039	0.00	19.6	-0.7
2014-03-17	0.044	0.00	29.1	-2.0
2014-03-18	0.069	0.00	44.5	20.4
2014-03-19	0.021	0.11	38.2	29.5
2014-03-20	0.061	0.01	37.5	23.4
2014-03-21	0.068	0.00	41.9	15.4
2014-03-22	0.029	0.00	30.4	8.5
2014-03-23	0.038	0.03	27.9	3.1
2014-03-24	0.045	0.00	25.6	2.4

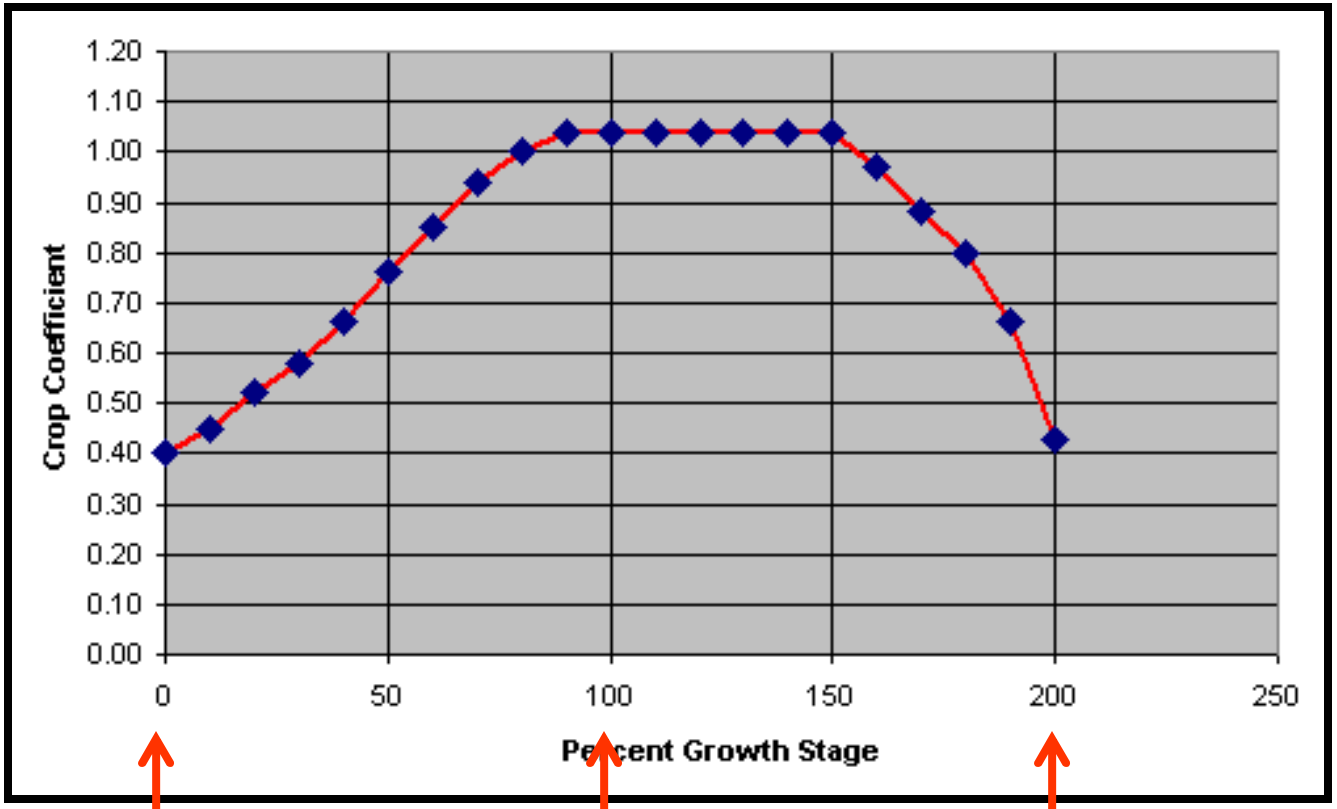
2014-06-27	0.172	0.00	85.0	55.8
2014-06-28	0.188	0.02	90.3	65.4
2014-06-29	0.147	0.49	81.2	69.1
2014-06-30	0.197	0.09	85.9	69.1
2014-07-01	0.183	0.02	77.6	65.2
2014-07-02	0.086	0.41	69.3	50.1
2014-07-03	0.158	0.01	70.2	41.9
2014-07-04	0.187	0.00	75.8	42.7
2014-07-05	0.209	0.00	79.7	47.5
2014-07-06	0.094	0.03	77.0	58.0
2014-07-07	0.193	0.05	80.4	64.7
2014-07-08	0.049	0.06	70.7	53.9
2014-07-09	0.130	0.01	68.3	51.6
2014-07-10	0.179	0.00	74.4	43.4
2014-07-11	0.142	0.00	81.3	48.7
2014-07-12	0.093	0.24	80.2	62.1
2014-07-13	0.152	0.00	74.7	53.8
2014-07-14	0.152	0.04	78.4	51.7
2014-07-15	0.043	0.49	59.3	53.5
2014-07-16	0.157	0.00	69.8	51.1
2014-07-17	0.179	0.00	78.0	45.9
2014-07-18	0.173	0.00	80.9	50.1
2014-07-19	0.176	0.00	84.1	53.4
2014-07-20	0.157	0.00	83.8	54.6
2014-07-21	0.187	0.00	86.5	58.7
2014-07-22	0.142	0.31	85.8	62.5
2014-07-23	0.119	0.00	67.9	56.9
2014-07-24	0.165	0.00	73.8	44.5
2014-07-25	0.135	0.00	77.1	48.2
2014-07-26	0.112	0.23	80.8	60.2
2014-07-27	0.052	0.27	70.5	58.4
2014-07-28	0.124	0.00	65.2	51.7

Expenses: Water use

- Reference evapo-transpiration (ET)
  - Reference crop, alfalfa (ET_{ref})
- $ET_{crop} = ET_{ref} \times K_{crop}$
  - K = depends on the specific crop and the stage of development

Crop coefficients (K) - Cherry

$ET_{crop} = ET_{ref} \times K$



Crop coefficients (K) - Cherry

$ET_{crop} = ET_{ref} \times K_{crop}$

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2014-06-28	0.188	0.02	90.3	65.4
2014-06-29	0.147	0.49	81.2	69.1
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2014-07-18	0.173	0.00	80.9	50.1
2014-07-19	0.176	0.00	84.1	53.4
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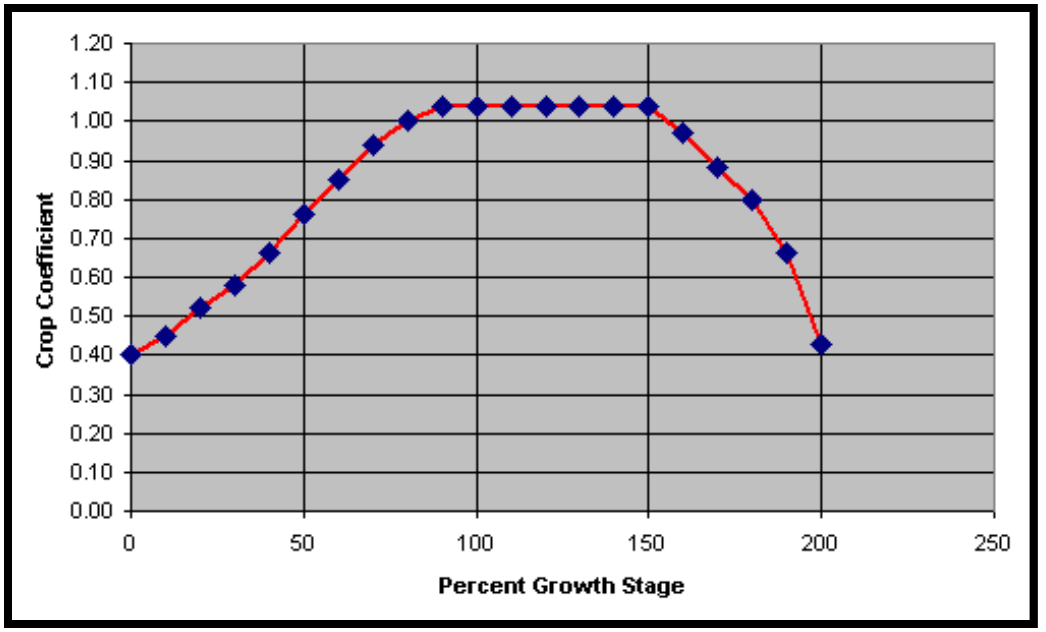


July 4

ET_{ref} (RPET) = 0.187 in/day

K_{crop} = 1.05

$ET_{crop} = 0.187 \times 1.05 = 0.196$ in/day

Crop coefficients

USU Extension Website:

http://fruit.usu.edu

Cherry

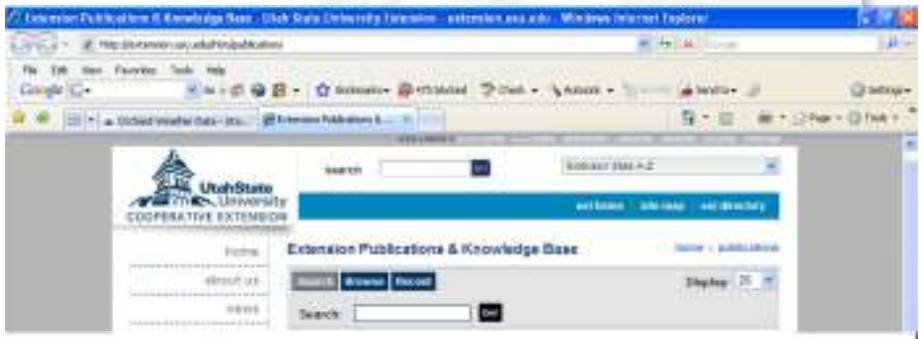
Apple

Peach

Strawberry

Caneberry

- Raspberry
- Blackberry



July 2007 Horticulture/Fruit/2007-03pr

Orchard Irrigation: Cherry

Dr. Brent Black, USU Extension Fruit Specialist, *Dr. Robert Hill*, USU Extension Irrigation Specialist, and *Dr. Grant Cardon*, USU Extension Soils Specialist

Proper irrigation is essential to maintaining a healthy and productive cherry orchard. Over irrigation slows root growth, increases iron chlorosis on alkaline soils, and leaches nitrogen, sulfur and boron out of the root zone leading to nutrient deficiencies. Excessive soil moisture also provides an environment ideal for crown and collar rots. Over irrigation can also induce excessive

available water represents about 50% of the total available water. (Figure 2.)

The goal of a well-managed irrigation program is to maintain the soil moisture between field capacity and the point of allowable depletion, or in other words, to make sure that there is always readily available water.

AgriMet Crop Coefficients, Bureau of Reclamation - Windows Internet Explorer

http://www.usbr.gov/pn/agrimet/cropcurves/crop_curves.html

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RECLAMATION

Pacific Northwest Region

Managing Water in the West

AgriMet

The Pacific Northwest Cooperative Agricultural Weather Network

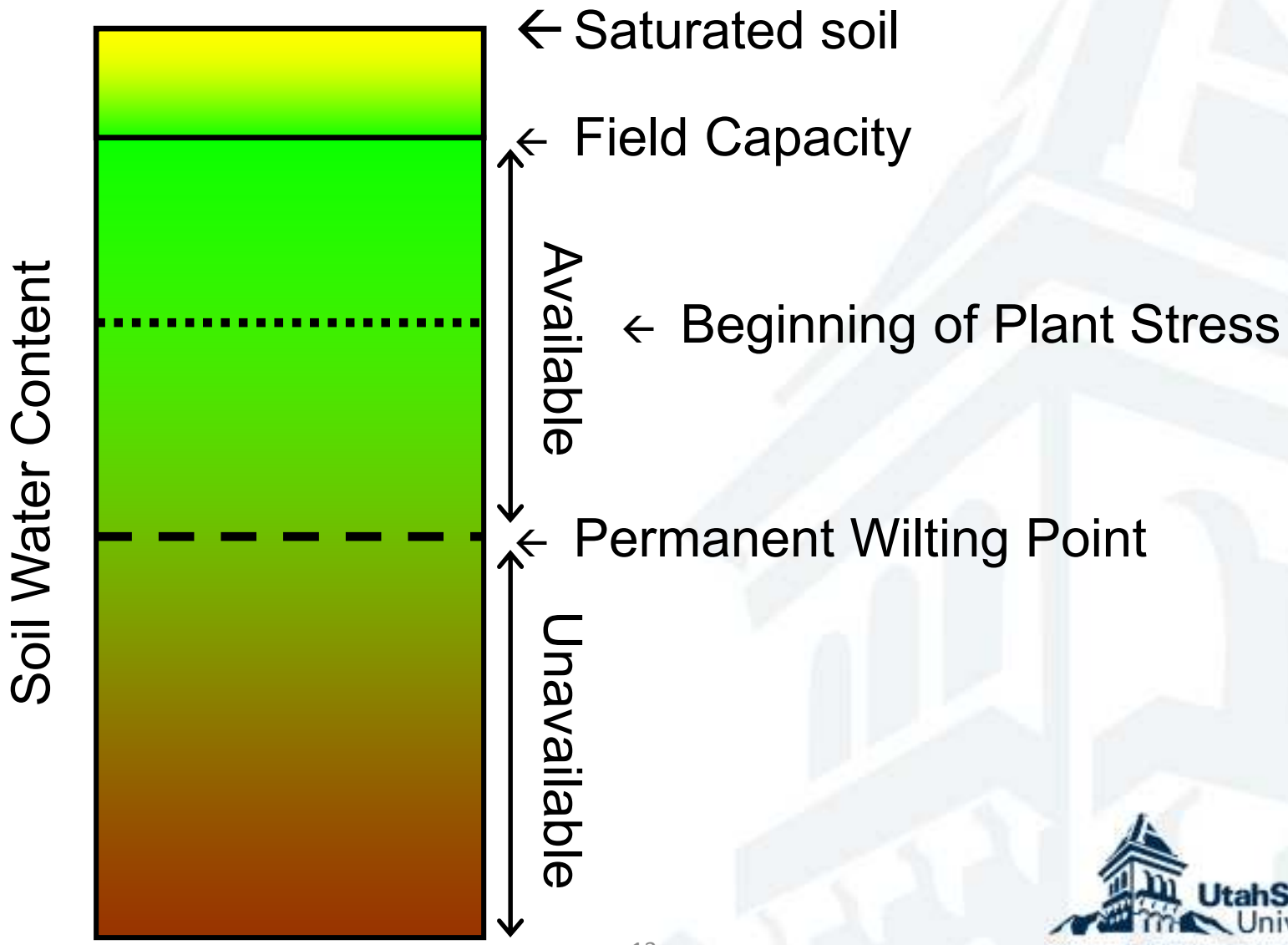
AgriMet Crop Coefficients

AgriMet estimates crop evapotranspiration (ETc) by first modeling *reference* evapotranspiration (ETr) from observed weather conditions at each weather station. AgriMet uses alfalfa as its reference crop. This reference ET is then multiplied by a crop coefficient (Kc) that varies through the season depending on the growth stage of the crop. Crop coefficients, from plant emergence to termination, define a growth curve know as a *crop curve* . The product of reference ET times the crop coefficient is the estimated crop specific consumptive use:

ETc = ETr * Kc

For more information on crop coefficients, see About Crop Curves . For information on specific crop coefficients, click on the links below. Note that these crop coefficients are for use with **Alfalfa** Reference (Tall Crop) ET.

Soil Water Content



Measuring Soil Moisture: Methods

- Soil Matric Potential (tension or suction)
  - Low number = more water
  - Indicates how hard a plant has to “pull” to get water
- Volumetric Water Content
  - Indicates the amount of water needed to recharge the soil

Determining Soil Moisture: Tensiometer

- Soil matric potential

  (tension or suction)
- Units = Centibars
  - Range 0 to 75 centibars

  Low number = more water

Determining Soil Moisture: Electrical resistance blocks

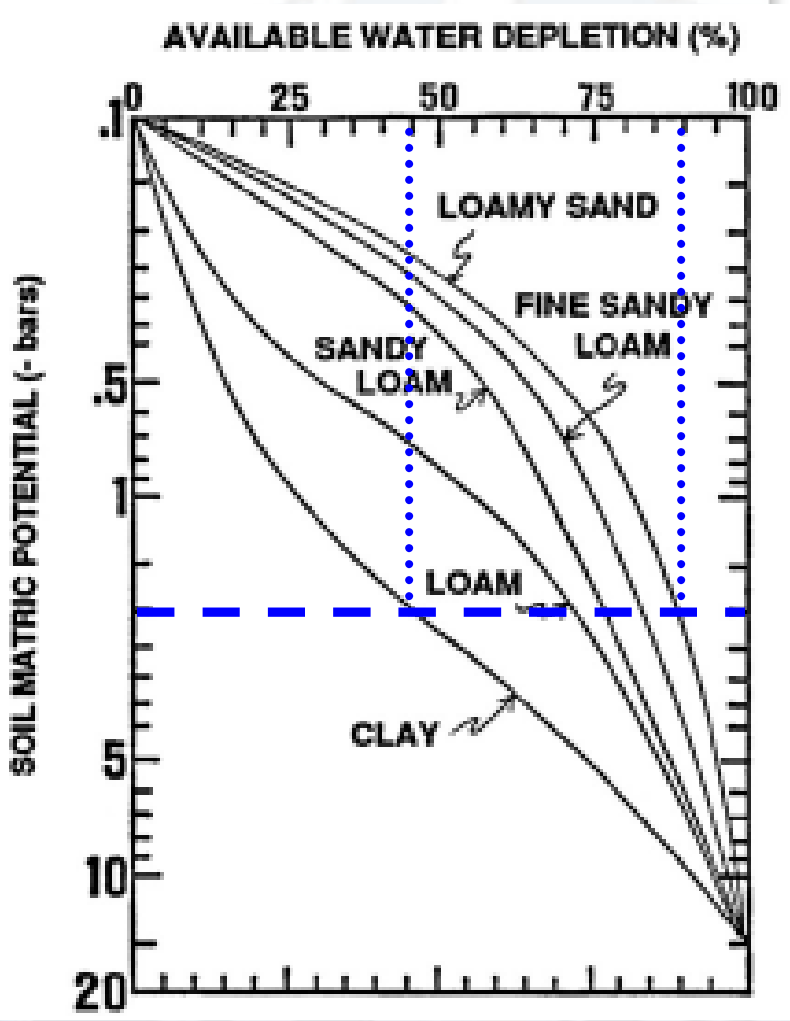
- Electrical conductivity

  Low number (resistance) = more water
- Units = Centibars
  - Range 0 to 200 centibars
- Price:
  - Sensors: $40 to $60 each
  - Meter: $300
- Readings vary by soil type
  - Require good soil contact
  - Salinity artificially elevates readings

Determining Soil Moisture: Resistance Block

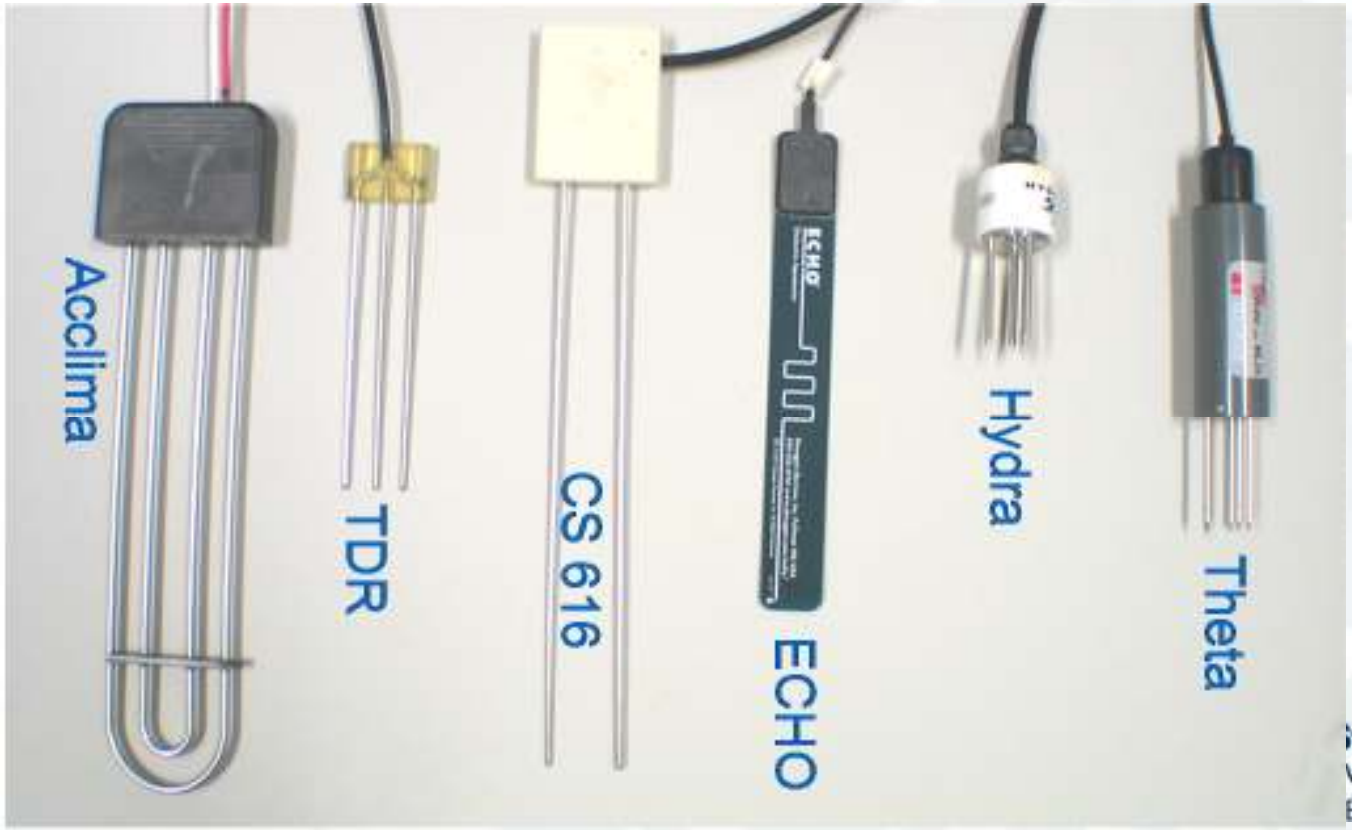
Resistance block readings in different soils

- Maximum readings (200)
  - Fine soil 45% depleted
  - Course soil 90% depleted



Determining Soil Moisture: Electromagnetic Probes

- Measure volumetric water content



Determining Soil Moisture: Volumetric water – Sentek

- Requires access tube
  - Capacitance of magnetic field
  - Measures very close to the tube
  - Tube installation is critical
  - Lengths of 3 and 4.5 feet
- Price:
  - Probe $2,600 - $2,700
  - Access tubes $55 - $60

Interpreting Volumetric Water

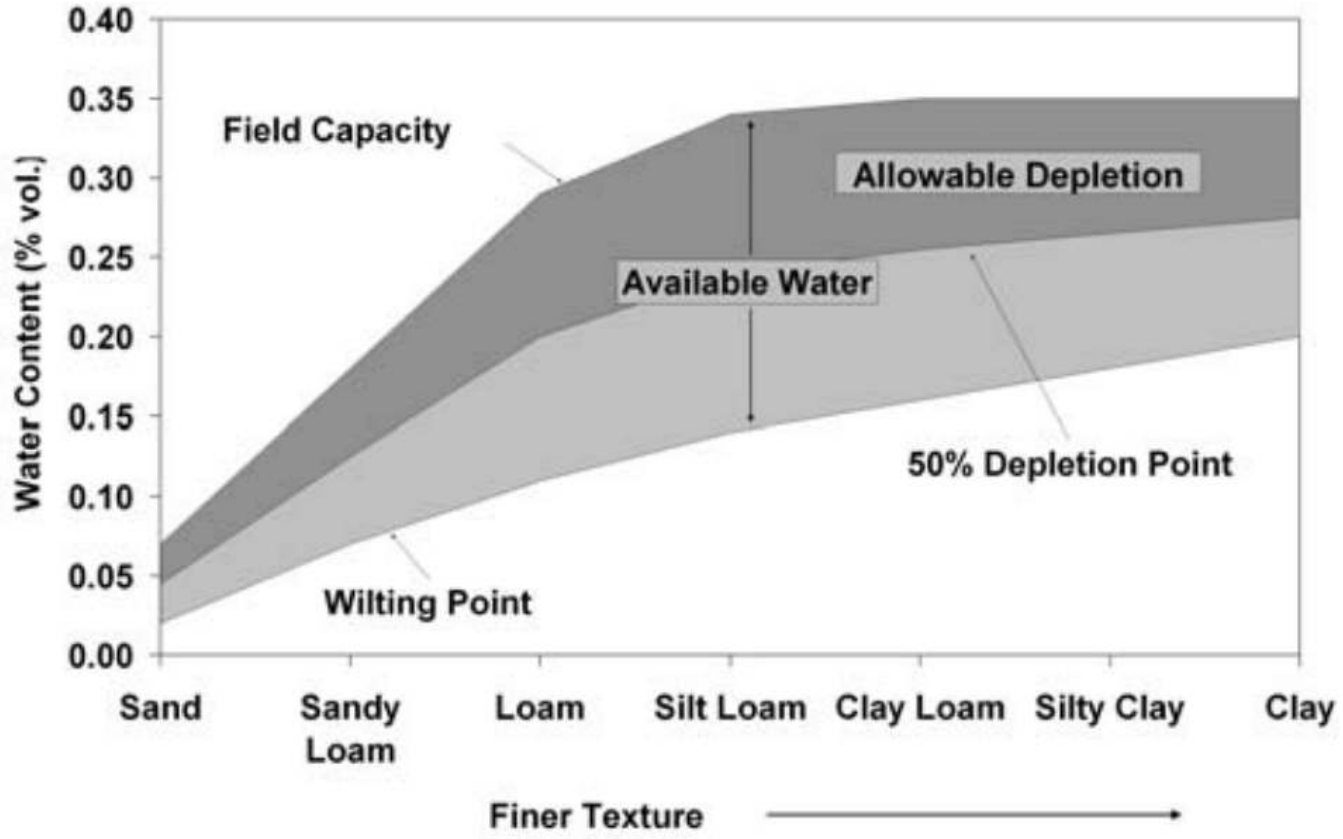
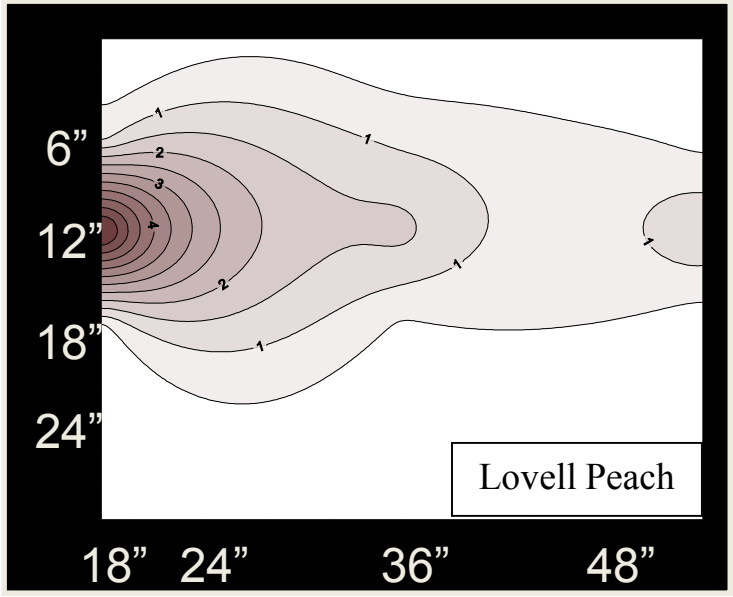


Figure 2. The amount of allowable depletion, or the readily available water, represents about 50 percent of the total available water.

Determining Soil Moisture: Where to measure?

- Monitoring depths
  - 6 to 8”
  - 24”



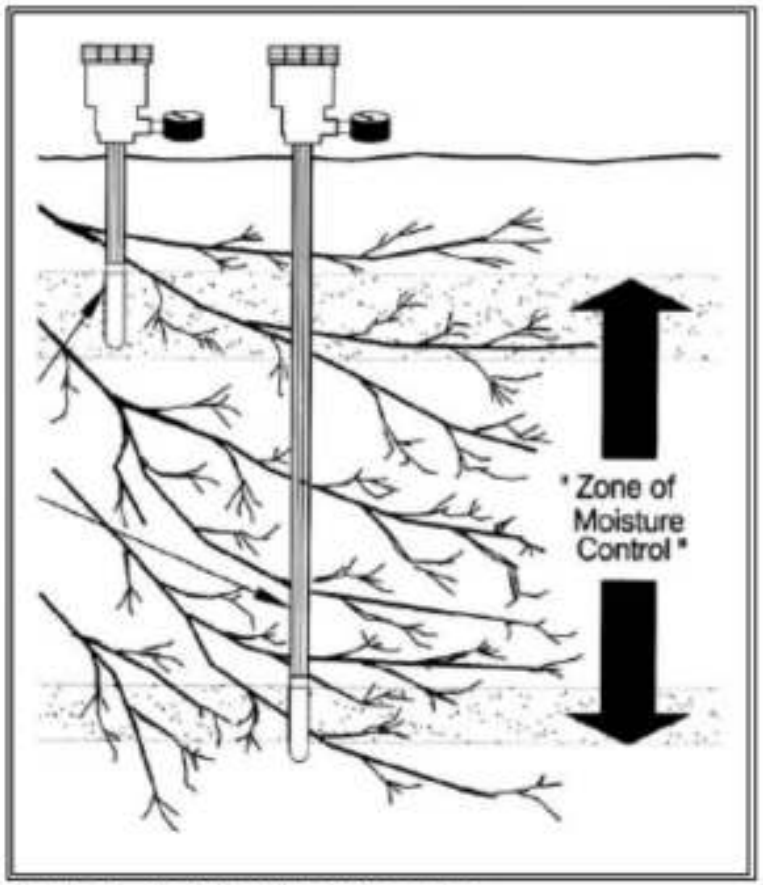


Figure 5 Soil Moisture Measuring

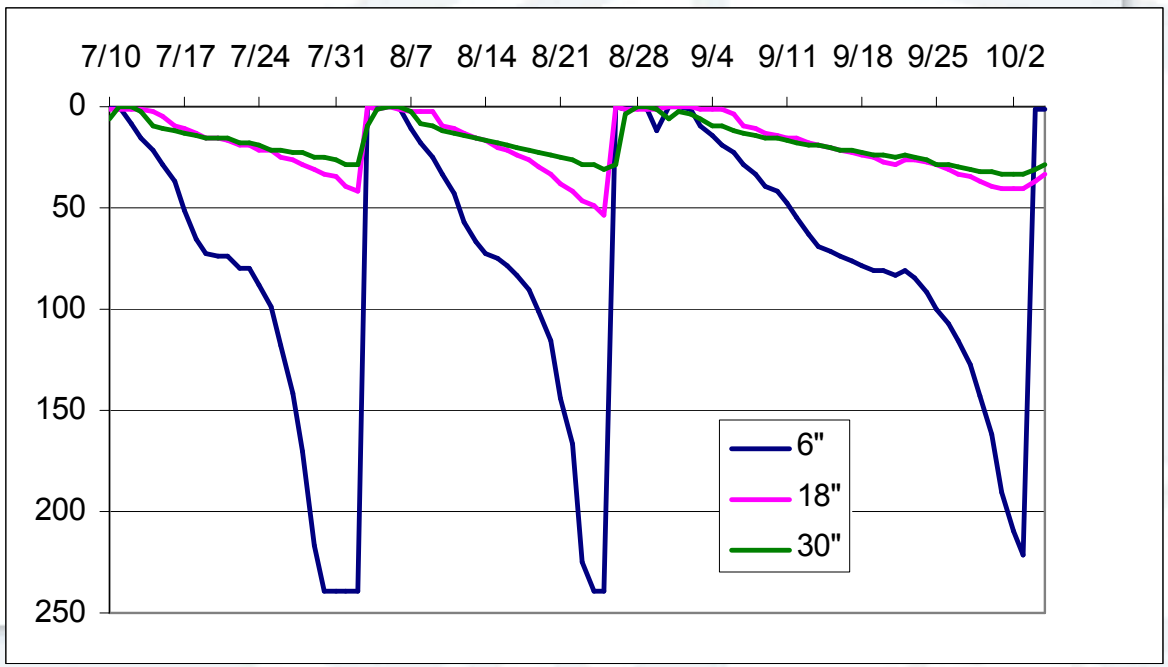
Determining Soil Moisture: Automated system

- Dedicated data loggers
  - WaterMark ($400 - $600)
  - M.K. Hanson
  - Watchdog
- Linked to weather station

Learning from an automated system

- 10-year-old peach block
- Box Elder County
- Under-tree sprinklers
- Clean cultivated soil

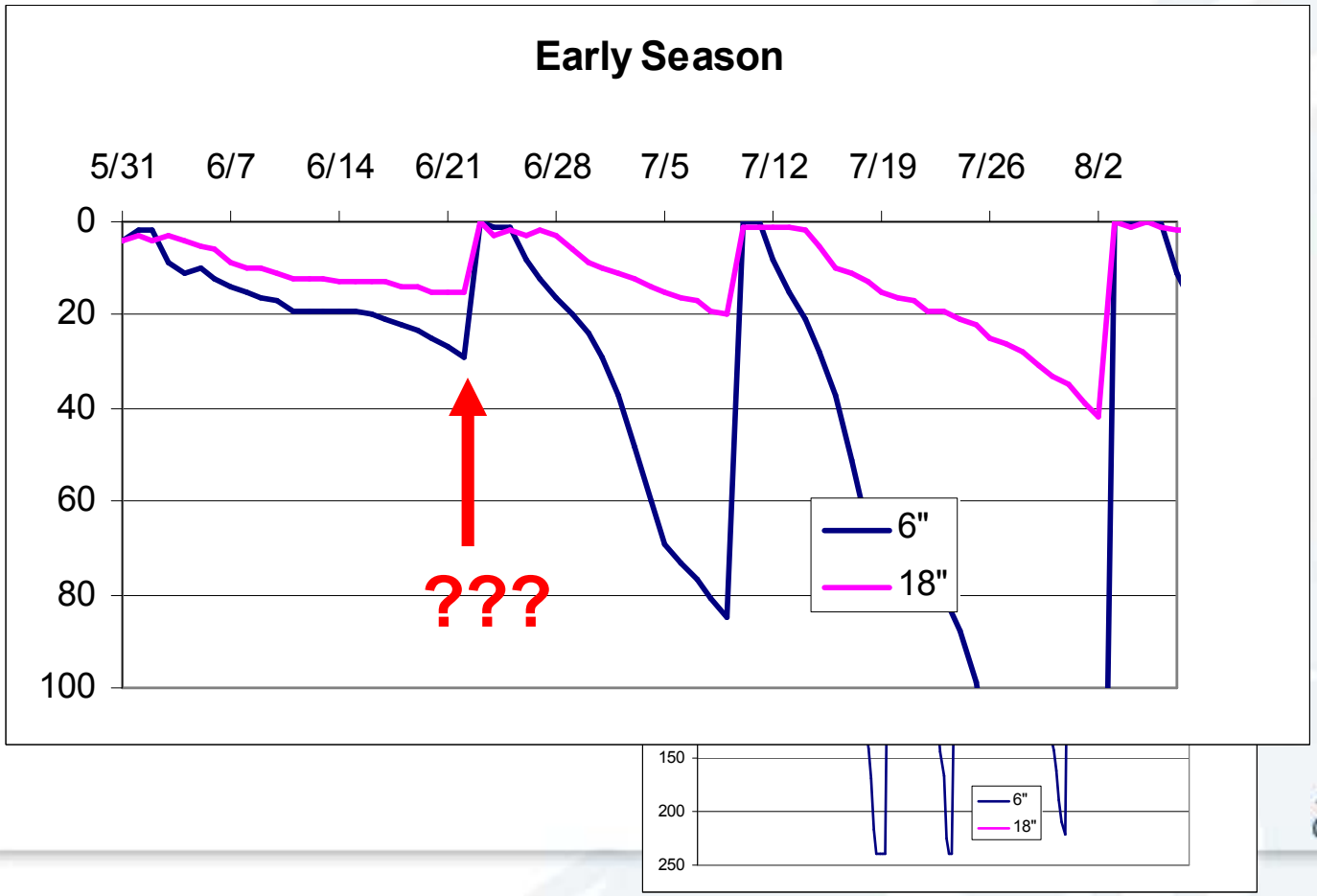
- Data logger
  - 6”
  - 18”
  - 2.5’



Soil moisture

What can we learn?

Is it needed?



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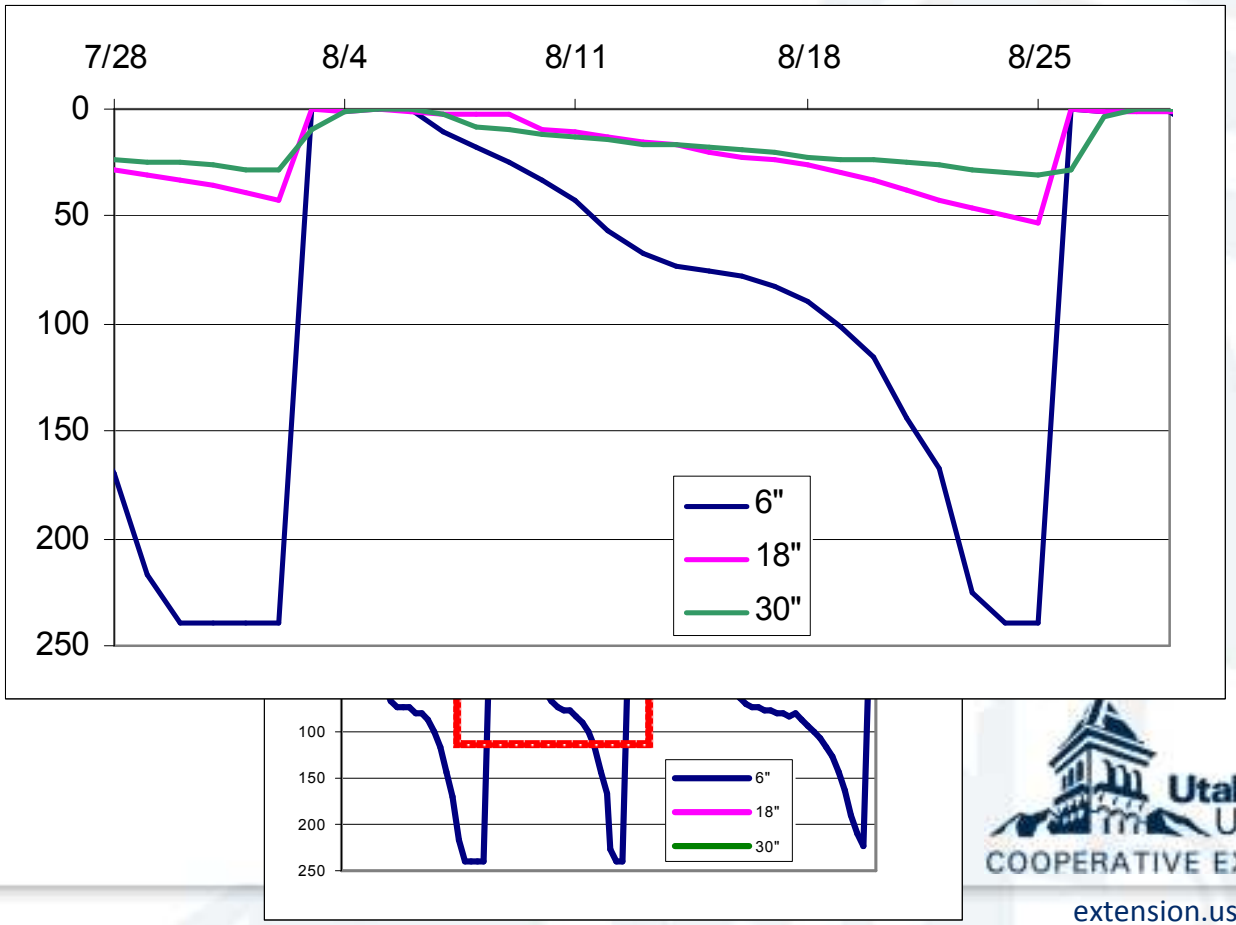
Soil moisture

What can we learn?

Quantity



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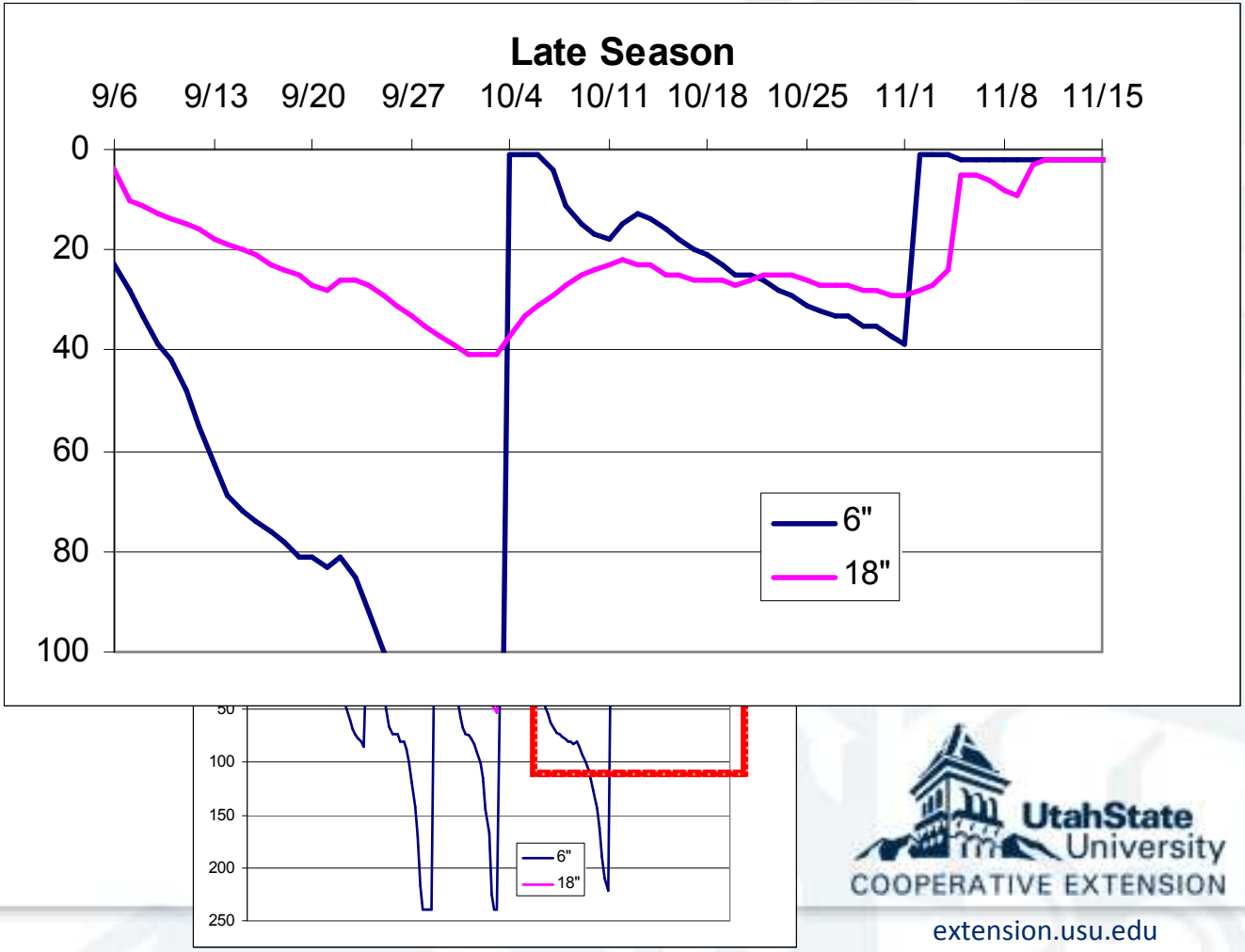
Soil moisture

What can we learn?

Quantity



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Plant-based system: What is the tree feeling?

- Mid-day stem water potential
  - How hard is the tree "pulling" to get water?

- Practical for a grower?

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Regulated Deficit Irrigation

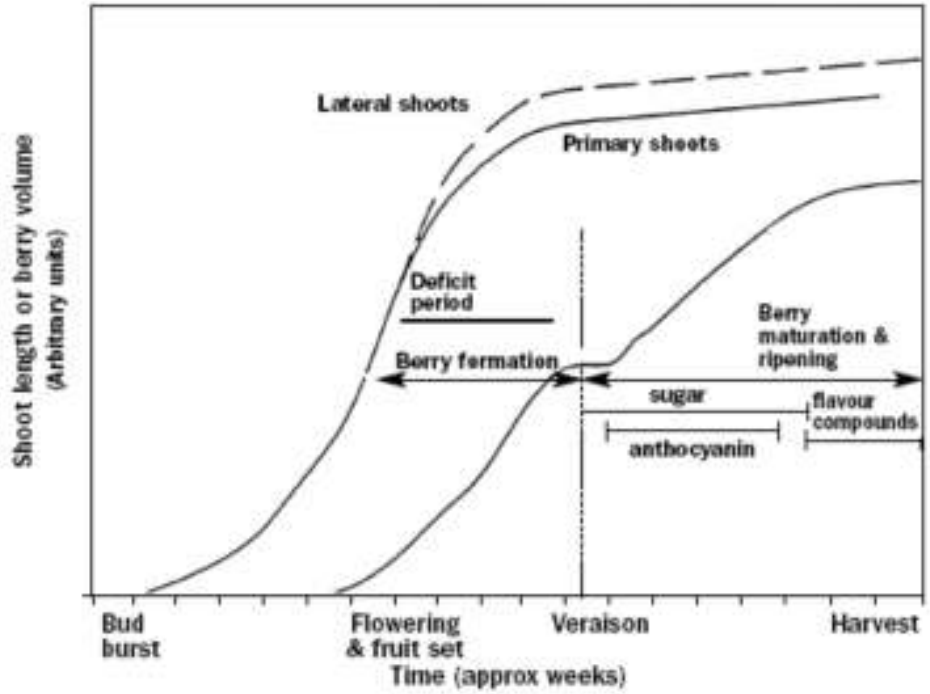
- Deficit ≡ less coming in than going out

  deficit irrigation ≡ intentional drought stress
- Regulated ≡ specific timing and severity

- Why?
  - Save water
  - Induce some type of favorable crop response

Regulated Deficit Irrigation (RDI)

- Grape
  - Fruit quality
    - Color
    - Sugar
    - Flavors
  - May reduce fruit size!
    - Apple
    - Peach
    - Sweet cherry



Kriedemann and Goodwin

RDI for Tart Cherry?

- Water savings
- Reduced shoot growth?
- Improved fruit quality

RDI for Tart Cherry?

- Water savings.
- Reduced shoot growth?
- Improved fruit quality.
- Improved tree health.

Growth Stages – *fruit development*

Tukey and Young (1939)

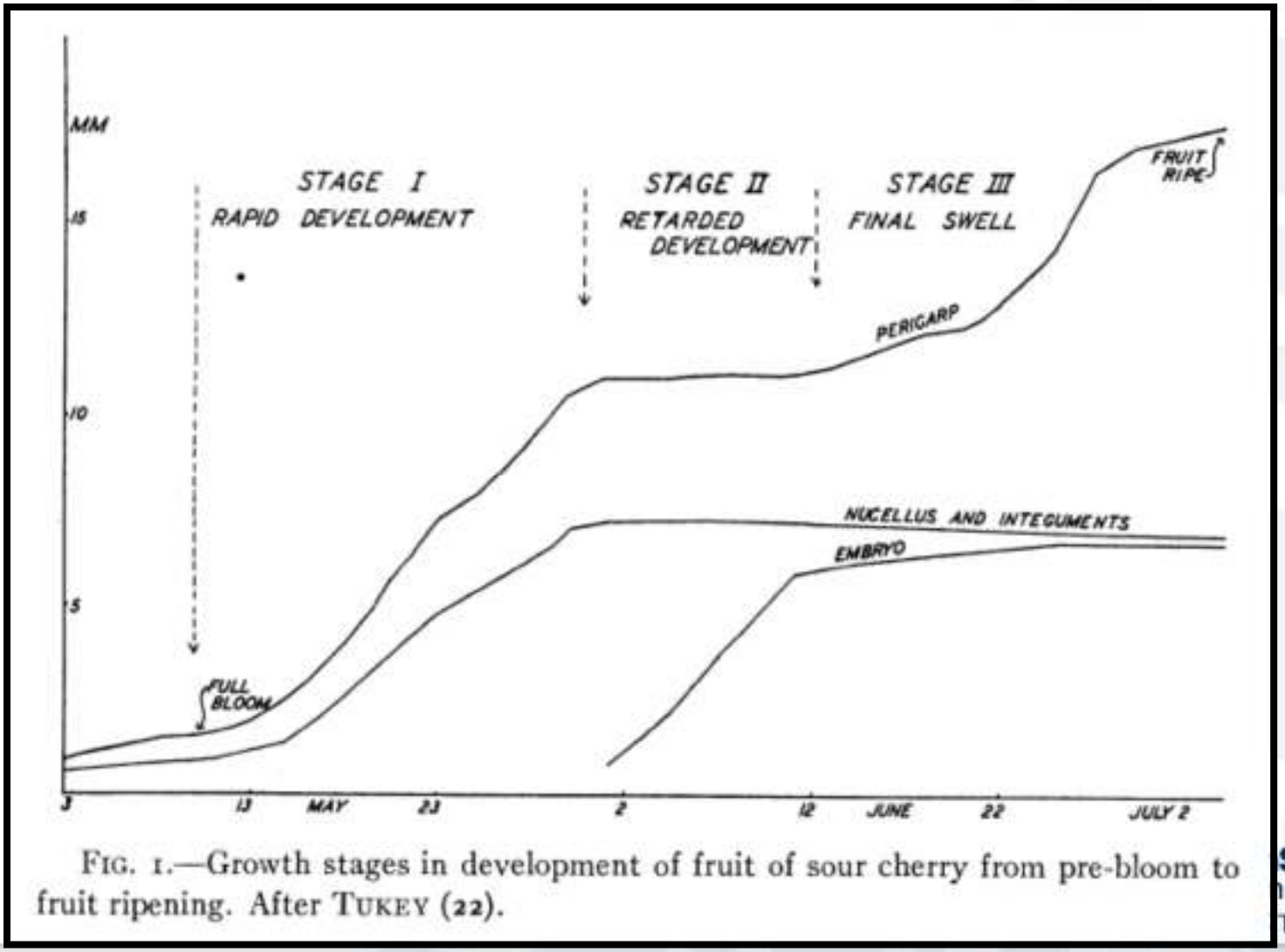
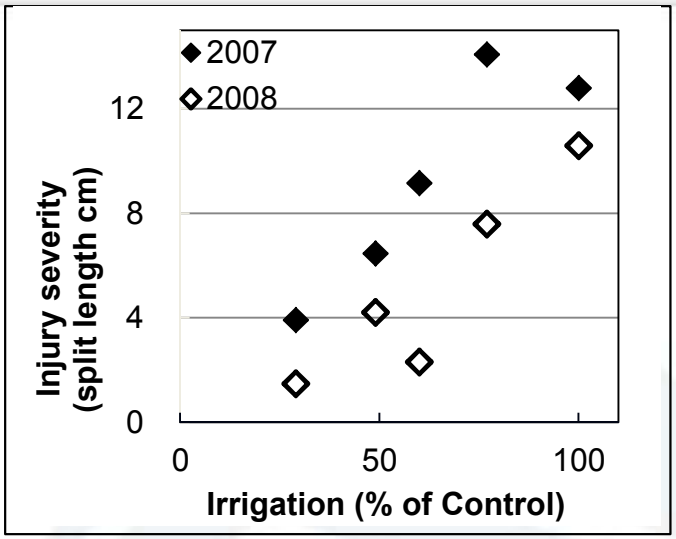
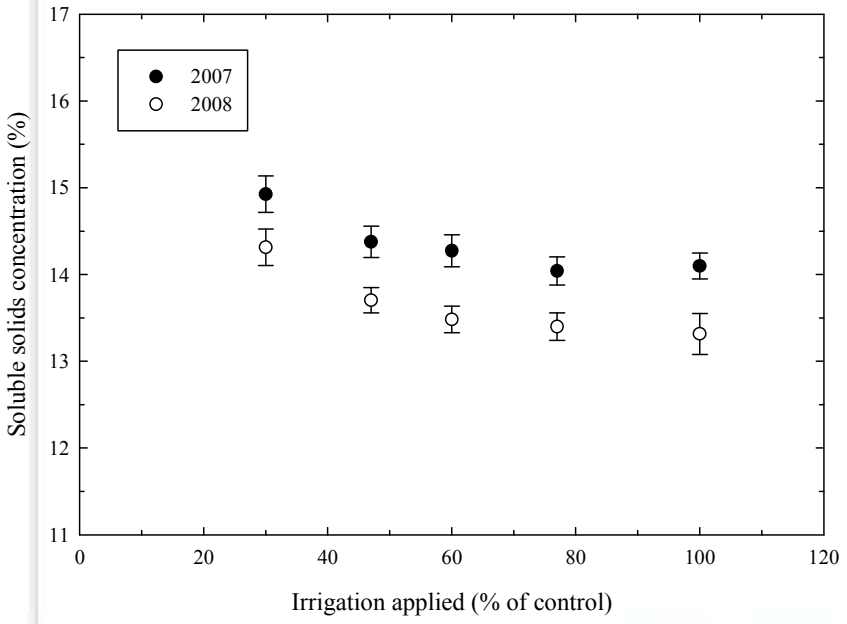
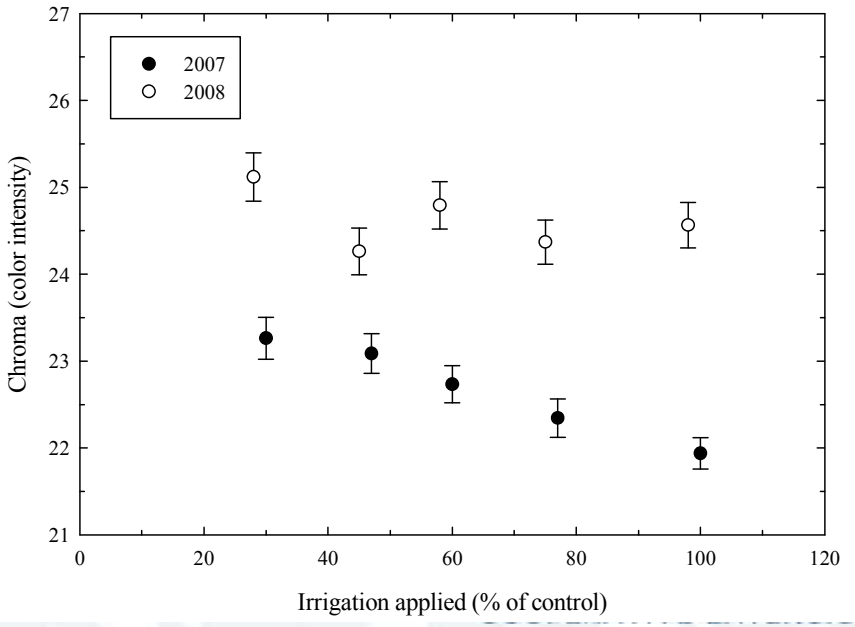


FIG. 1.—Growth stages in development of fruit of sour cherry from pre-bloom to fruit ripening. After TUKEY (22).

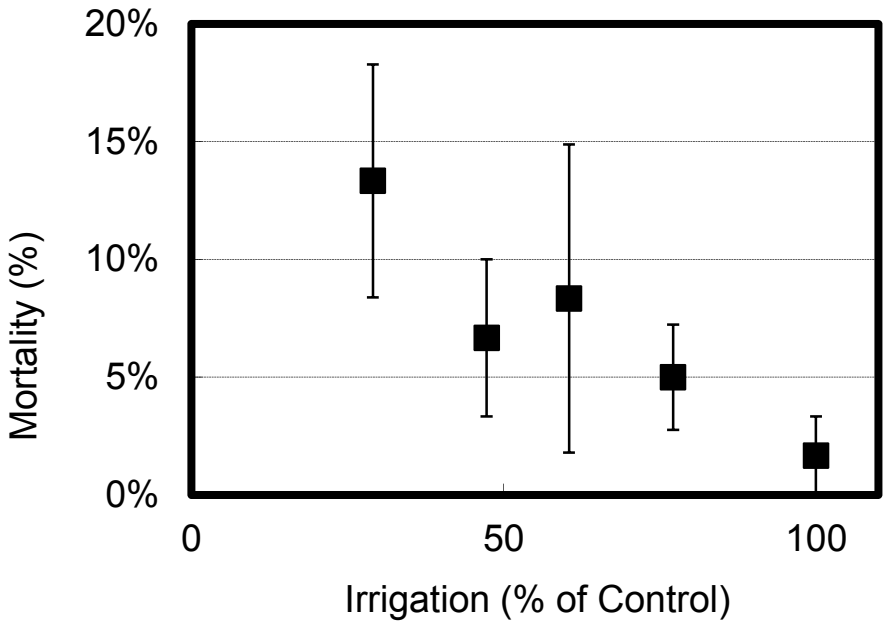
- 2007 and 2008
  - Moderate crop load
  - No effect on yields
  - Only slight effect on fruit size
  - Improved fruit quality
  - Reduced trunk injury

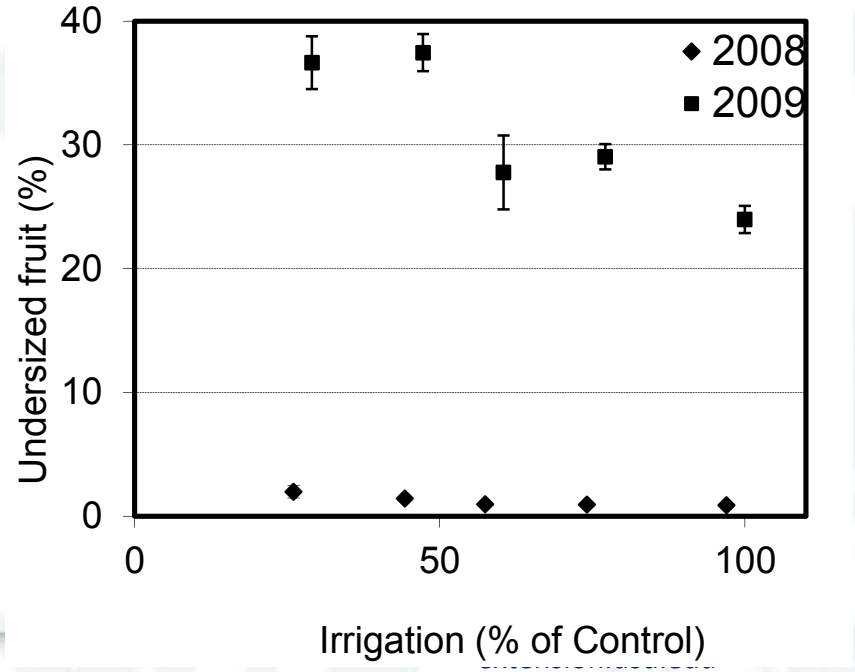




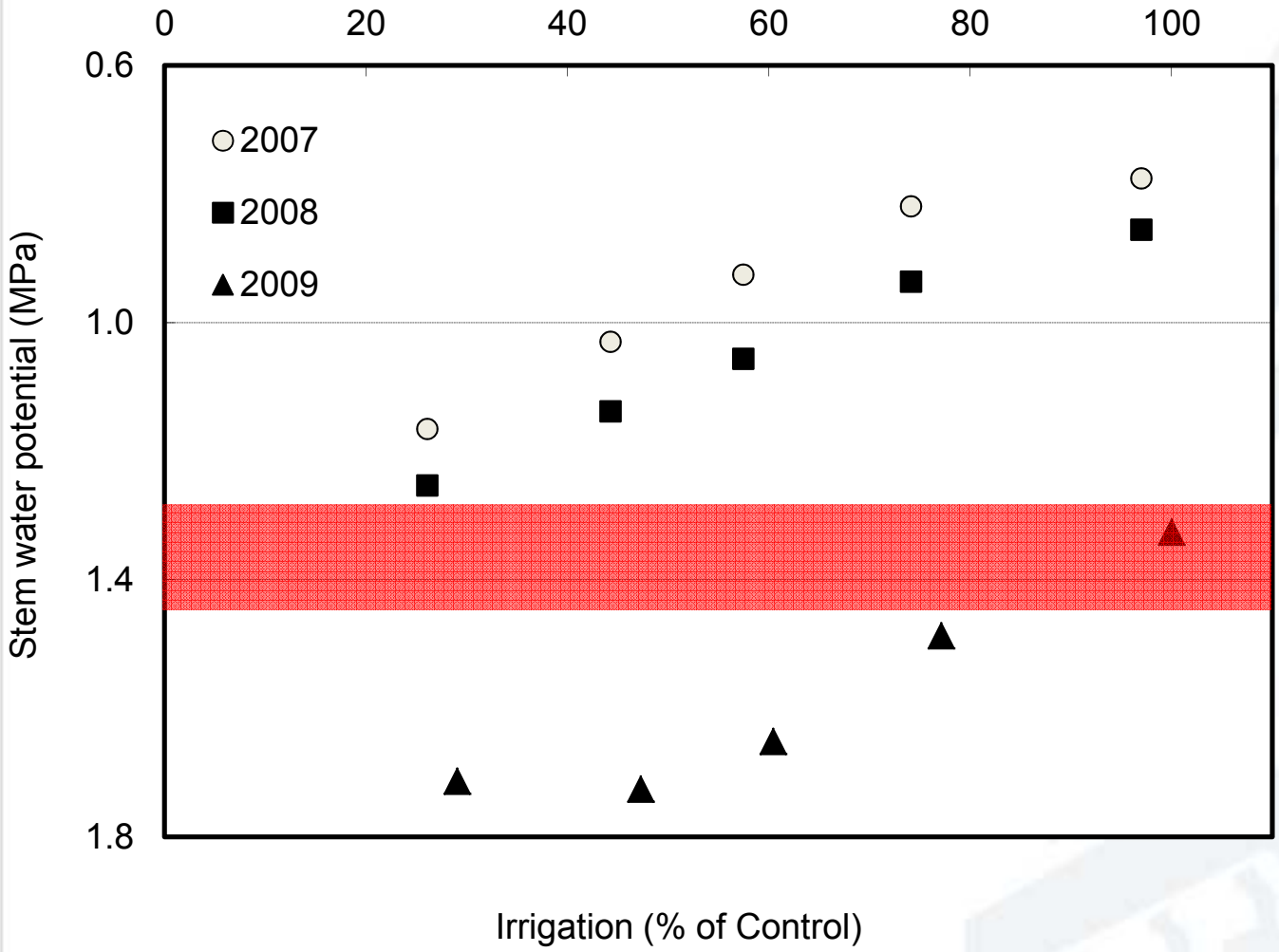


- 2009
  - Heavy bloom and very good fruit set
  - Huge crop load
  - Irrigation deficit reduced yields
  - Reduced fruit size (lower packout)
  - Tree mortality





Mid-day stem water potential



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Plant-based approaches

Measurement methods

- Stomatal conductance

- Leaf temperature

- Leaf water potential

- Stem water potential

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Measurement methods

- ~~Stomatal conductance~~

- ~~Leaf temperature~~

  Canopy temperature?

- ~~Leaf water potential~~

- Stem water potential

Canopy Temperature

- Specific needs
- Light breeze
- Clear sky
- Low humidity
- Uniform canopy

- Moderate crop load
- Careful positioning (background)

Plant-based approach

- Xylem water potential?

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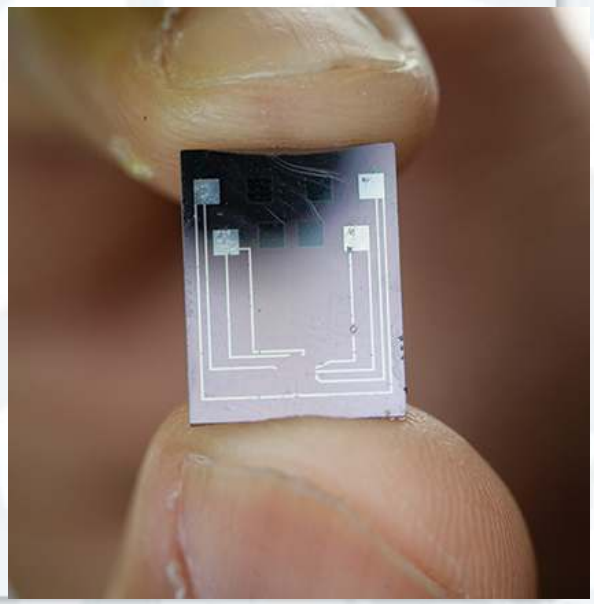

Summary

- Weather-based scheduling
  - Resources available in Michigan
- Soil moisture monitoring
  - Automated systems useful to fine tune timing and quantity
- Plant water status
  - Technology is evolving
- Deficit irrigation
  - Can reduce trunk injury
  - Proceed with caution