NYFVI Precision Irrigation Project:

Using Soil Electrical Conductivity Measurements for Precision Water Management in Vegetable Crops – Year 1 Research Update

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Study Says Early Sprir In Next 30 Years

Posted By: Christina Herrick | Email

September 6, 2016

Warm springs in the Great Lakes and North growers – may start earlier by mid-century i reduced, according to a new Cornell Univers Dynamics.

Very warm springs have been anomalies, bu shows an increased frequency to nearly one i century.

"The spring of 2012, with its summerlike wa and then had a lengthy freeze. This was a nig it showed us a snapshot of what global warm Toby Ault, Assistant Professor in Earth and University, an author on the study.

Unusually warm temperatures early in sprin breaking records in more than 15,000 U.S. s

Modeling shows that frequency and magnitu than a month earlier, for example, througho

"The time to act on curbing greenhouse gas 2012 – ruinous to farmers and producers – i 40 years from now in addition to a host of ot

The researchers sought to understand seaso as climate change unfolds. To ensure their n distinguished and separated normal climatic alterations by using a new ensemble of clima

Meteorologists said March 2012, the earliest interrupted winter plant dormancy. After a v blossomed earlier than usual that spring. Te were destroyed. Economic losses mounted.

Drought Rages On In Northeast

Posted By: Christina Herrick | Email • September 10, 2016

Dry conditions continue to expand into the Finger Lakes region of New York, with almost 10% of the state now in extreme drought, according to the latest data from the U.S. Drought Monitor.

Extreme drought conditions also expanded in New Hampshire, up to double digits this week.

David Simeral, of the Western Regional Climate Center, reports temperatures were one to five degrees above normal in the Northeast.

Last week, natural disaster funding was made available for growers in New York, Massachusetts, Pennsylvania, and New Hampshire, whose crops were affected by the drought conditions this growing season.

While the drought rages on in the Northeast, growers are highlighting one benefit of drought stress – higher Brix in fruit to be harvested.

"Peaches love heat. This hot weather we had in August – peaches love that," Jim Bittner of Bittner-Singer Orchards in Appleton, NY, tells *The Buffalo News*. "They take that sunlight and turn it into sugar."

"The apples are going to be smaller, but hopefully sweeter," Alfred Wodehouse of Stonehill Orchards in North Collins, NY, tells *The News*.

Project Challenge: Increasing Irrigation Water Scarcity

- There is **increasing water scarcity** as a result of growing population and changing climate.

- There is, therefore, the urgent need for efficient irrigation water management practices.

But…,
do we really need water?

- 1 kg of apples .... 200 l of water

Information courtesy of Jaume Lordan Sanahuja

Dept. of Horticulture, NYSAES, Cornell University

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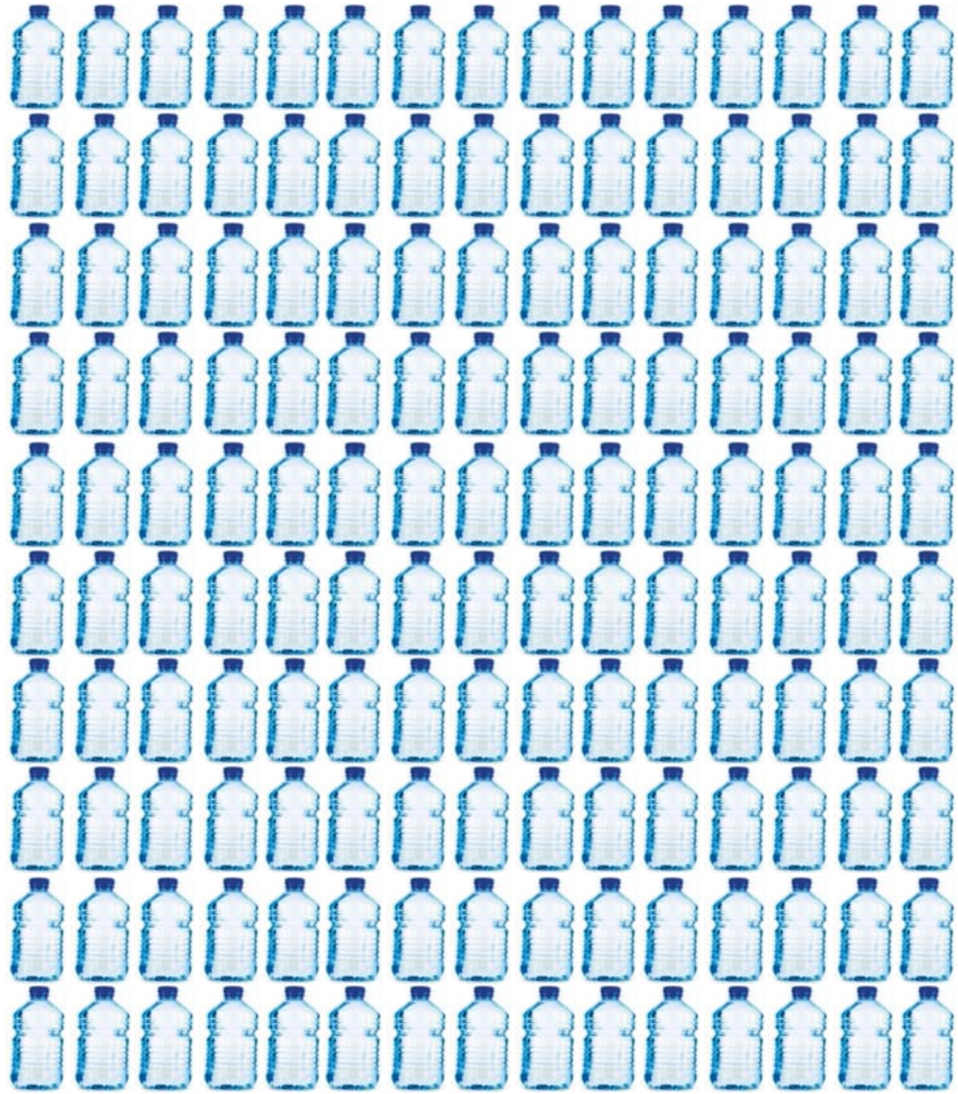

Information courtesy of Jaume Lordan Sanahuja

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- 1 kg of apples .... 200 l of water
- 1 liter of milk .... 1,000 l of water
- 1 beef steak .... 1,200 l of water
- 1 Hamburger .... 1,400 l of water

Water demands to feed population:

- 1 person/day .... 3,500 – 4,500 l of water
- 1 family/day .... 14,000 l of water
- 1 person/year .... 1,460 m^3 of water
- 1 family/year .... 5,110 m^3 of water

Information courtesy of Jaume Lordan Sanahuja
Dept. of Horticulture, NYSAES, Cornell University

Why irrigate

Functions of water in plants:

- ✓ Mantenance of cell turgor
- ✓ It regulates the plant temperature (through transpiration)
- ✓ Uptake & transport of nutrients & secondary plant compounds
- ✓ Element involved in many internally chemical processes (Photosynthesis)

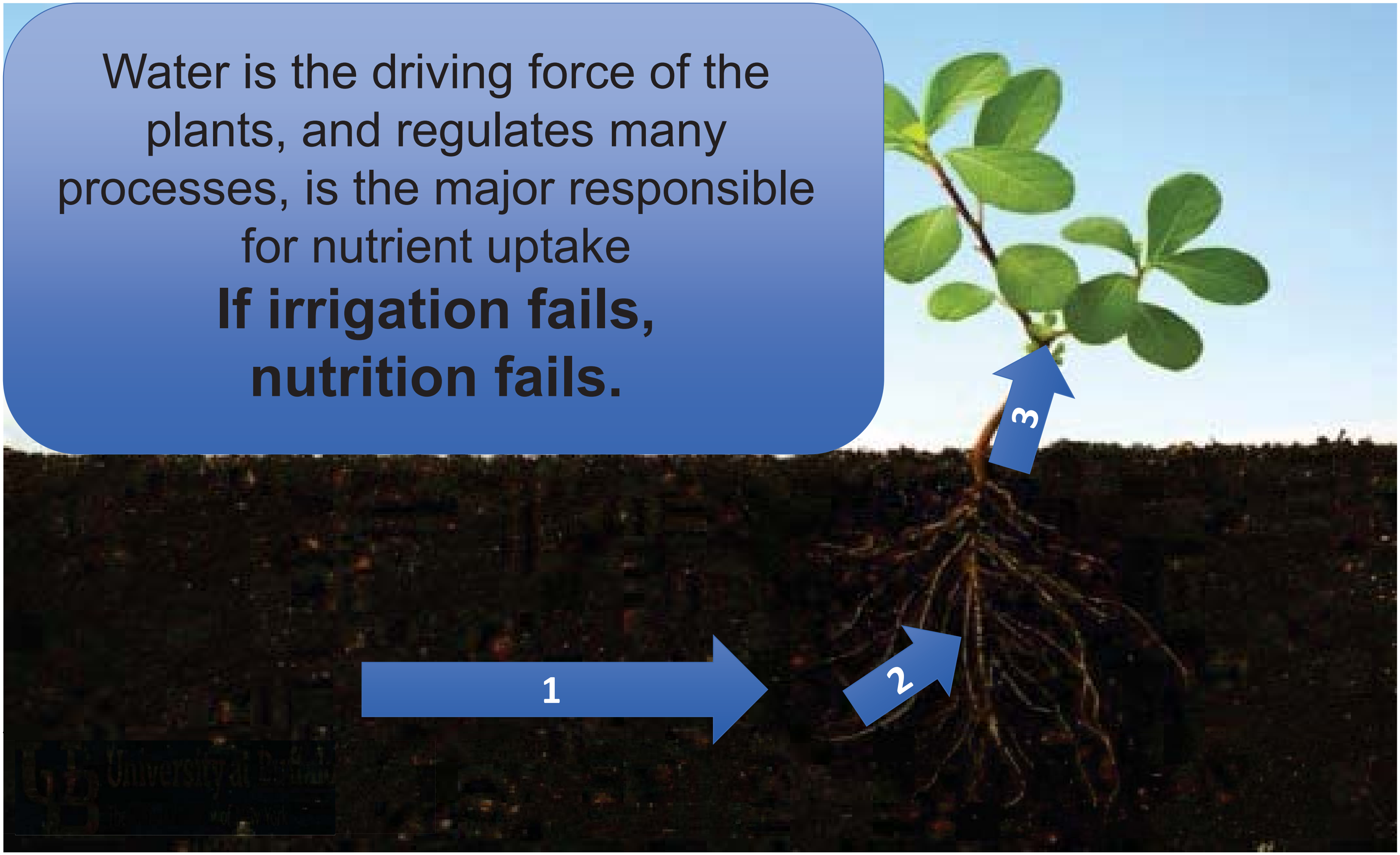
What if water is missing?

Nutrient Uptake

Information courtesy of Jaume Lordan Sanahuja
Dept. of Horticulture, NYSAES, Cornell University

Water is the driving force of the plants, and regulates many processes, is the major responsible for nutrient uptake

If irrigation fails, nutrition fails.



Why Irrigate?

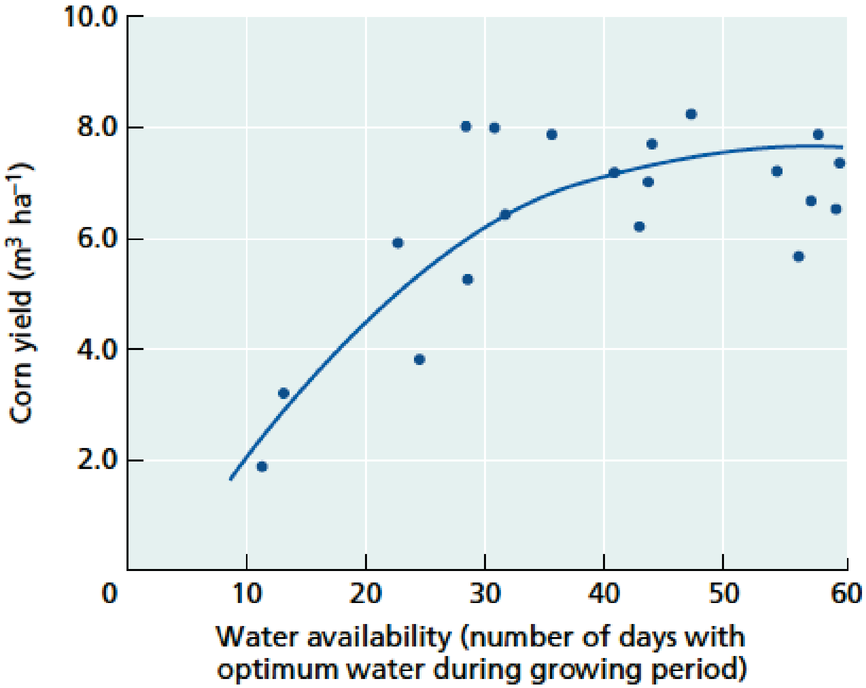


FIGURE 3.1 Corn yield as a function of water availability. The data plotted here were gathered at an Iowa farm over a 4-year period. Water availability was assessed as the number of days without water stress during a 9-week growing period. (Data from *Weather and Our Food Supply* 1964.)

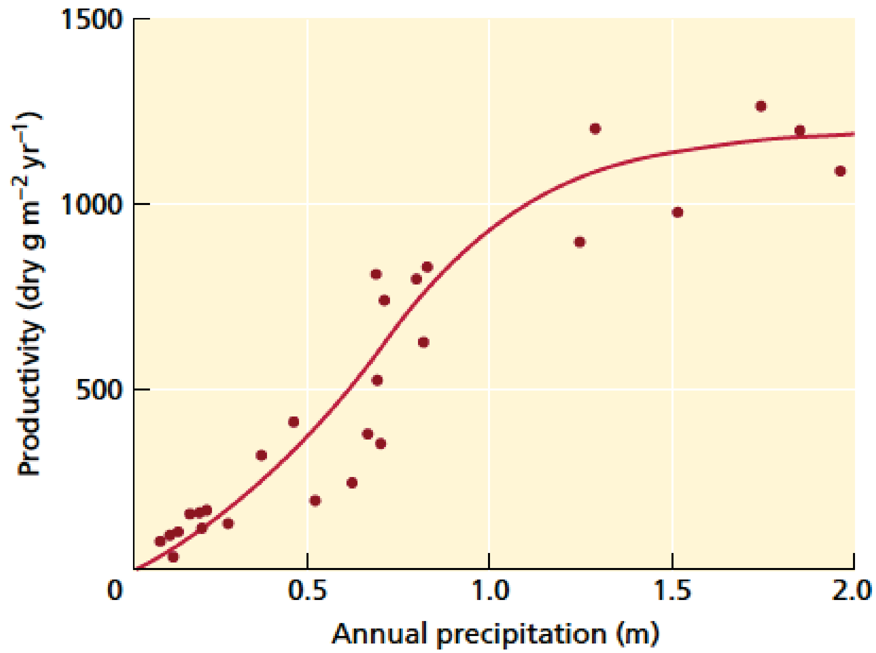


FIGURE 3.2 Productivity of various ecosystems as a function of annual precipitation. Productivity was estimated as net aboveground accumulation of organic matter through growth and reproduction. (After Whittaker 1970.)

Information courtesy of Jaume Lordan Sanahuja
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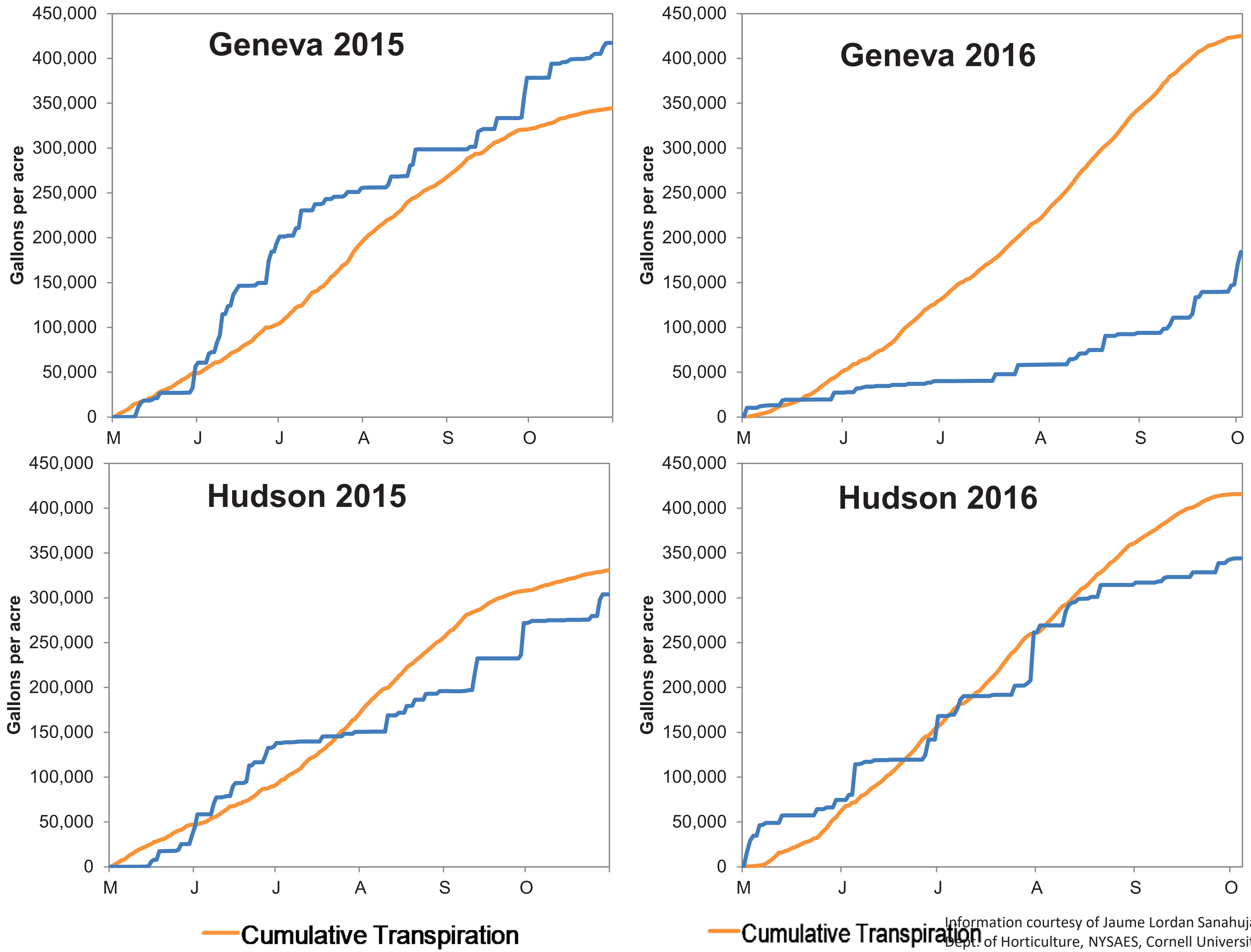

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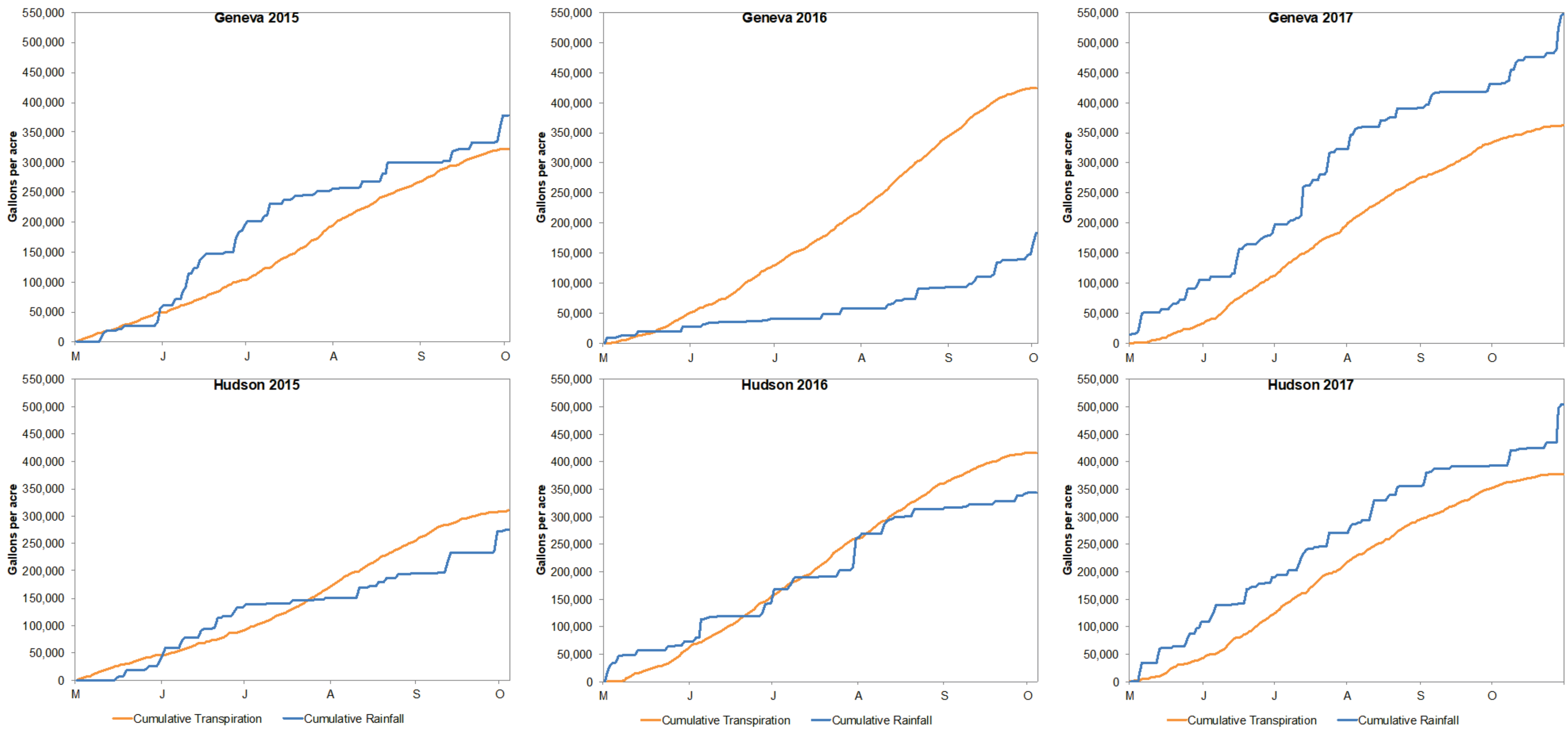

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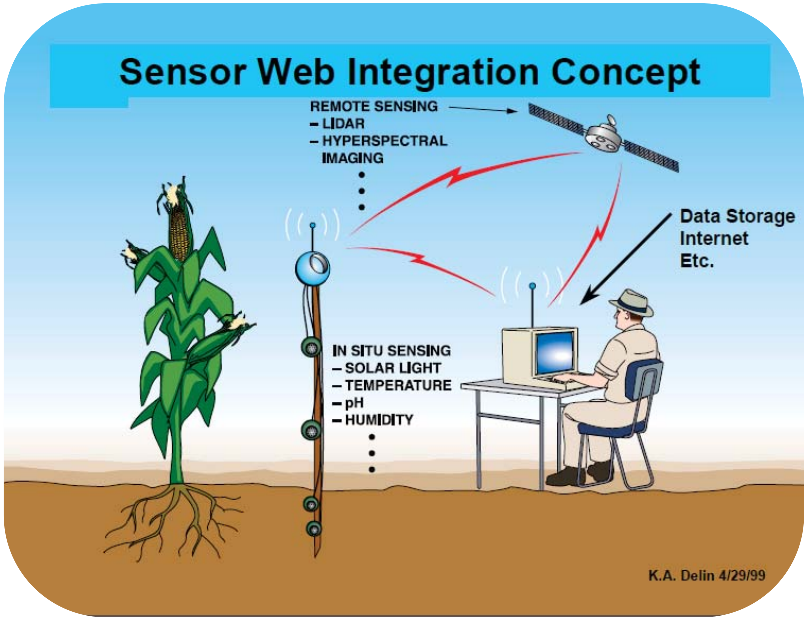
How to irrigate?



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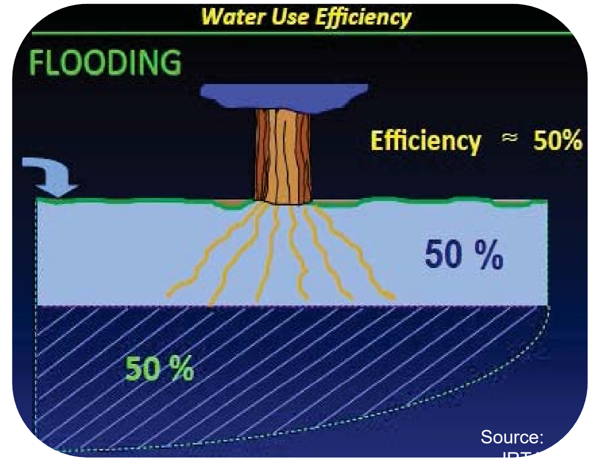
Automating Irrigation **Scheduling** – Basic Principles

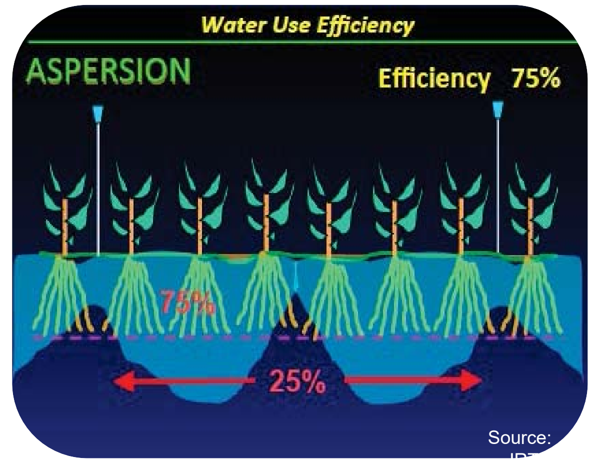
- Irrigation scheduling: calculating irrigation dose & how to implement it

- Need to know:
  - ✓ Location & weather
  - ✓ Crop
  - ✓ Soil

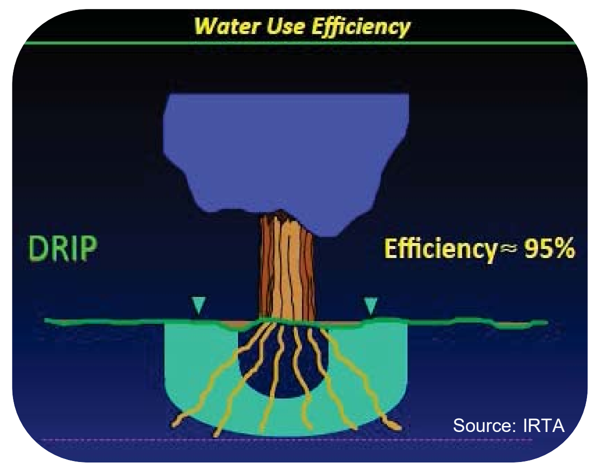
Flooding



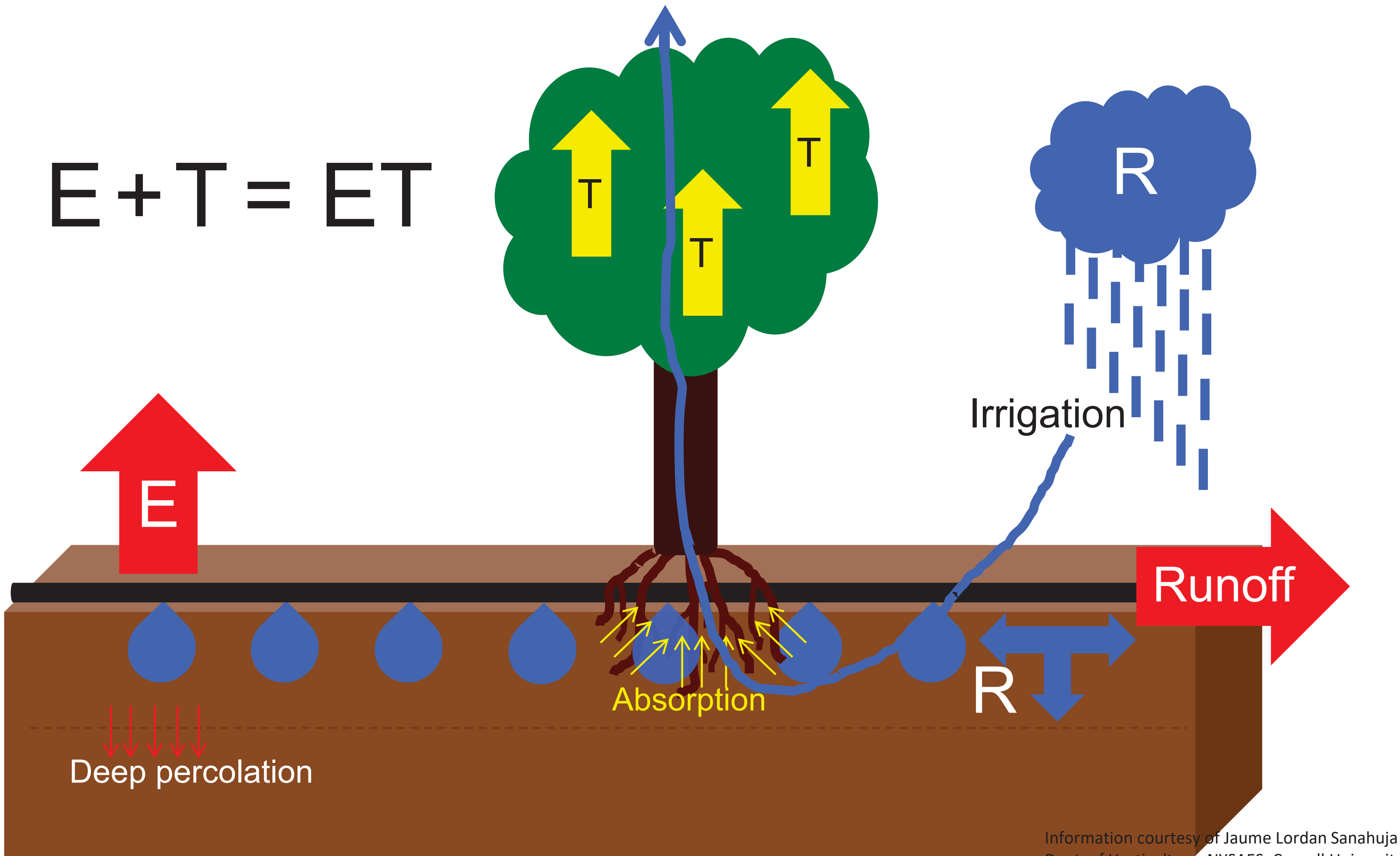
Aspersion



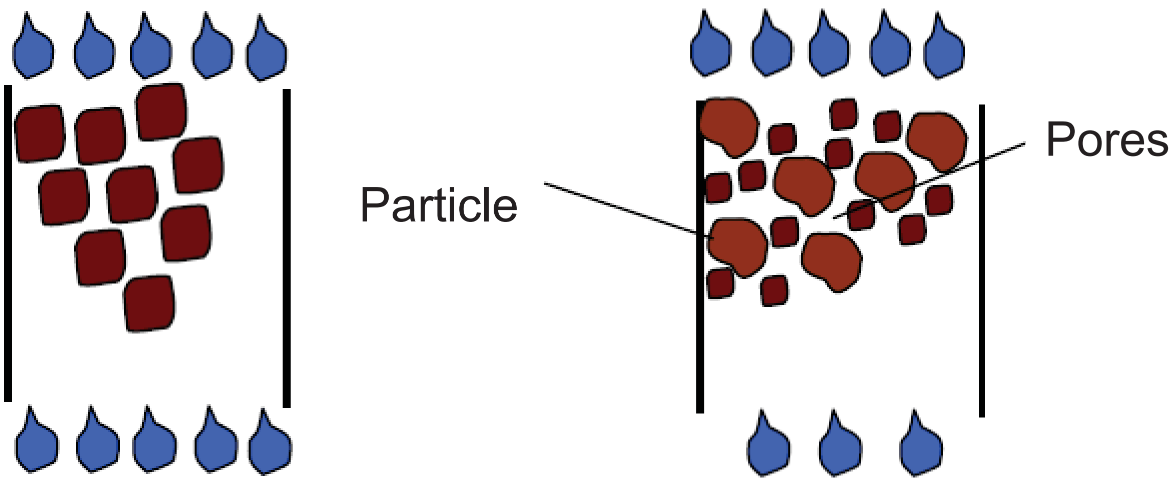
Drip



Water use & irrigation requirements

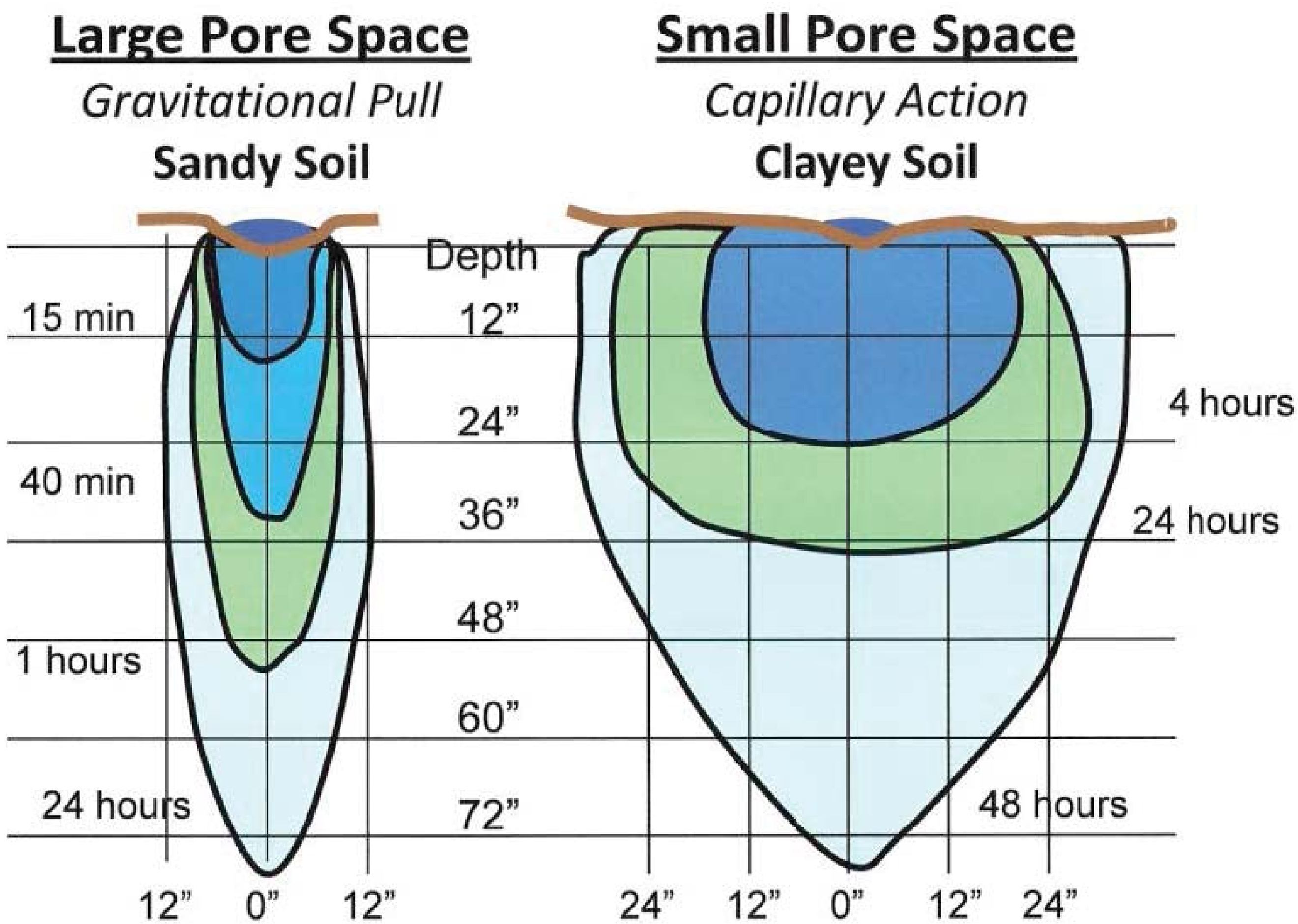


Each soil has its own properties

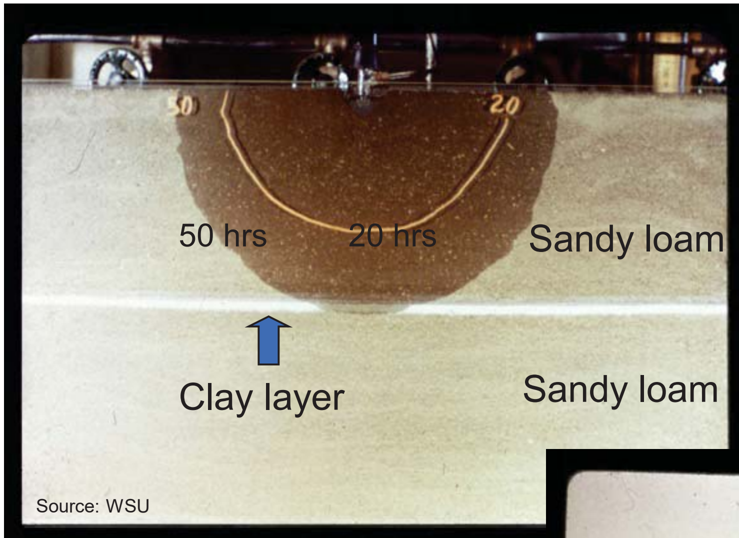


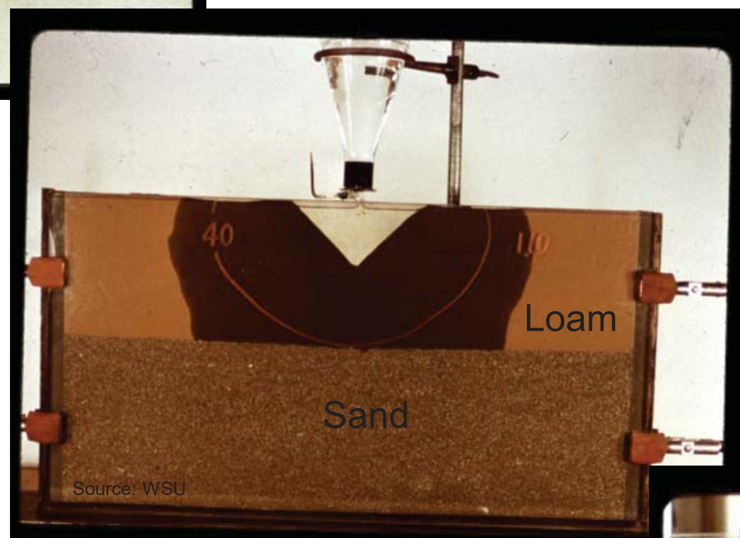
Sandy soil	Loam type soil	Clay soil
Quick drainage **Low humidity retention**	**Slow drainage, but not limiting** **Good humidity retention**	**Very slow & poor drainage** **High humidity retention** **Aireation problems**

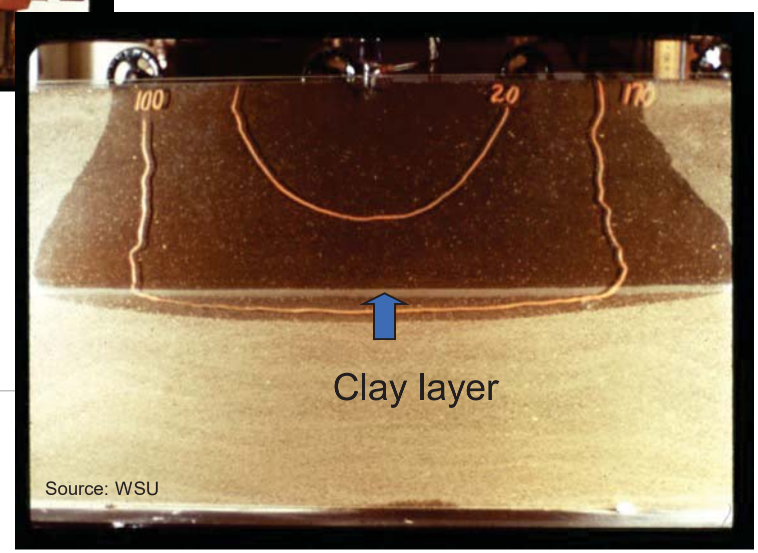
Source: agriculture.vic.gov.au



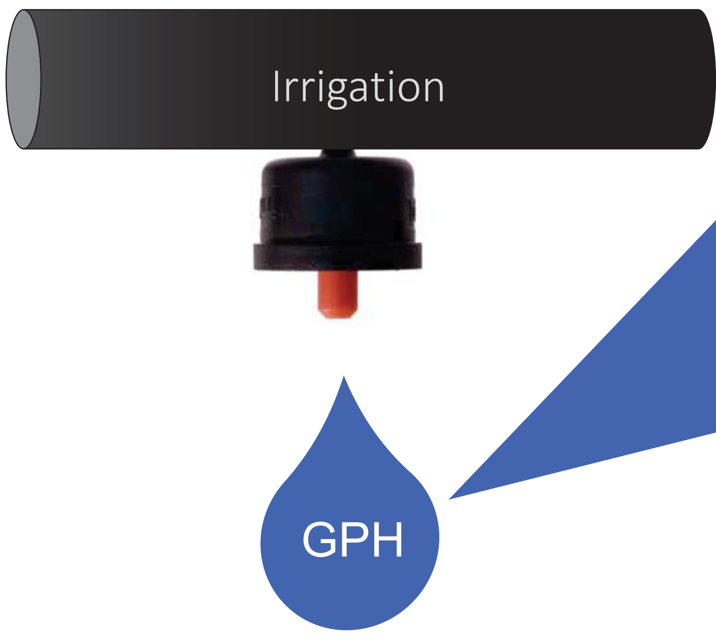
Source: intechopen.com


50
20
50 hrs
20 hrs
Sandy loam
Clay layer
Sandy loam
Source: WSU


40
1.0
Loam
Sand
Source: WSU


100
2.0
170
Clay layer
Source: WSU

When?



If we need to irrigate 10,526 gallons/acre:

$$\frac{10,526}{1037} = 10 \text{ h}$$

Sandy soils irrigate daily: 1.6 h/day

Clay soils irrigate twice a week: 5 h/day

Available water in relation to soil textural class

Soil type:

- Sand 1"/ft → 1" * 27154 gallons/inch = **27,154 gallons/acre** *0.1 = 2715 gallons/acre
- Sandy loam 2"/ft → 2" * 27154 gallons/inch = **54,308 gallons/acre** *0.1 = 5431 gallons/acre
- Loam 3" → 3"/ft * 27154 gallons/inch = **81,462 gallons/acre** *0.1 = 8146 gallons/acre
- Clay loam 3.8"/ft → 3.8" * 27154 gallons/inch = **103,185 gallons/acre** *0.1 = 10318 gallons/acre
- Clay 4" → 4"/ft * 27154 gallons/inch = **108,616 gallons/acre** *0.1 = 10862 gallons/acre

Information courtesy of Jaume Lordan Sanahuja
Dept. of Horticulture, NYSAES, Cornell University

Automating irrigation **schedulling** – dose

Water Balance with the FAO/Penman-Monteith (FAO-56) model:

Weather data

2

Estimate ETc

ETc = ETo * Kc

Water balance

Irrigation need ≈ ETc

Information courtesy of Jaume Lordan Sanahuja
Dept. of Horticulture, NYSAES, Cornell University

Estimate ETc

ETc = ETo * Kc

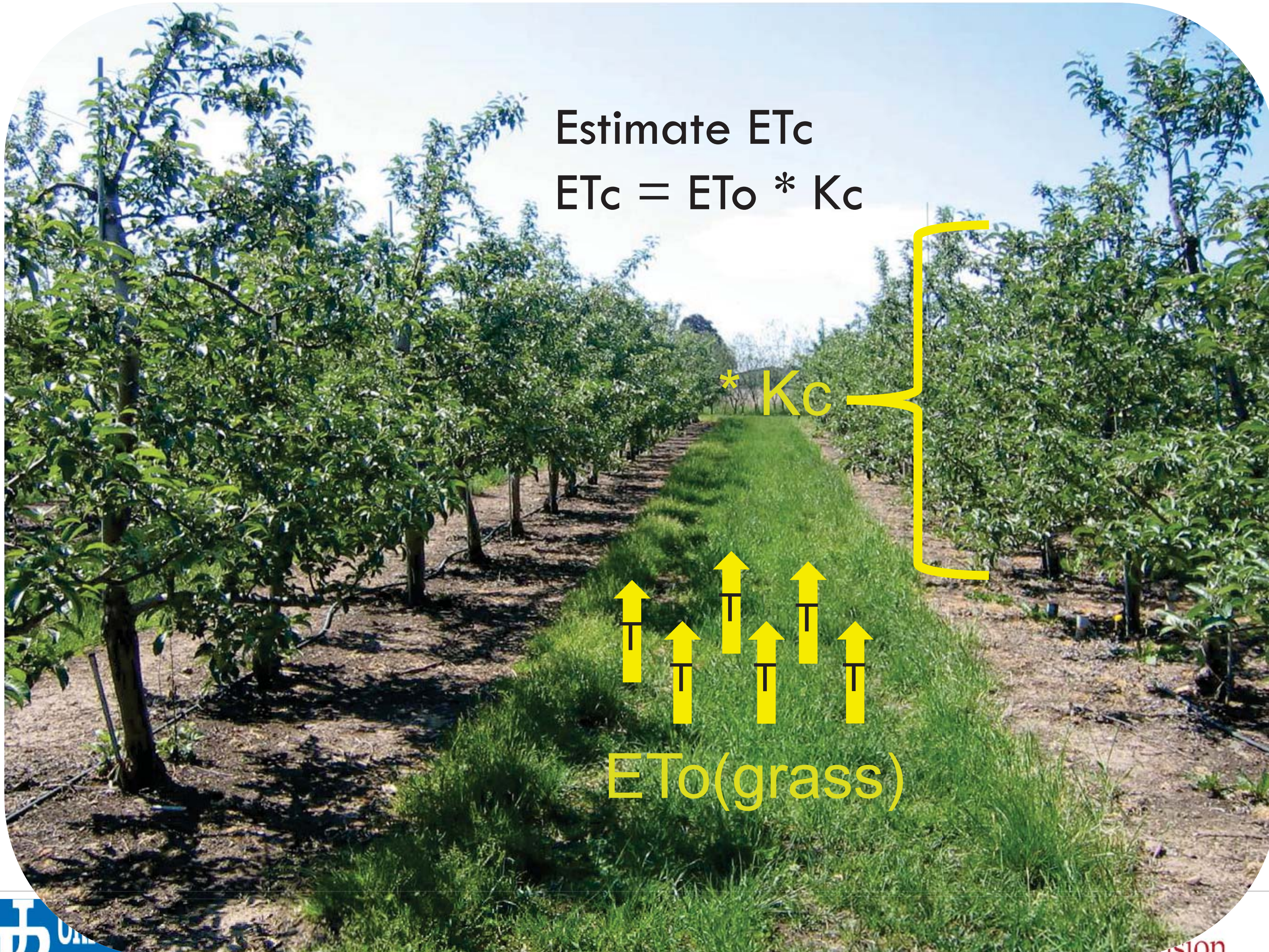
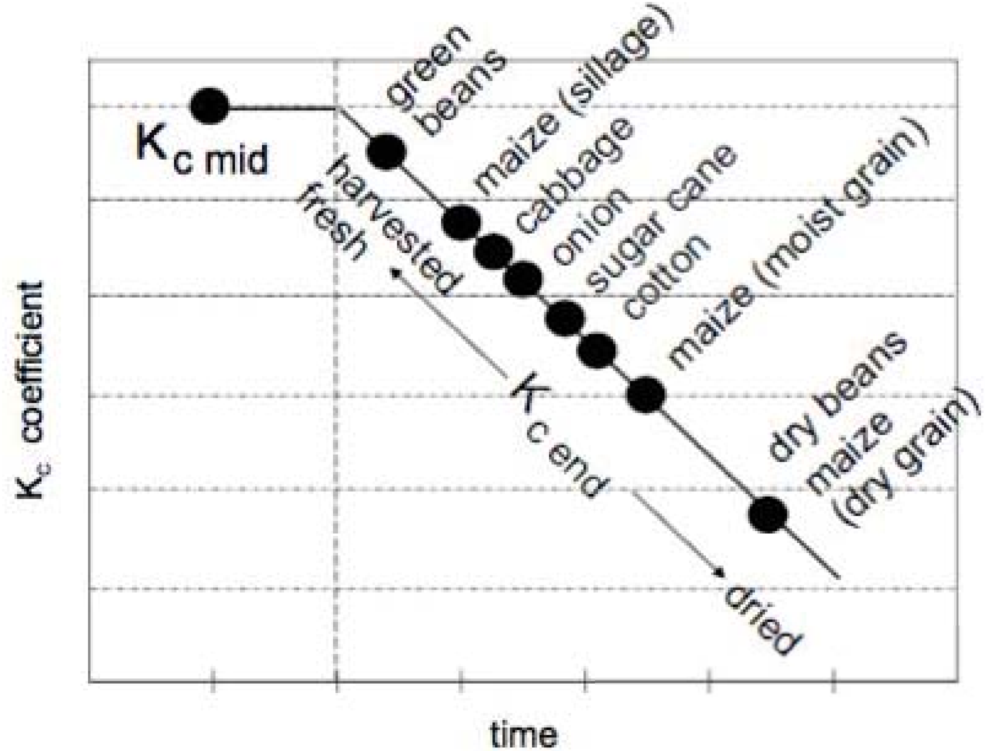


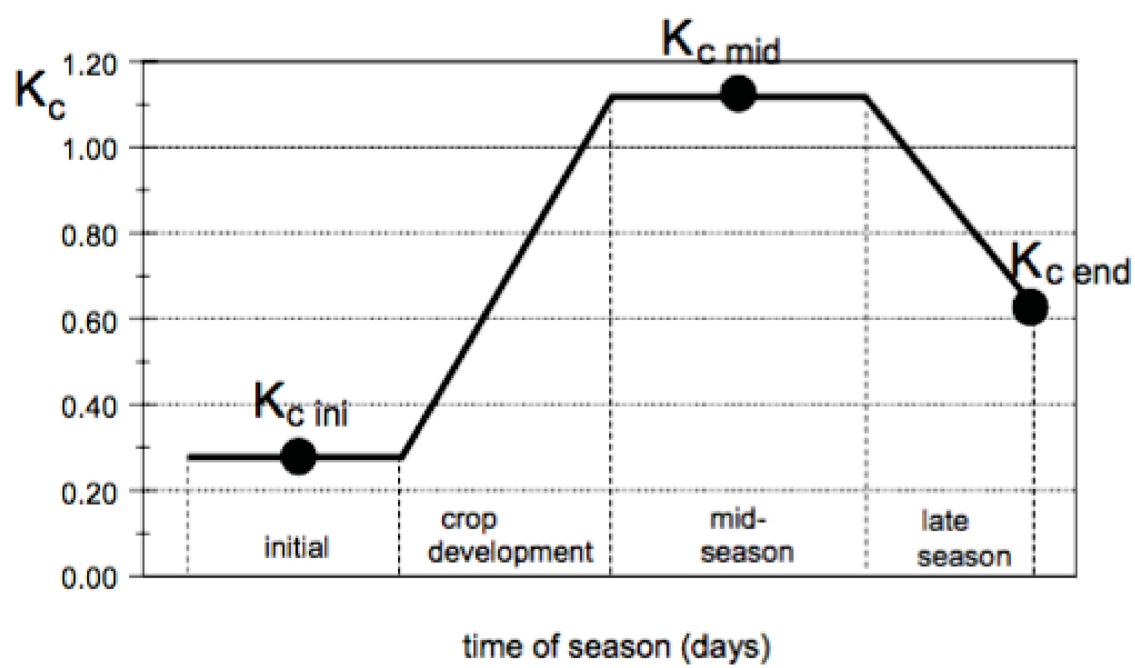
TABLE 12

Single (time-averaged) crop coefficients, K_c, and mean maximum plant heights for non stressed, well-managed crops in subhumid climates (RH_{min} ≈ 45%, u_2 ≈ 2 m/s) for use with the FAO Penman-Monteith ET_o.

Crop	$K_{c\ ini}$[1]	$K_{c\ mid}$	$K_{c\ end}$	Maximum Crop Height (h) (m)
a. Small Vegetables	**0.7**	**1.05**	**0.95**	
Broccoli		1.05	0.95	0.3
Brussel Sprouts		1.05	0.95	0.4
Cabbage		1.05	0.95	0.4
Carrots		1.05	0.95	0.3
Cauliflower		1.05	0.95	0.4
Celery		1.05	1.00	0.6
Garlic		1.00	0.70	0.3
Lettuce		1.00	0.95	0.3
Onions - dry		1.05	0.75	0.4
- green		1.00	1.00	0.3
- seed		1.05	0.80	0.5
Spinach		1.00	0.95	0.3
Radish		0.90	0.85	0.3
b. Vegetables – Solanum Family (*Solanaceae*)	**0.6**	**1.15**	**0.80**	
Egg Plant		1.05	0.90	0.8
Sweet Peppers (bell)		1.05[2]	0.90	0.7
Tomato		1.15[2]	0.70-0.90	0.6
c. Vegetables – Cucumber Family (*Cucurbitaceae*)	**0.5**	**1.00**	**0.80**	
Cantaloupe	0.5	0.85	0.60	0.3
Cucumber – Fresh Market	0.6	1.00[2]	0.75	0.3
– Machine harvest	0.5	1.00	0.90	0.3
Pumpkin, Winter Squash		1.00	0.80	0.4
Squash, Zucchini		0.95	0.75	0.3
Sweet Melons		1.05	0.75	0.4
Watermelon	0.4	1.00	0.75	0.4
d. Roots and Tubers	**0.5**	**1.10**	**0.95**	
Beets, table		1.05	0.95	0.4
Cassava – year 1	0.3	0.80[3]	0.30	1.0
– year 2	0.3	1.10	0.50	1.5
Parsnip	0.5	1.05	0.95	0.4
Potato		1.15	0.75[4]	0.6
Sweet Potato		1.15	0.65	0.4
Turnip (and Rutabaga)		1.10	0.95	0.6
Sugar Beet	0.35	1.20	0.70[5]	0.5



Irrigation needs according to phenology



Information courtesy of Jaume Lordan Sanahuja
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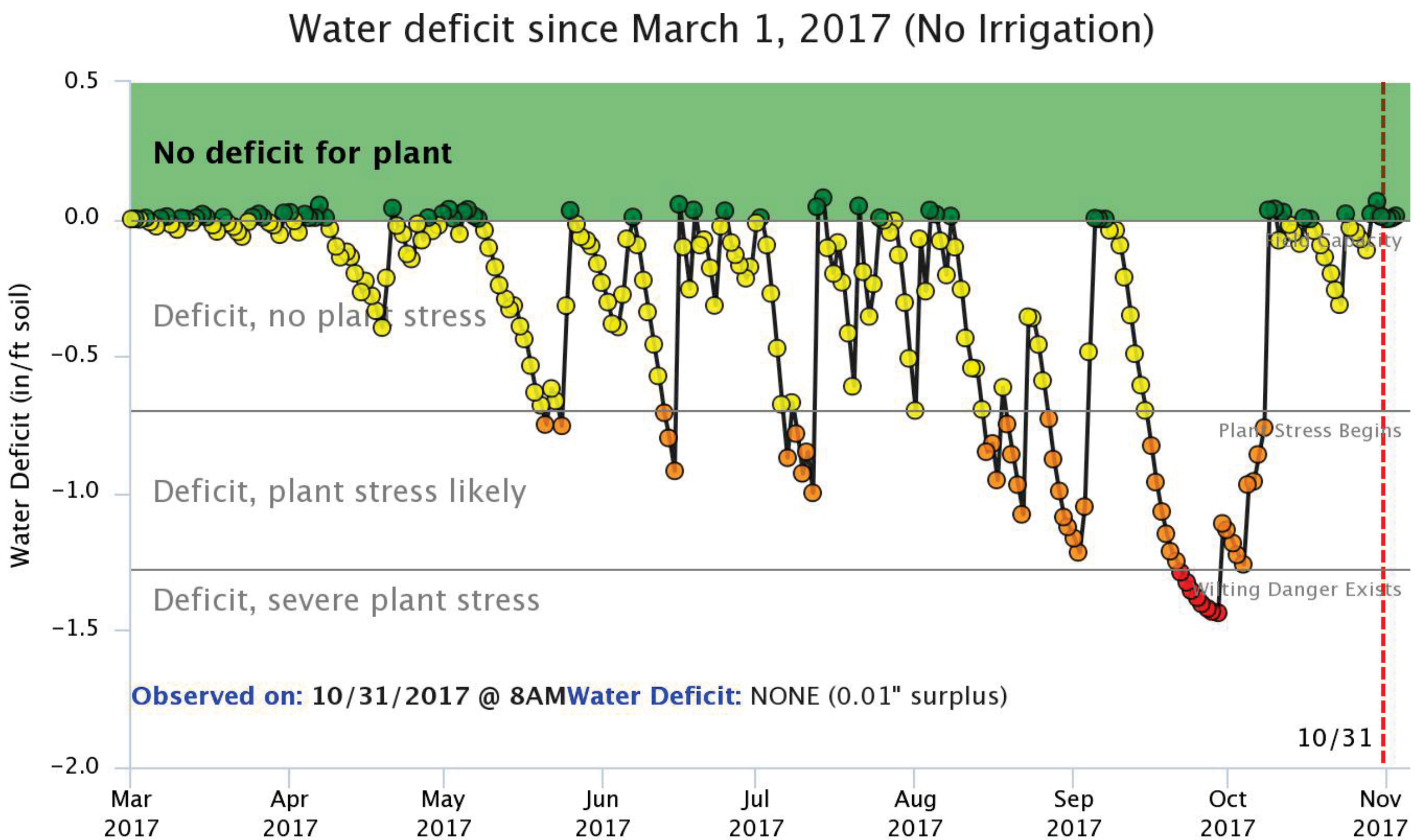
Source: FAO No. 56

Climate Smart Irrigation calculator

http://climatesmartfarming.org/tools/csf-water-deficit-calculator/



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Problem Statement:
Wide Variabilities in Soil Properties Across a Field

- There are wide variabilities in soil properties that control the soil's ability to hold plant available water.
- Understanding the **underlying soil variabilities** is critical to guide the application of precise amounts of water to prevent **under-** or **over-irrigation**

- **Under-irrigation** causes plant water stress, thereby reducing yield.
- **Over-irrigation** induces runoff and nutrient leaching, leading to water and fertilizer wastages with dire environmental consequences.

The Primary Goal of the Project

To map variabilities in soil properties to guide site-specific application of water to reduce water, energy, and fertilizer wastages while increasing **production and profitability** in an **environmentally** friendly fashion.

Traditional Approach to Understanding Soil Variabilities Across a Field

- **Direct soil sampling method**

- Perform various tests on soil samples to determine soil type.

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Challenges of the Direct Soil Sampling Approach

- Cumbersome, time consuming, and expensive

- Offers direct measurements at limited sample locations!

Approach to Understanding Soil Variabilities Across a Field

An electromagnetic (EM) induction survey is used to map **detailed** soil variabilities across a field in a rapid, inexpensive, and non-invasive manner.

The EM Instrument for the Project

EM38 MK2 Instrument mounted in a sled

- The instrument injects electromagnetic waves into the ground and records the ground response.
- The recorded data are processed to produce a high-resolution "soil map" of the field.

A Demonstration of the Soil Mapping

- The survey is rapid, non-invasive, and inexpensive.
- Year 1 sled design was not rugged enough for the survey.

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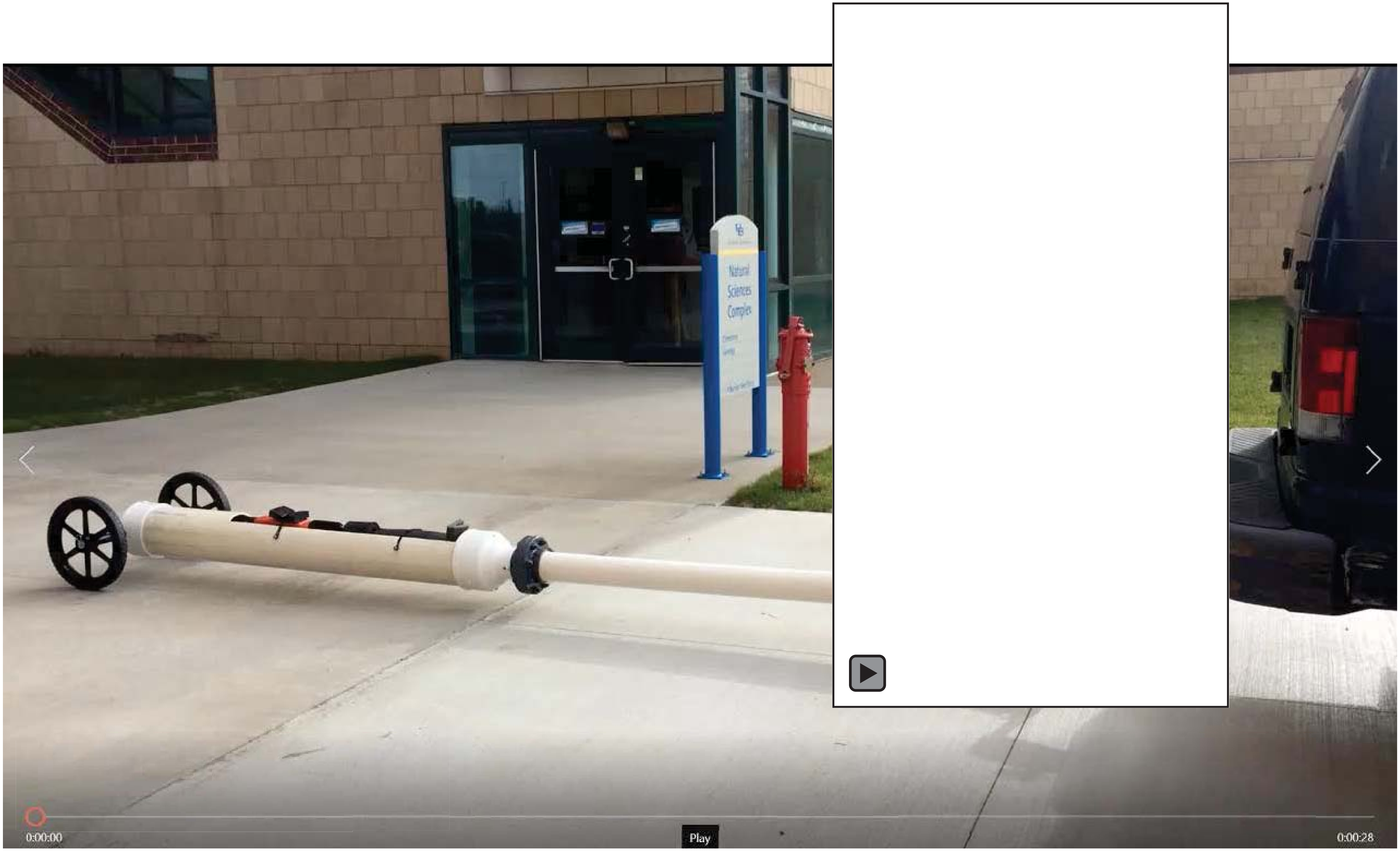
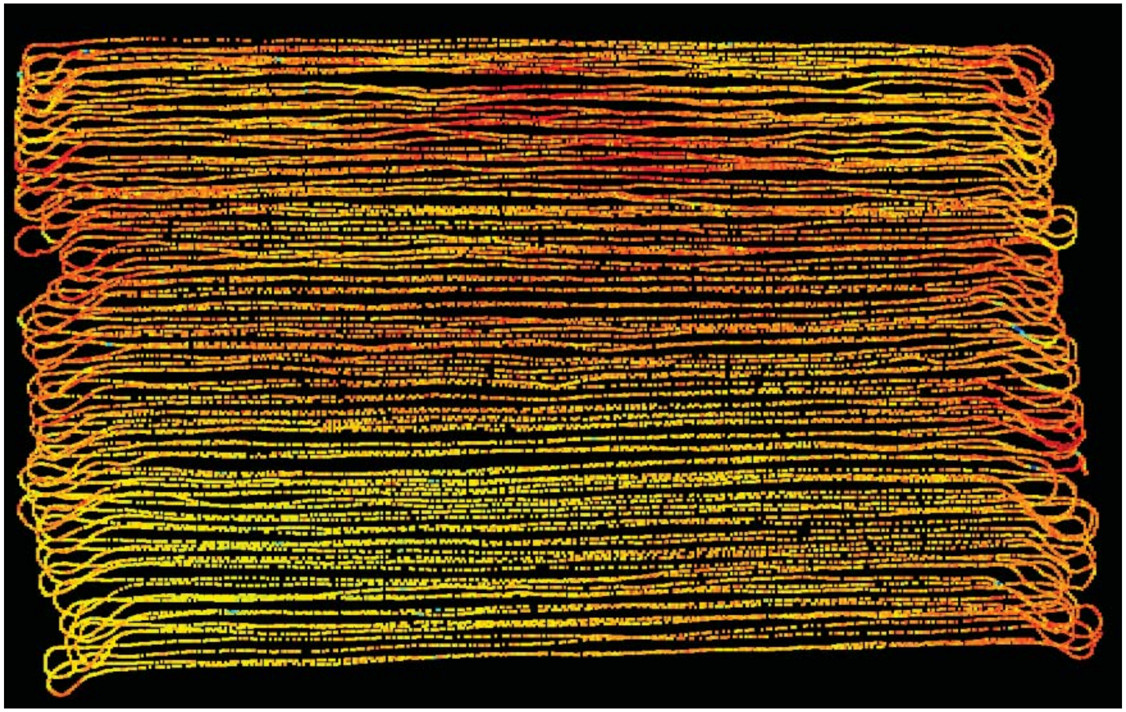
A New Cart System for Year 2



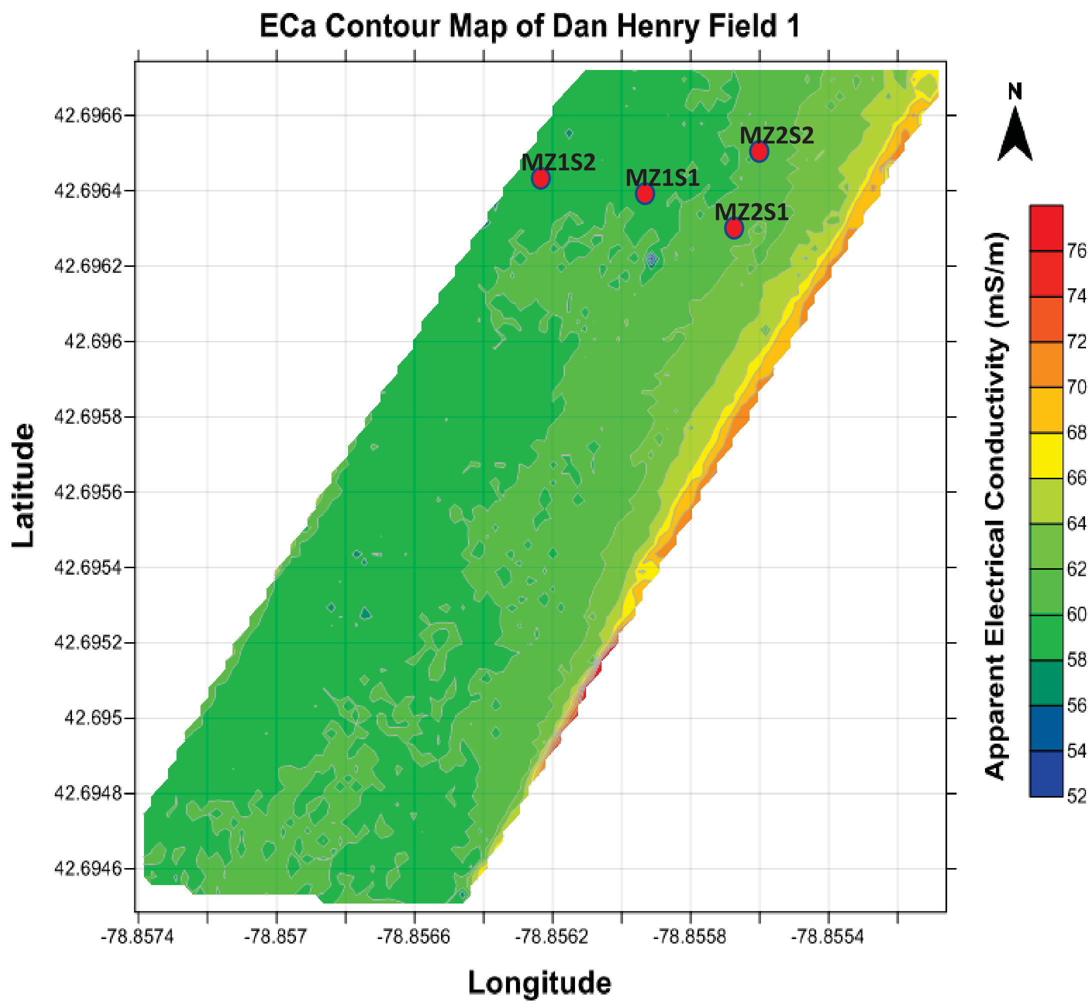
An Example of a High-density Data of a Field

We collected over 50K data points across a 7-acre field in just three hours.



A Detailed “Pseudo-Soil Map” of a Field

- We identified at least two major soil units within this field.
- The red circles show selected locations within the two major units for irrigation experiments.



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Understanding the Soil Water-holding Capacity

Field Irrigation Experiments

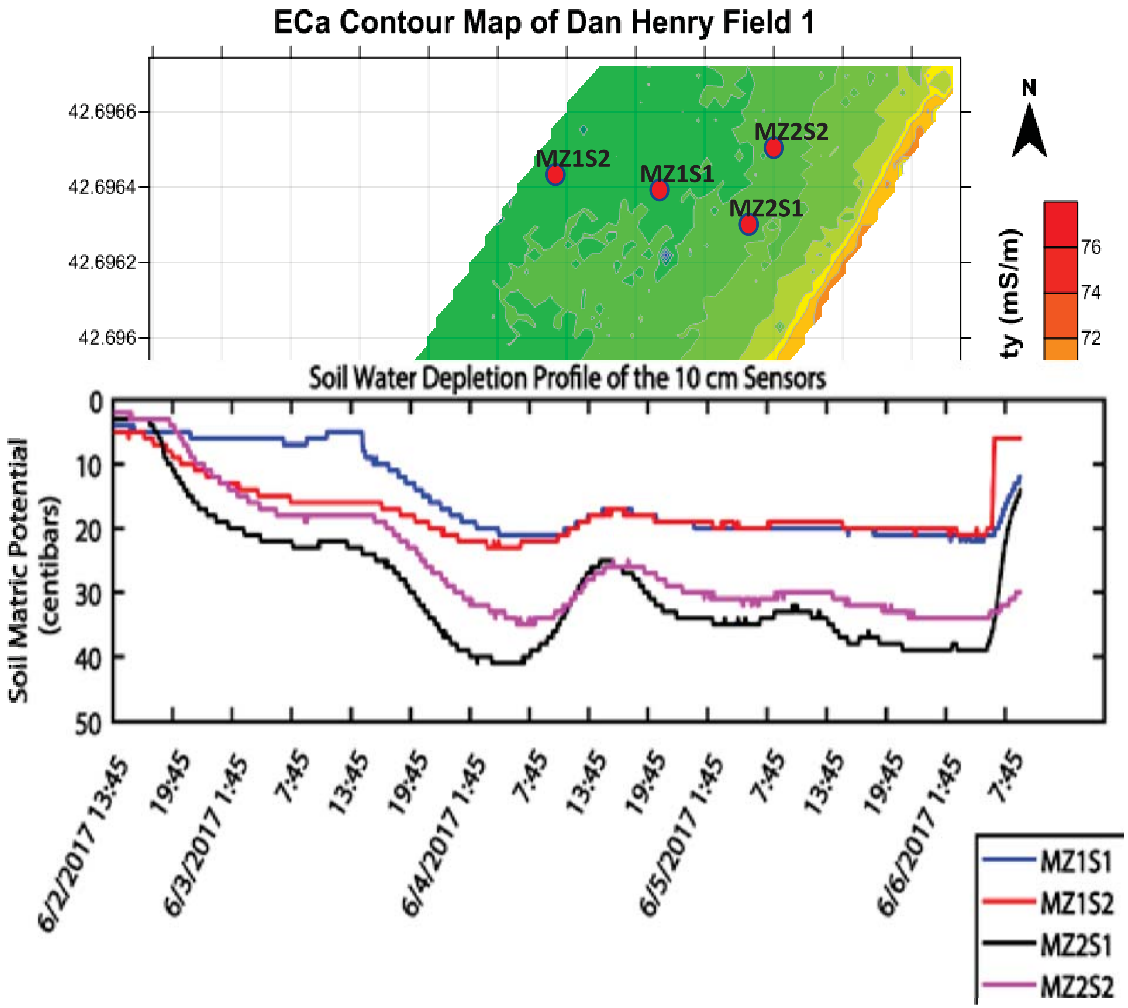
- Different soil types hold water that will be available to the plant differently.

- We perform irrigation experiments to determine the water-holding properties representative of each identified soil unit in the field.

Irrigation experiment with soil moisture monitoring at the 10 cm and 30 cm depths.

Results of an Irrigation Experiment

The water depletion profile in different soil units behaved differently, demonstrating the importance of understanding soil variability in irrigation management practices.



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Conclusion

Management zones (MZs) will be created from each identified soil unit and the results of the irrigation experiment will guide the irrigation scheduling of each MZ to prevent under- or over-irrigation to save water, energy, and fertilizer.

Cooperators needed for Project Year Two

Expected Contributions from Cooperators

- Provide access to a field for project implementation.
- Provide farm historical irrigation, yield, and revenue data.
- Provide a fueled four wheeler/tractor for soil mapping.
- Apply project recommendations to guide irrigation.

Please, contact me if you want to participate in the project. dep10@cornell.edu

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ACKNOWLEDGEMENT

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