When and how much should I irrigate?

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&
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Quick Investigation!

- What are the differences between these plants?
- What types of conditions (environmental or otherwise) do you think were present for each type of plant?
- What can we learn from these three plants?

Flowing right along…

- Irrigation 101
- What's the right amount?
- Got the right tools?

Irrigation 101

- Irrigation Development
- Economic Impact
  - In 2003, a drought year, the impact of irrigated agriculture on Nebraska's economy had a net total economic impact of more than $4.5 billion; adjusted to $3.6 billion for normal precipitation conditions.
- How do you know when to irrigate?

Irrigation 101

- Irrigation

"The artificial supply of water to land, to maintain or increase yields of food crops, a critical element of modern agriculture. Irrigation can compensate for the naturally variable rate and volume of rain"

(Britannica, 2010)

What do you want?

http://static.howstuffworks.com/gif/irrigation-flooded-field.jpg

http://www.twdb.state.tx.us/IMAGES/assistance/awcfund.gif

http://images.publicradio.org/content/2006/07/17/20060717_corn_39.jpg

Proper Irrigation Management

- Maintains adequate soil moisture in the crop root zone for healthy plant growth and optimum yield.

- The objective of irrigation management is to establish proper timing and amount of irrigation for greatest effectiveness.

- It also reduces the potential for runoff and reduces soil erosion and pesticide movement into the surface and groundwater.

For proper irrigation…

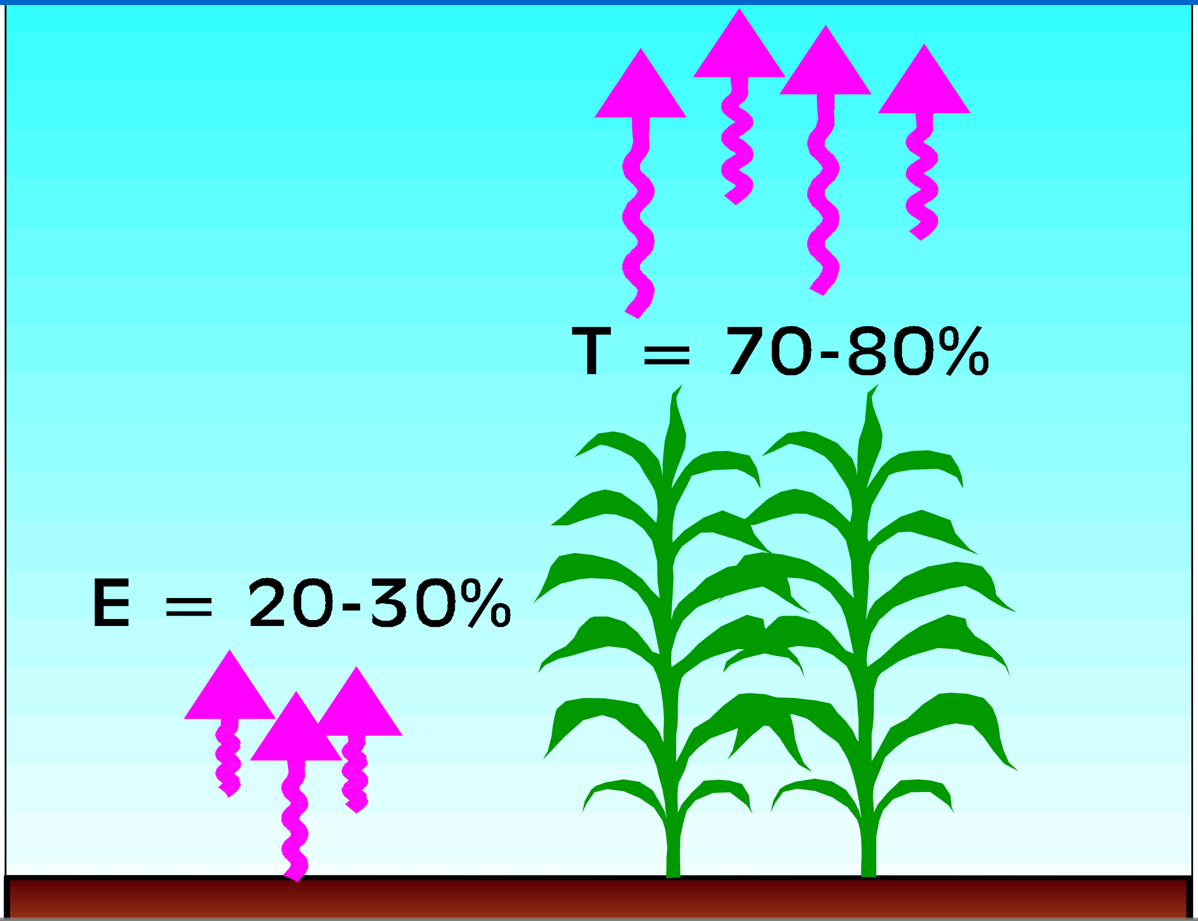
1) Crop Water Use (or Evapotranspiration, ET)
(crop leaves and soil surface)

2) Soil Water Status
(below ground, soil profile)

Crop Water Use (Evapotranspiration, ET)

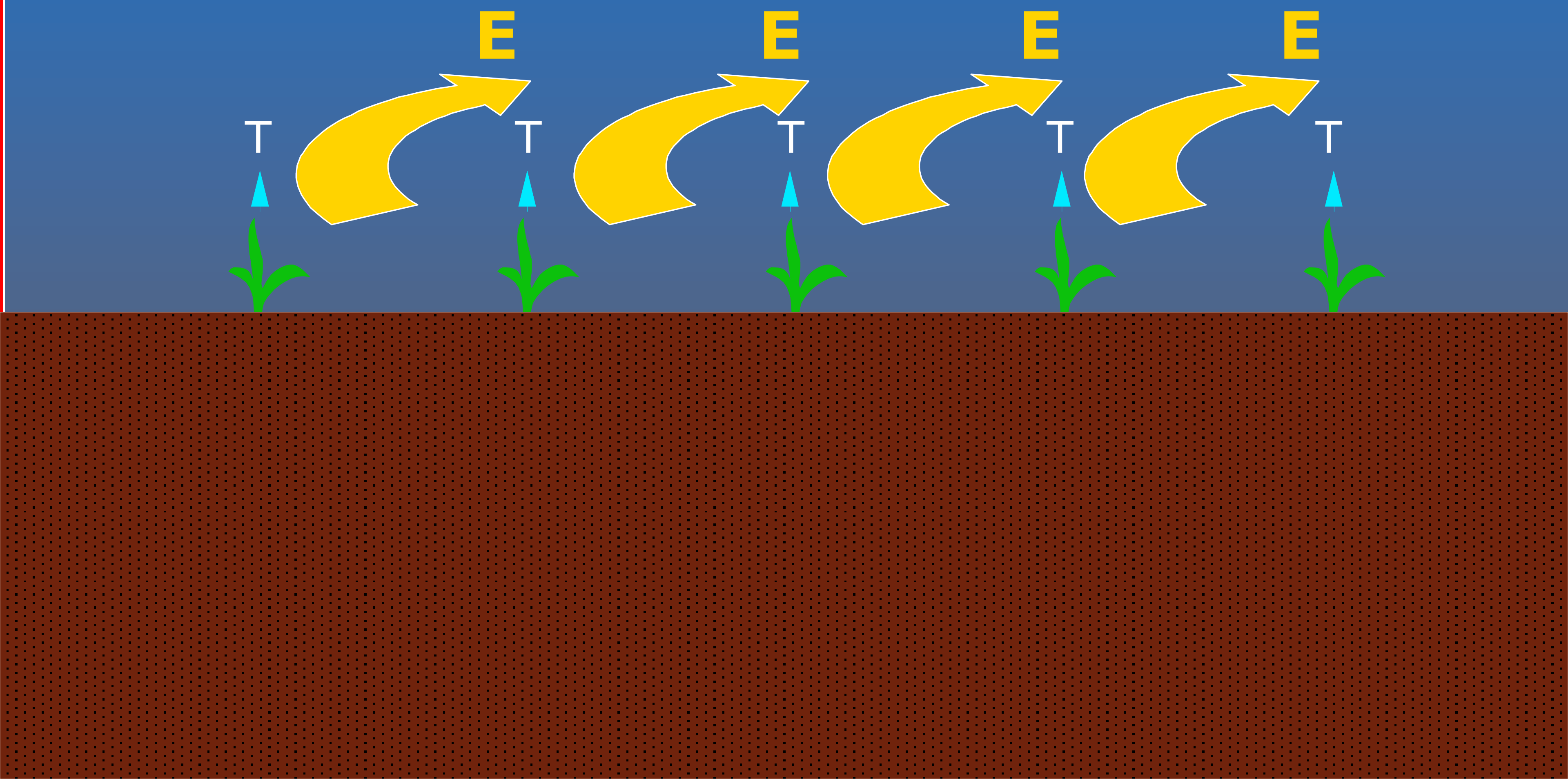
- **Combined process of both evaporation from soil and plant surfaces and transpiration from plant canopies through the stomates to the atmosphere.**
- **“How much water is “lost” from leaves & soil surface” from the plant**

Crop Water Use = Evapotranspiration (ET)



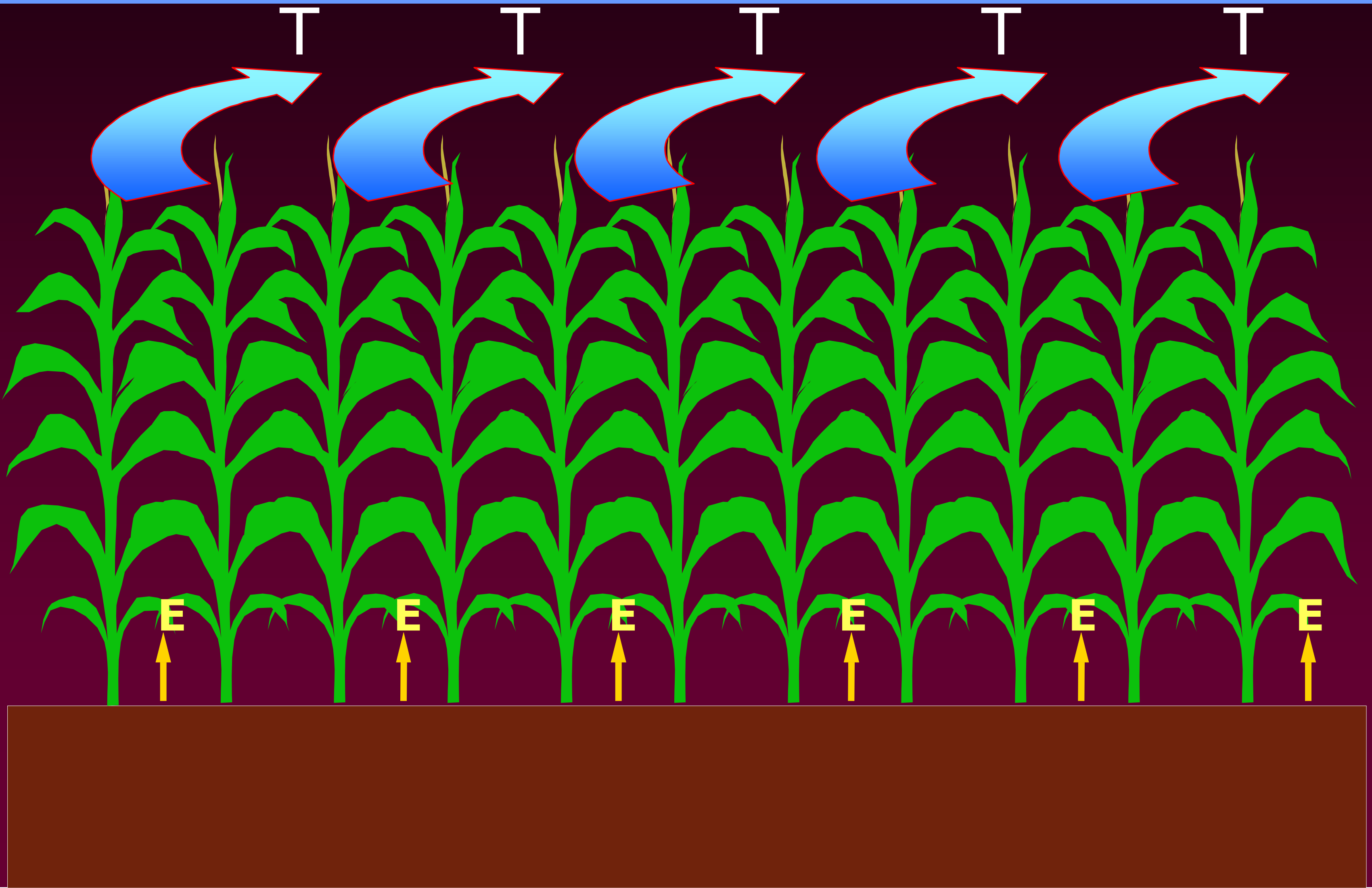
ET = Evaporation + Transpiration

When the crop is small, almost all ET is <u>EVAPORATION</u>



When the crop fully shades the ground,

90 - 98% of ET is TRANSPIRATION

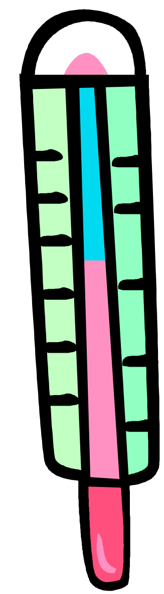


What affects a crop's ET?

Weather data:

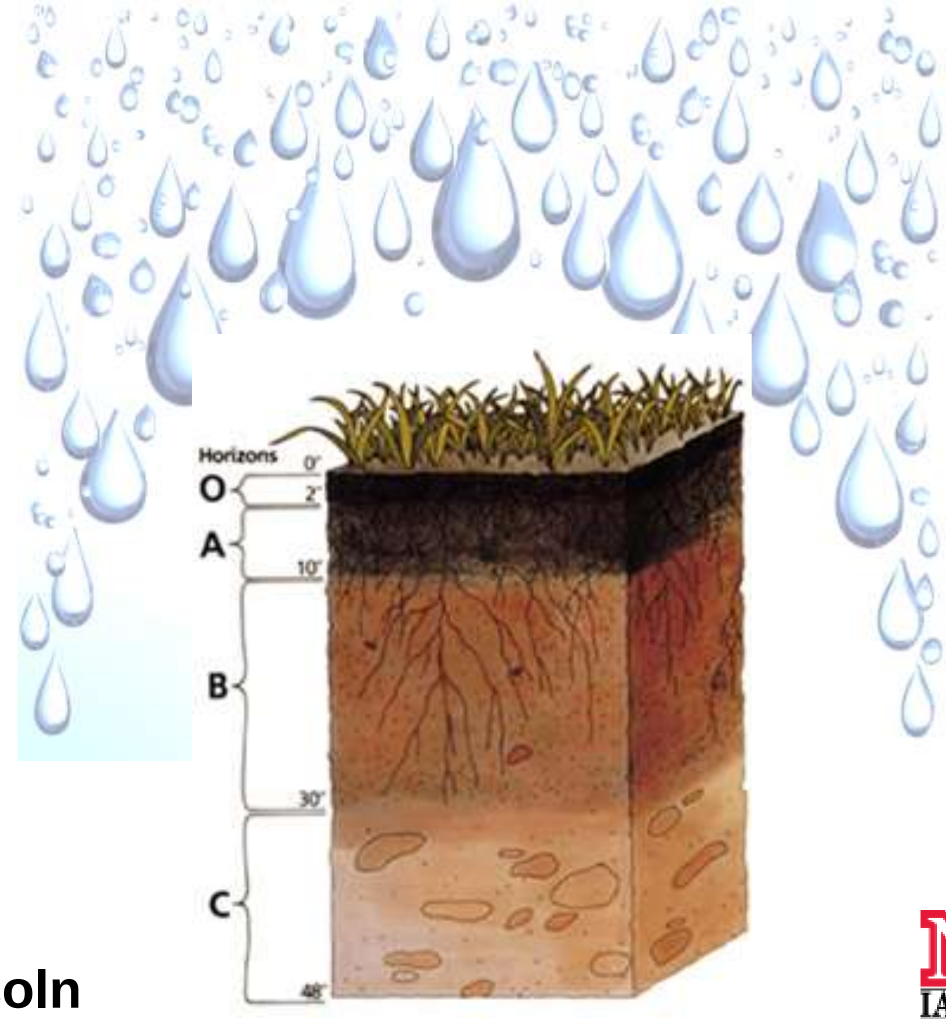
- Solar Radiation
- Air Temperature
- Relative Humidity
- Wind Speed



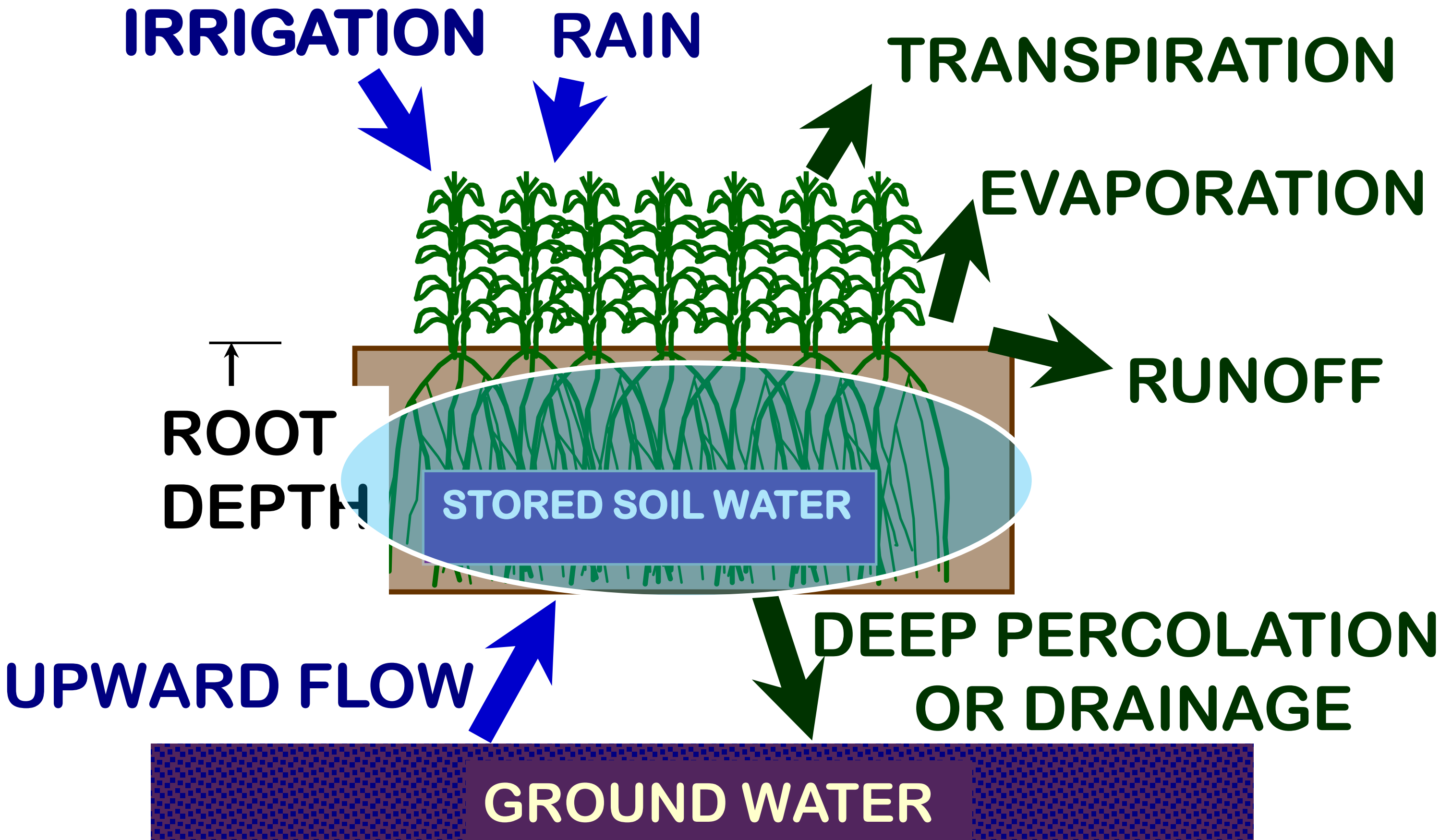



Soil Water Status

- Amount of water present in the soil profile
- Take into account a crop's root zone when monitoring



SOIL WATER BALANCE

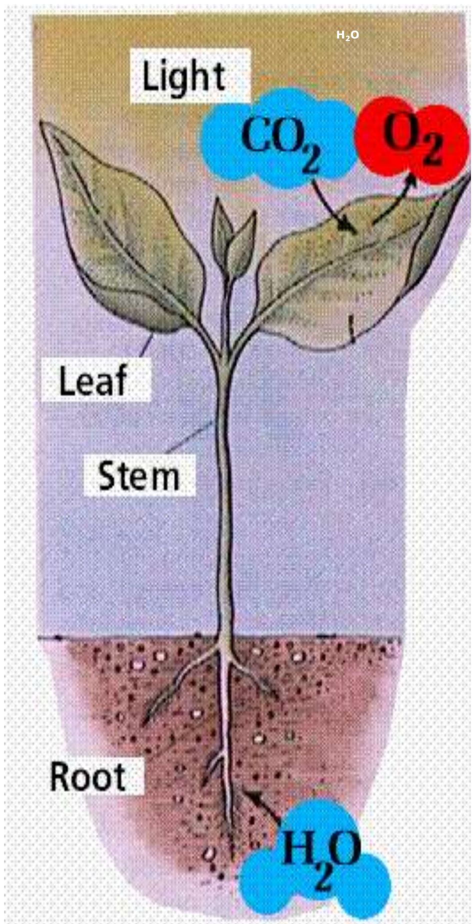


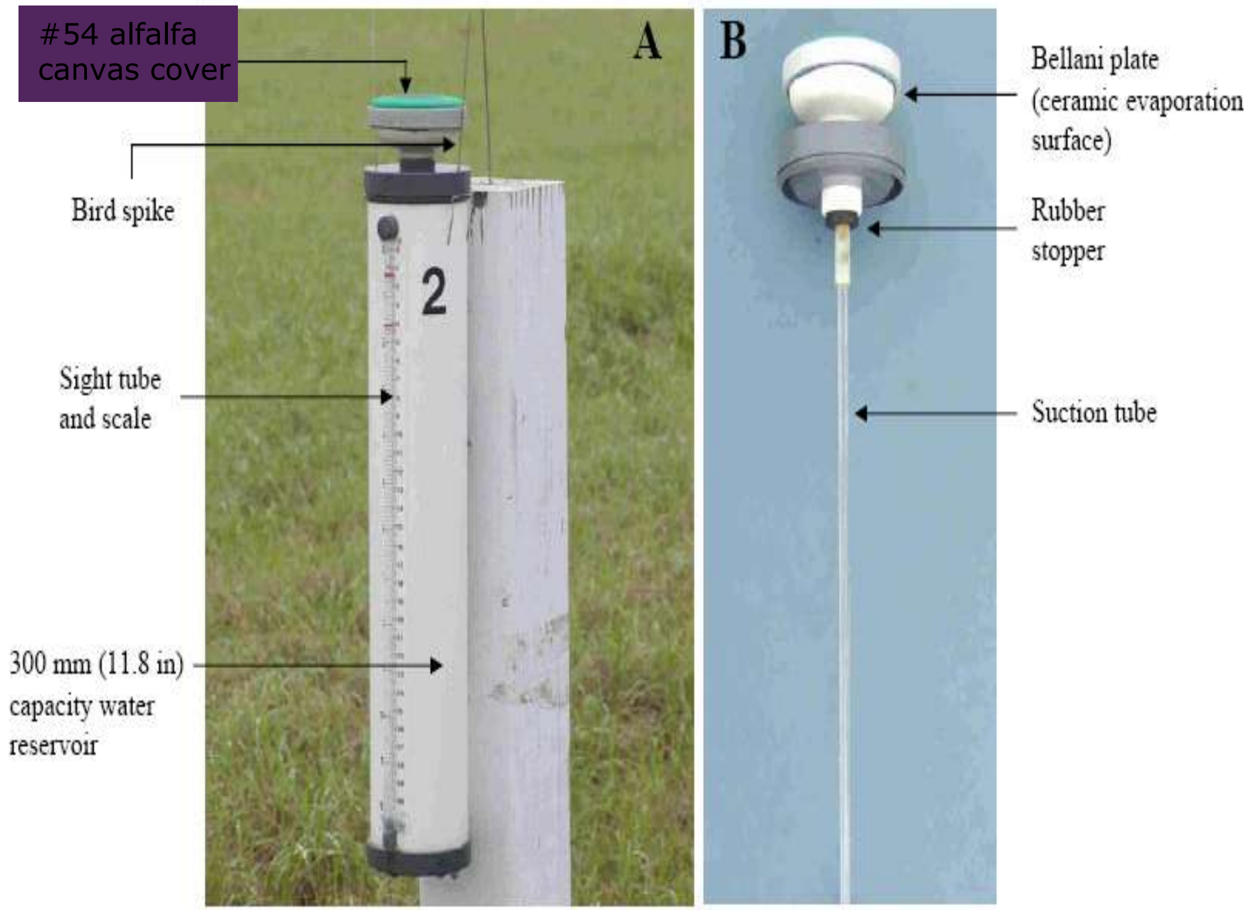
Soil water monitoring takes into account of all these factors

How do we decide when to irrigate?

- **ETgage** – measure crop ET
- **Watermark Sensors** – measure soil water status

ATMOMETER (ETgage)





Actual crop water use = ETr x Kcr

From ETgage

From ETgage NebGuide

Crop coefficient (Kc)

Table I. Alfalfa-based crop coefficients (Kc) at the beginning of each growth stage for corn, soybean, and wheat (High Plains Regional Climate Center, 2005).

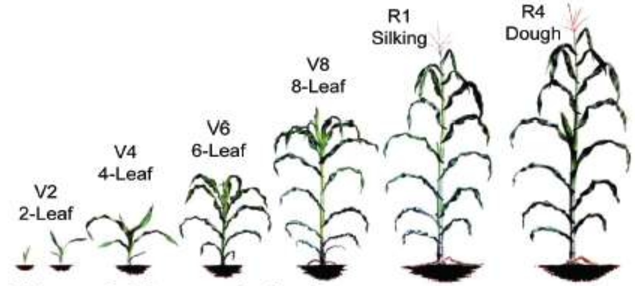
Corn		*Soybean*		*Wheat*	
Growth Stage	*Kc*	*Growth Stage*	*Kc*	*Growth Stage*	*Kc*
2 leaves	0.10	Cotyledon	0.10	Emergence	0.10
4 leaves	0.18	First Node	0.20	Visible Crown	0.50
6 leaves	0.35	Second Node	0.40	Leaf Elongation	0.90
8 leaves	0.51	Third Node	0.60	Jointing	1.03
10 leaves	0.69	Beginning Bloom	0.90	Boot	1.10
12 leaves	0.88	Full Bloom	1.00	Heading	1.10
14 leaves	1.01	Beginning Pod	1.10	Flowering	1.10
16 leaves	1.10	Full Pod	1.10	Grain Fill	1.10
Silking	1.10	Beginning Seed	1.10	Stiff Doug	1.00
Blister	1.10	Full Seed	1.10	Ripening	0.50
Dough	1.10	Beginning Maturity	0.90	Mature	0.10
Beginning dent	1.10	Full Maturity	0.20		
Full dent	0.98	Mature	0.10		
Black layer	0.60				
Full maturity	0.10				

Crop Water Use by Growth Stage – Corn

Nebraska Lincoln EXTENSION

Corn Growth Stages
2 leaf (V2): Two collars visible.
4 leaf (V4): Four collars visible.
6 leaf (V6): Growing point above ground, tassel forms.*
8 leaf (V8): Ear formation begins.
Silking (R1): Silks are visible outside husk.
Dough (R4): Endosperm milk turns thick and pasty.

*** Paint/Mark V6 leaf to make counting easier!**



Weekly ET$_{gage}$® Change in Inches

Crop Stage	Kc	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00
V2	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
V4	0.18	0.18	0.20	0.22	0.23	0.25	0.27	0.29	0.31	0.32	0.34	0.36	0.38	0.40	0.41	0.43	0.45	0.47	0.49	0.50	0.52	0.54
V6	0.35	0.35	0.39	0.42	0.46	0.49	0.53	0.56	0.60	0.63	0.67	0.70	0.74	0.77	0.81	0.84	0.88	0.91	0.95	0.98	1.02	1.05
V8	0.51	0.51	0.56	0.61	0.66	0.71	0.77	0.82	0.87	0.92	0.97	1.02	1.07	1.12	1.17	1.22	1.28	1.33	1.38	1.43	1.48	1.53
V10	0.69	0.69	0.76	0.83	0.90	0.97	1.04	1.10	1.17	1.24	1.31	1.38	1.45	1.52	1.59	1.66	1.73	1.79	1.86	1.93	2.00	2.07
V12	0.88	0.88	0.97	1.06	1.14	1.23	1.32	1.41	1.50	1.58	1.67	1.76	1.85	1.94	2.02	2.11	2.20	2.29	2.38	2.46	2.55	2.64
V14	1.01	1.01	1.11	1.21	1.31	1.41	1.52	1.62	1.72	1.82	1.92	2.02	2.12	2.22	2.32	2.42	2.53	2.63	2.73	2.83	2.93	3.03
V16, Silking, Blister, Dough, Begin Dent.	1.10	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20	2.31	2.42	2.53	2.64	2.75	2.86	2.97	3.08	3.19	3.30
Full dent	0.96	0.96	1.06	1.15	1.25	1.34	1.44	1.54	1.63	1.73	1.82	1.92	2.02	2.11	2.21	2.30	2.40	2.50	2.59	2.69	2.78	2.88
Black layer	0.60	0.60	0.66	0.72	0.78	0.84	0.90	0.96	1.02	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80
Full maturity	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30

This chart can be used with readings from an ETgage® or other ET reference. First, identify the change in the ET rate across the horizontal row and then identify the current growth stage in the left column. Follow the two columns to the point where they intersect to identify the ET rate to use in your irrigation scheduling. When planning irrigation, account for soil moisture, precipitation, weather conditions, and the ET rate for growth stage of your crop.

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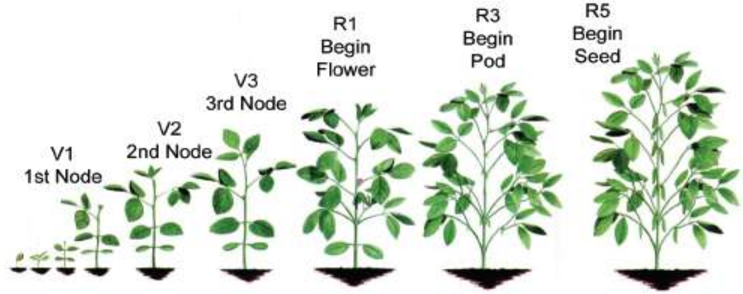
Crop Water Use by Growth Stage – Soybeans

Nebraska Lincoln EXTENSION

Soybean Growth Stages
VC: Cotyledon leaves with unifoliate leaves unrolled.
V1: 1st node containing trifoliolate leaf fully expanded.
V2: 2nd node containing trifoliolate leaf fully expanded.
V2: 3rd node containing trifoliolate leaf fully expanded.
R1: At least one flower on any node.
R3: A pod 3/16 inch on one of four uppermost nodes.
R5: Seed is 1/8 inch long in a pod of the upper four nodes.
Begin Maturity: one brown leaf on main stem.



Weekly ET gage® Change in Inches

Crop Stage	Kc	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00
VC Cotyledon	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
V1 1st Node	0.20	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
V2 2nd Node	0.40	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20
V3 3rd Node	0.60	0.60	0.66	0.72	0.78	0.84	0.90	0.96	1.02	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80
R1 Begin Bloom	0.90	0.90	0.99	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.89	1.98	2.07	2.16	2.25	2.34	2.43	2.52	2.61	2.70
R2 Full Bloom	1.00	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00
Begin Pod Full Pod R5 Begin Seed Full Seed	1.10	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20	2.31	2.42	2.53	2.64	2.75	2.86	2.97	3.08	3.19	3.30
Begin Mature	0.90	0.90	0.99	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.89	1.98	2.07	2.16	2.25	2.34	2.43	2.52	2.61	2.70
Full Mature	0.20	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
Mature	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30

This chart can be used with readings from an ETgage® or other ET reference. First, identify the change in the ET rate across the horizontal row and then identify the current growth stage in the left column. Follow the two columns to the point where they intersect to identify the ET rate to use in your irrigation scheduling. When planning irrigation, account for soil moisture, precipitation, weather conditions, and the ET rate for growth stage of your crop.

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Example

Corn is at **12-leaf growth stage** and the water level in the ETG (with a No. 54 canvas cover) sight tube decreased **1.30 inches** during the 7-day period since the last irrigation. Determine the actual crop ET (ETc), net irrigation requirement (NIR), and the gross irrigation requirement (GIR) if irrigation is applied with a center pivot with an application efficiency of **85%** (AE = 0.85). Rainfall = 0.

ETr = 1.30 inches (reference ET from the ETG)

Kc = 0.88 (from table for 12-leaf stage)

ETc = ETr x Kc	**ETc = 1.30 inches x 0.88**	**= 1.1 inches**
NIR = ETc – Rainfall	NIR = 1.1 inches – 0	= **1.1** inches
GIR = NIR / IE	GIR = 1.1 inches / 0.85	= **1.3**

40” above soil and 12-24” above canopy.

More information on how to use an ETgage for irrigation management

NebGuide

Published by University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

G05-1579

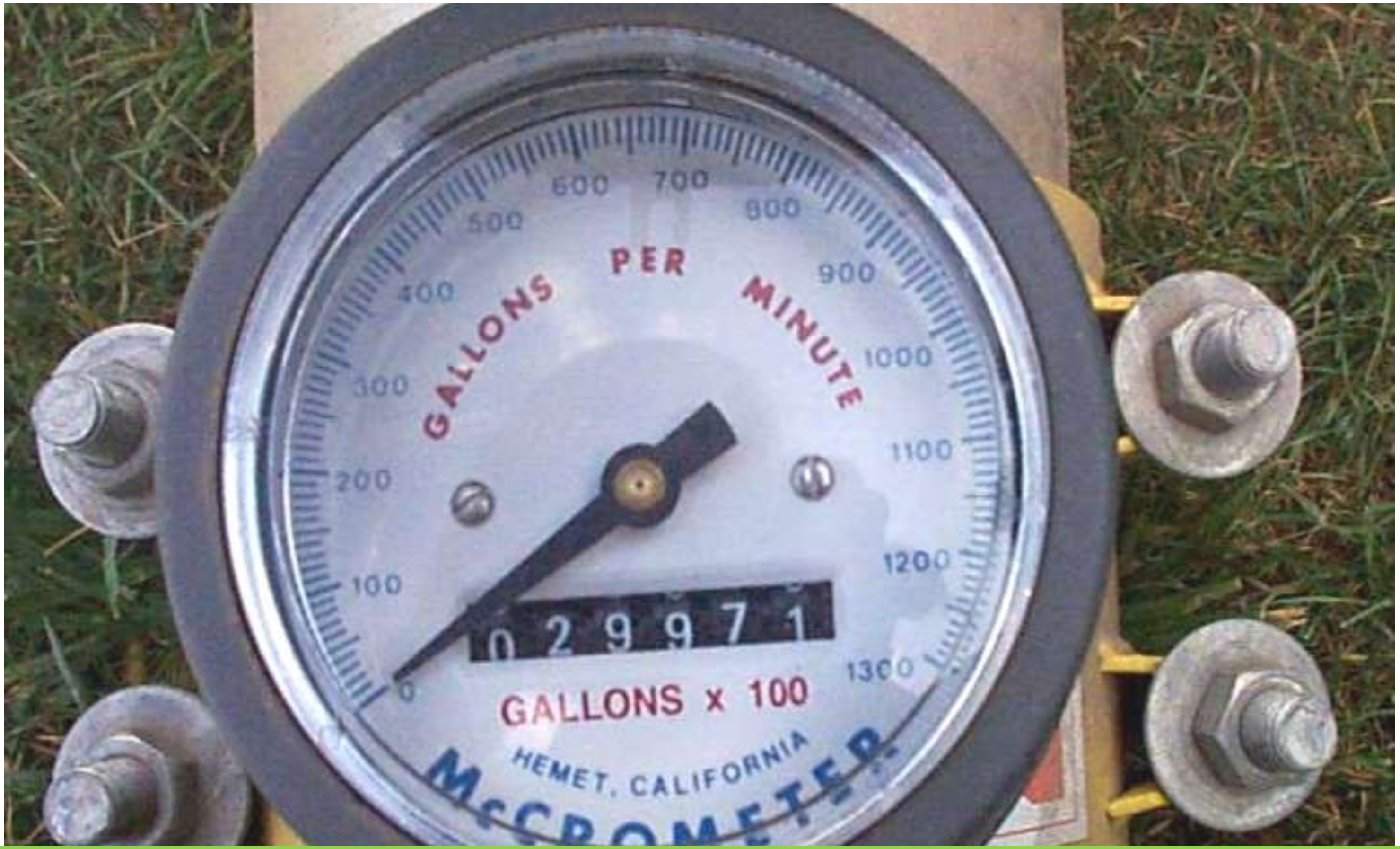
Using Modified Atmometers (ET$_{gage}$®) for Irrigation Management

Suat Irmak, José O. Payero and Derrel L. Martin
Extension Water Resources /Irrigation Engineers

This NebGuide describes the atmometer (evapotranspiration gage) and explains how it can be used for irrigation scheduling. Examples are provided to show how information collected with an atmometer can be used to estimate crop water use for corn and soybean.

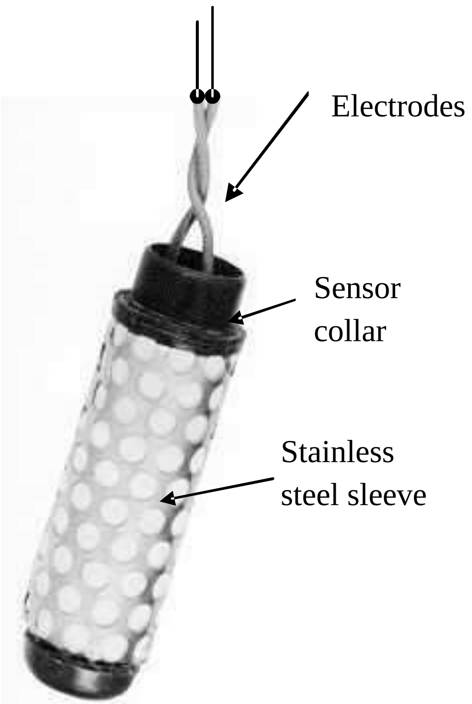
Soil Water Monitoring

Key to applying the optimum amount of irrigation



For effective irrigation, must know water applied

Watermark soil water sensors



Hand -held meter

Installed in the row

1, 2, 3 feet deep

Irrigation trigger levels for different soil types

Table 1. Depletion (in/ft) in available water versus soil matric potential and suggested range of irrigation trigger point for different soil textures.

	Soil type, depletion in inches per foot associated with a given soil matric potential value measured by the Watermark sensors, and available water holding capacity for different soil types							
Soil matric potential (kPa)	Silty clay loam topsoil, Silty clay subsoil (Sharpsburg)	Silt-loam topsoil, Clay loam subsoil (Keith)	Upland silt loam topsoil, Silty clay loam subsoil (Hastings, Crete, Holdrege)	Bottom land silt-loam (Wabash, Hall)	Fine sandy loam	Sandy loam	Loamy sand (O'Neill)	Fine sand (Valentine)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.20	0.30	0.30	0.30
33	0.20	0.14	0.00	0.00	0.55	0.50	0.45	0.55
50	0.45	0.36	0.32	0.30	0.80	0.70	0.60	0.70
60	0.50	0.40	0.47	0.44	1.00	0.80	0.70	0.70
70	0.60	0.50	0.59	0.50	1.10	0.80	0.80	0.80
80	0.65	0.55	0.70	0.60	1.20	1.00	0.93	1.00
90	0.70	0.60	0.78	0.70	1.40	1.20	1.04	N/A
100	0.80	0.68	0.85	0.80	1.60	1.40	1.10	N/A
110	0.82	0.72	0.89	0.88	N/A	N/A	N/A	N/A
120	0.85	0.77	0.91	0.94	N/A	N/A	N/A	N/A
130	0.86	0.82	0.94	1.00	N/A	N/A	N/A	N/A
140	0.88	0.85	0.97	1.10	N/A	N/A	N/A	N/A
150	0.90	0.86	1.08	1.20	N/A	N/A	N/A	N/A
200	1.00	0.95	1.20	1.30	N/A	N/A	N/A	N/A
Water holding capacity (in/ft)	**1.8-2.0**	**1.8-2.0**	**2.20**	**2.00**	**1.80**	**1.40**	**1.10**	**1.00**
***Suggested range of irrigation trigger point (kPa)**	**75-80**	**80-90**	**90-100**	**75-80**	**45-55**	**30-33**	**25-30**	**20-25**

(*) The trigger points were calculated with the assumption of no sensor malfunction. The trigger points were calculated based on the 35% depletion of the total soil water holding capacity per foot of soil layer. The sensor readings and the trigger points should be verified/checked against the crop appearance in the actual field conditions during the season. Trigger point should be the average of first 2 feet of sensors prior to crop reproductive stages and 3 feet once crop reaches the reproductive stage. However, for the sandy soils, the average of top 2 sensors should be used as a trigger point at all times.

(N/A) Not available

The irrigation trigger point changes with soil type because each soil holds different amount of water under a given matric potential value measured with Watermark sensors.

Table 1.
Depletion (in/ft) in available water versus soil matric potential and suggested range of irrigation trigger point for different soil textures.

Soil matric potential (kPa)	Soil type, depletion in inches per foot associated with a given soil matric potential value measured by the Watermark sensors, and available water holding capacity for different soil types							
	Silty clay loam topsoil, Silty clay subsoil (Sharpsburg)	Silt-loam topsoil, Clay loam subsoil (Keith)	Upland silt loam topsoil, Silty clay loam subsoil (Hastings, Crete, Holdrege)	Bottom land silt-loam (Wabash, Hall)	Fine sandy loam	Sandy loam	Loamy sand (O'Neill)	Fine sand (Valentine)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.20	0.30	0.30	0.30
33	0.20	0.14	0.00	0.00	0.55	0.50	0.45	0.55
50	0.45	0.36	0.32	0.30	0.80	0.70	0.60	0.70
60	0.50	0.40	0.47	0.44	1.00	0.80	0.70	0.70
70	0.60	0.50	0.59	0.50	1.10	0.80	0.80	0.80
80	0.65	0.55	0.70	0.60	1.20	1.00	0.93	1.00
90	0.70	0.60	0.78	0.70	1.40	1.20	1.04	N/A
100	0.80	0.68	0.85	0.80	1.60	1.40	1.10	N/A
110	0.82	0.72	0.89	0.88	N/A	N/A	N/A	N/A
120	0.85	0.77	0.91	0.94	N/A	N/A	N/A	N/A
130	0.86	0.82	0.94	1.00	N/A	N/A	N/A	N/A
140	0.88	0.85	0.97	1.10	N/A	N/A	N/A	N/A
150	0.90	0.86	1.08	1.20	N/A	N/A	N/A	N/A
200	1.00	0.95	1.20	1.30	N/A	N/A	N/A	N/A
Water holding capacity (in/ft)	**1.8-2.0**	**1.8-2.0**	**2.20**	**2.00**	**1.80**	**1.40**	**1.10**	**1.00**
*Suggested range of irrigation trigger point (kPa)	**75-80**	**80-90**	**90-100**	**75-80**	**45-55**	**30-33**	**25-30**	**20-25**

(*) The trigger points were calculated with the assumption of no sensor malfunction. The trigger points were calculated based on the 35% depletion of the total soil water holding capacity per foot of soil layer. The sensor readings and the trigger points should be verified/checked against the crop appearance in the actual field conditions during the season. Trigger point should be the average of first 2 feet of sensors prior to crop reproductive stages and 3 feet once crop reaches the reproductive stage. However, for the sandy soils, the average of top 2 sensors should be used as a trigger point at all times.

(N/A) Not available

Which soil depth to consider for irrigation management?

Corn:

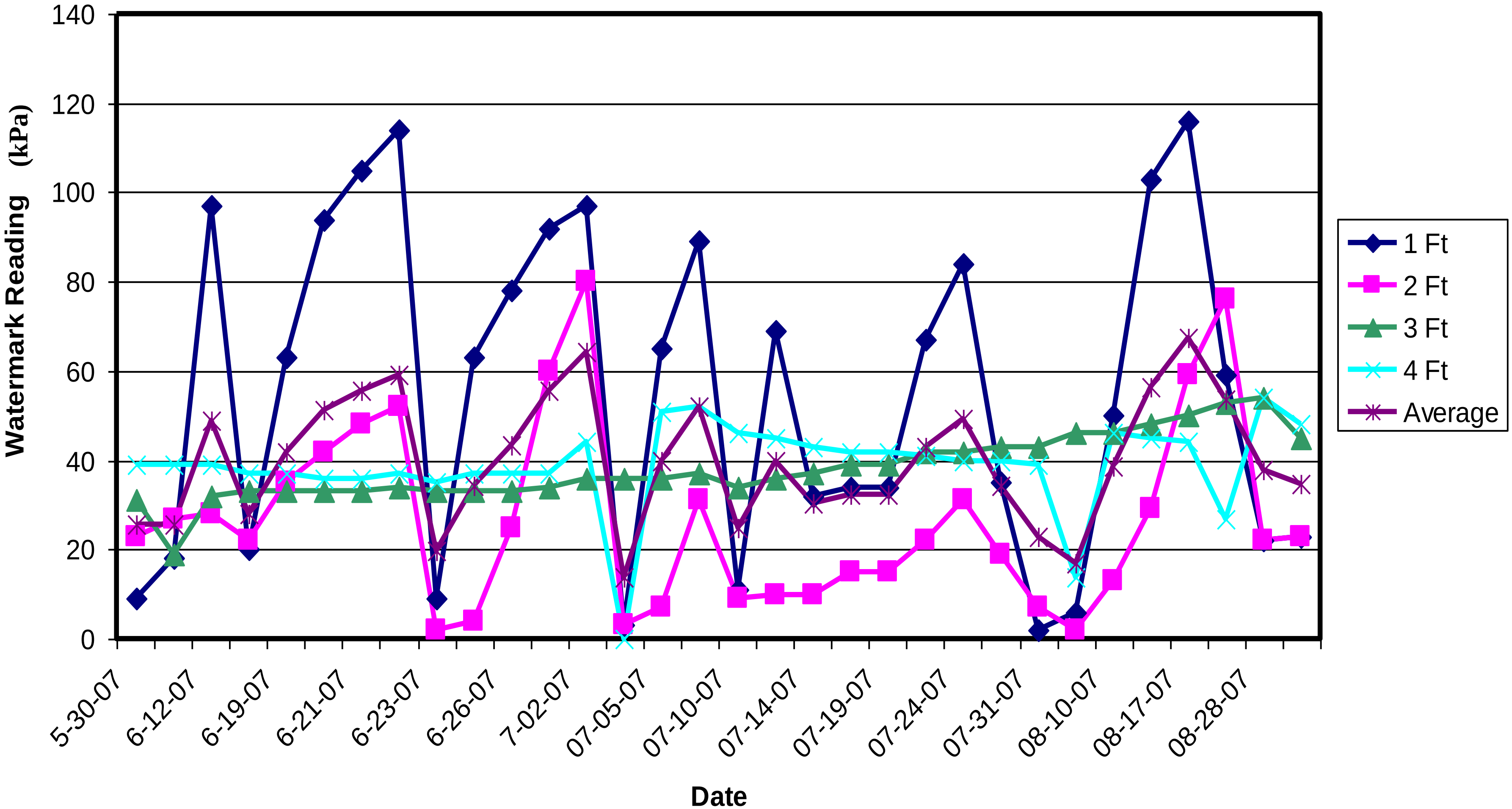
- Average of top 2 ft until tassel
- Average of top 3 ft after tassel

Soybeans:

- No irrigation before R3 stage. Average of top 3 ft thereafter.

Trigger irrigation when the average matric potential is between 90 and 100 kPa for both crops grown in ***silt-loam soils****.*

Example: change in soil water status



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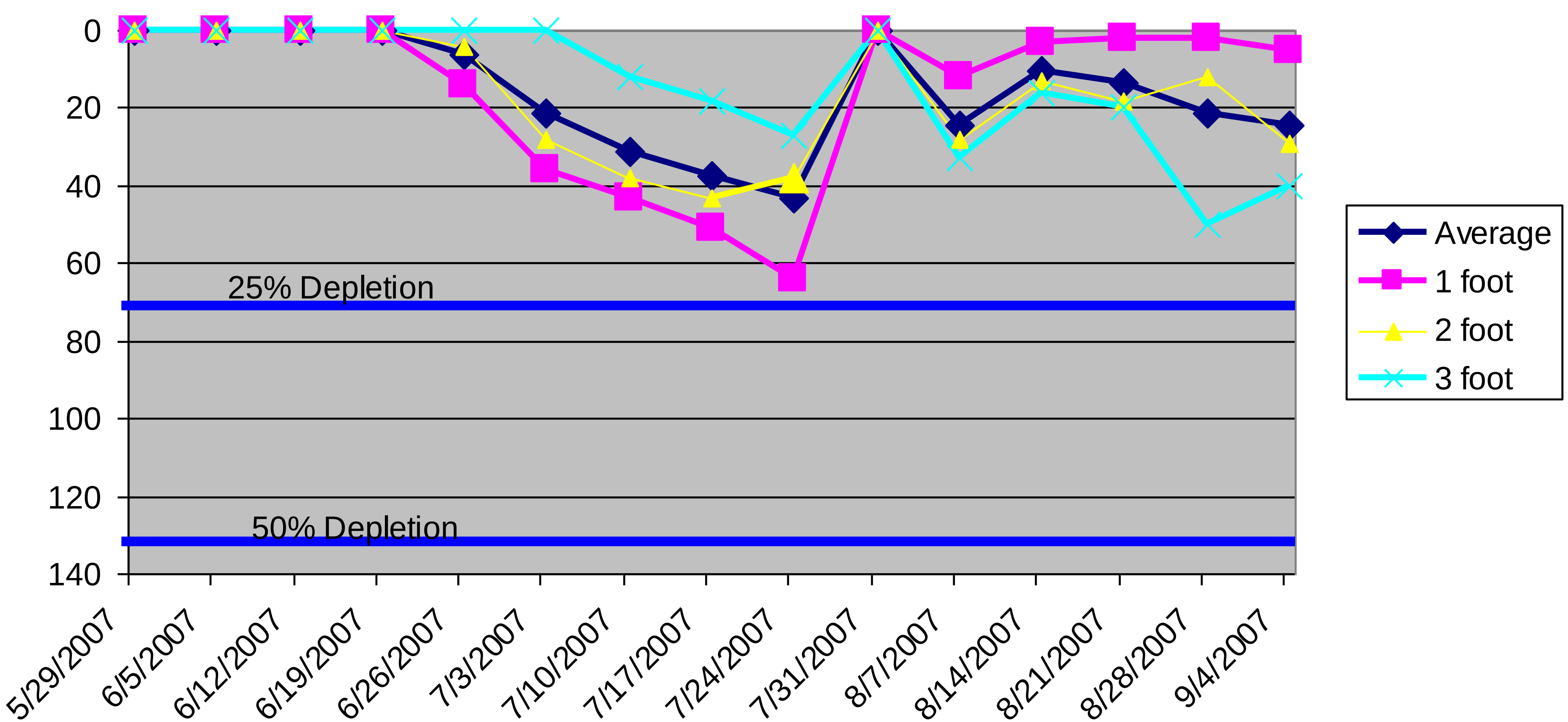

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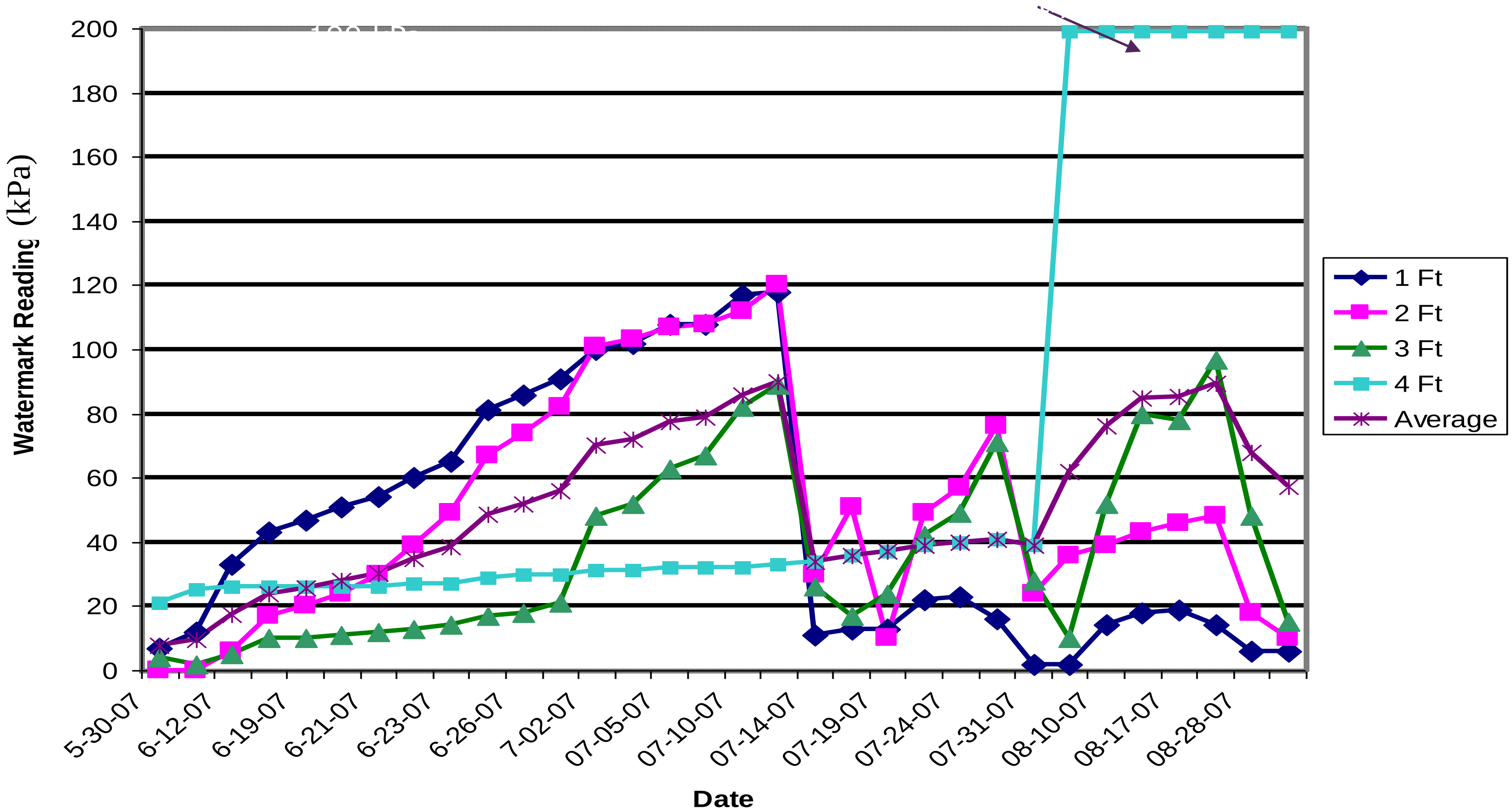

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More information on how to use Watermark sensors for irrigation management?

Nebraska University of Lincoln EXTENSION

EC783

Watermark Granular Matrix Sensor to Measure Soil Matric Potential for Irrigation Management

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Too much of a good thing?

Plants need O2 also!!!

UNL Research showed…

Irrigation levels at…..	yielded:
50%	194 bu/acre
75%	213 bu/acre
100%	217 bu/acre
125%	205 bu/acre

To achieve proper irrigation management…

Nebraska Ag Water Mgmt Demonstration Network

- To transfer high quality research-based information to farmers’ fields
- Implement tools to address and enhance crop *water use efficiency* and *energy savings*.

Collaborative Effort!

Nebraska Lincoln EXTENSION

Little Blue Natural Resources District

UPPER BIG BLUE NRD

NRCS Natural Resources Conservation Service

Producers & Consultants

NAWMDN Website

http://water.unl.edu/cropswater/nawmdn

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UNL › IANR › Water Issues › Agricultural Irrigation › ETGage

UNL Water

Your natural resource for reliable water information.

NAWMDN - Enabling producers to use water and energy resources efficiently.

Contact: Gary Zoubek, Extension Educator, York County

The Nebraska Agricultural Water Management Demonstration Network (NAWMDN) ETgage project is one part of a system for testing cutting-edge technologies and creating a network with growers, UNL Extension, NRDs, NRCS, crop consultants, and other interested partners, that will enable the adoption of water and energy conservation practices.

What is an ETgage?

Atmometers (ETgages) are designed to simulate evapotranspiration (ET) from a plant canopy in a way that agrees with a plant's resistance to ET. The ETgage is a tool that can be used to mimic ET rates and this information can be utilized for irrigation management. The simplicity of use and interpretation of the ETGage data, as well as the economic feasibility, make it easy for farmers and consultants to monitor crop water use and irrigation needs. For more information please see the "Using Modified Atmometers (ETgage®) for Irrigation Management" Extension publication.

ETgage Login

Site Name:

Password:

Login

Register your ETgage site
View Weekly ETgage data
Growth Stage Charts

Questions? Please contact:
Gary Zoubek, Extension Educator,
York County.
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402-362-5508

ETgage data information

Participating producers, consultants, NRD personnel and Extension Educators across Nebraska are uploading weekly ETgage information to this site. If you'd like to see the data from your area, simply go to the to see the data from your area, simply go to the View Weekly ETgage data page and click on your county. You will then see a Google™ Map view of county that has the ETgage sites marked

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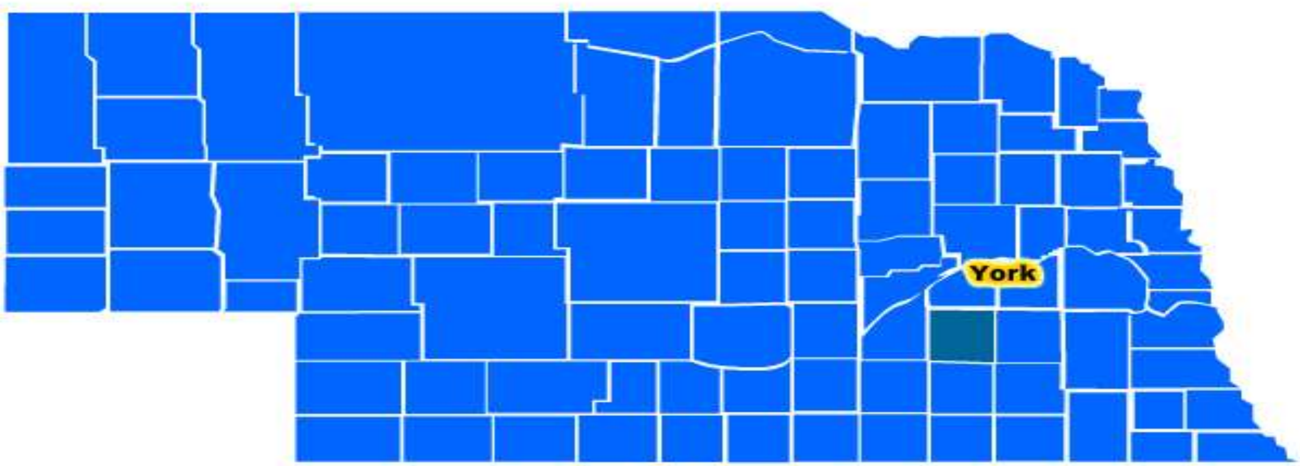
Weekly ETgage Site Data

Use this interactive ETgage map to access weekly information provided by growers, consultants, NRD staff and Extension Educators. To view the data, click on the county you'd like to view the data from. You will then see a Google™ Map view of the county that has the ETgage sites marked as balloons, simply click on the balloon near your location. You will then go to a page that includes the weekly ETgage change along with weekly rainfall amounts. The ETgage change along with your crop's stage of growth can be used to estimate your crop's water use.



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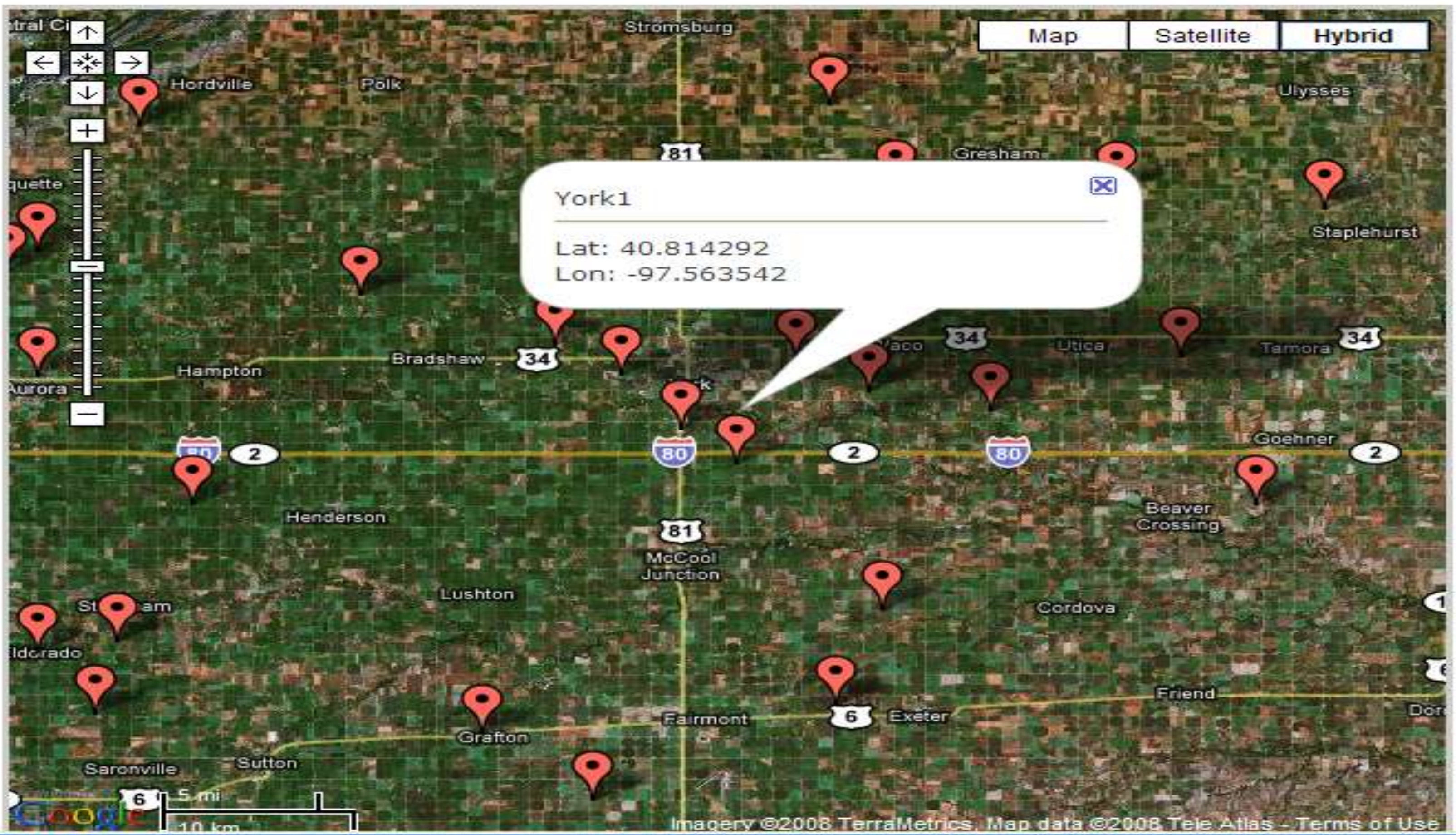
Introduction | Register | View Weekly Site Data | Growth Stage Charts

ETGage York County -- Select site to view ETGage information.



Survey Says..

Survey says…

- In 2008, the NAWMDN has grown from 15 producers (in 2005) to over 300 active partners.
- Average water savings for corn of 2.6 inches is associated with a savings of $24.00/acre and 2.1 inches in soybeans is associated with a savings of $19.40/acre. (2007)
  - This results in total energy savings of $2,808,000 and $2,269,800 for corn and soybeans, respectively over 117,000 acres.

What overall impact has the NAWMDN had on you?

- I've learned from it! Confident that this technology is helpful.
- More focused on reducing water use on growing crops.
- Makes you more aware of the need to schedule irrigation based upon facts vs. a gut feel to irrigate.

We flowed right along…

- Irrigation 101
- What’s the right amount?
- Got the right tools?

When and how much should I irrigate?

Gary Zoubek
&
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