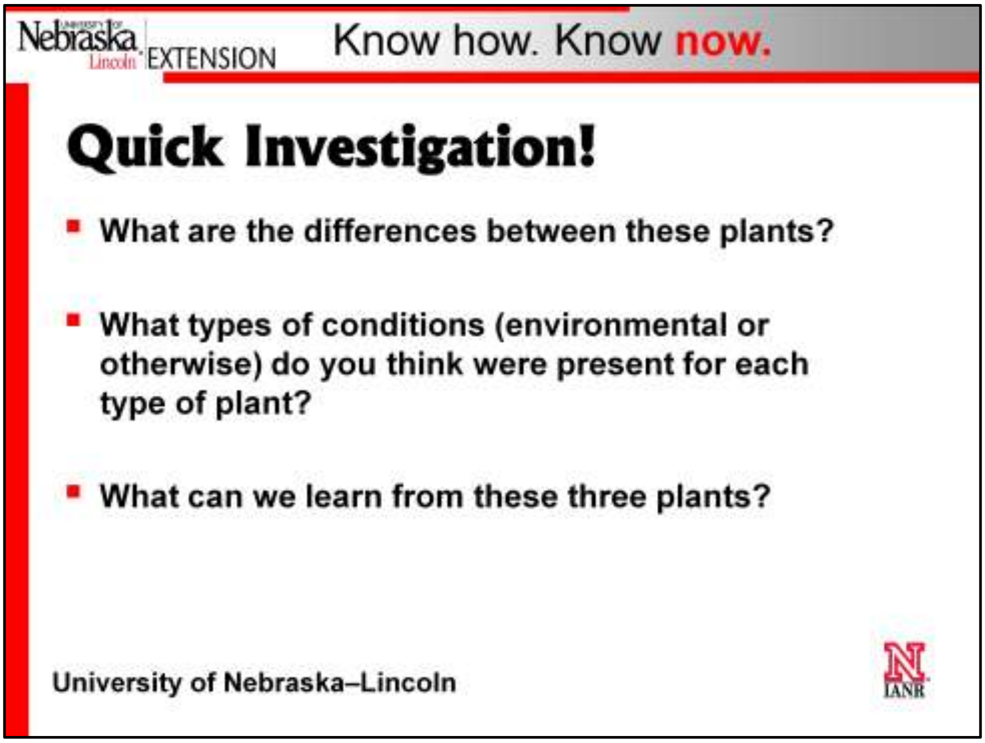
Nebraska Lincoln EXTENSION Know how. Know **now.**

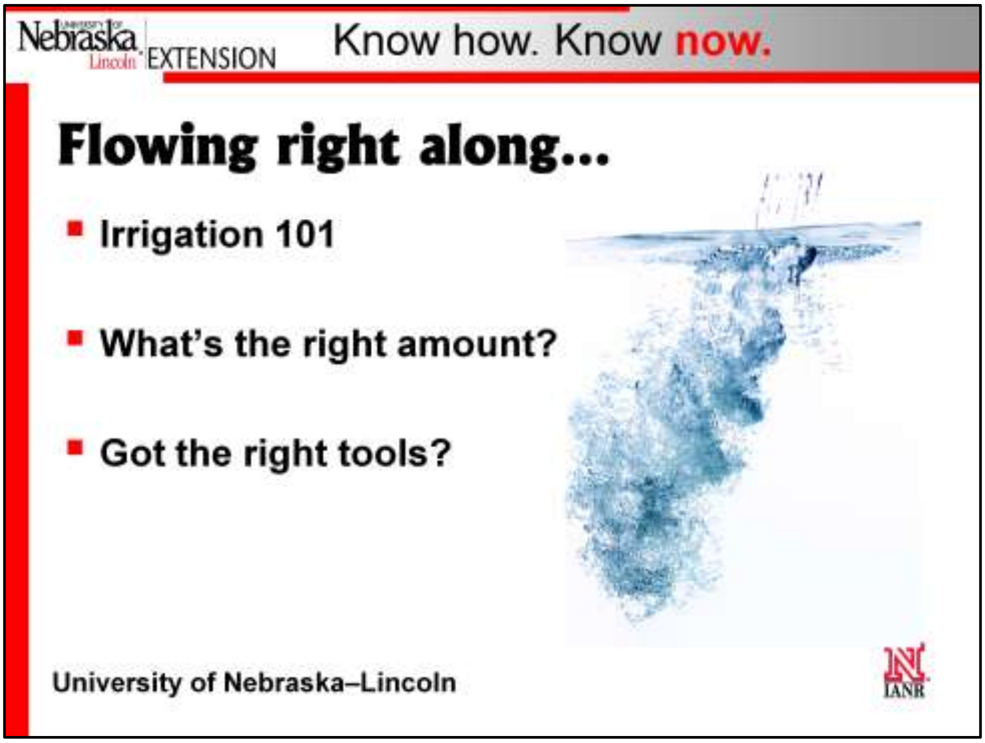
When and how much should I irrigate?

Gary Zoubek
&
Brandy VanDeWalle
Extension Educators
York & Fillmore Counties

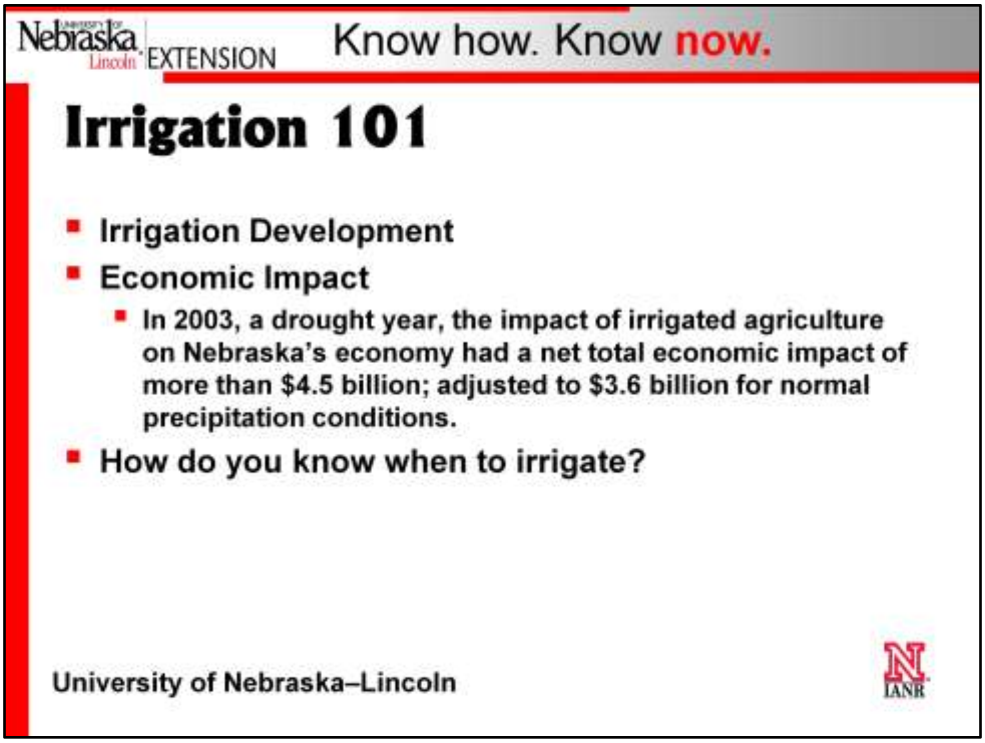
IANR



(PREP REQUIRED AHEAD OF TIME)
-Show youth three potted plants (healthy, flooded, drought) Try to not let youth see soil conditions.
-What are the differences between these plants?
-What types of conditions do you think were present for each type of plant?
-What can we learn from these three plants?
(Plants require a certain amount of water to thrive.)



Lesson Objectives:
Define and understand basic irrigation terminology.
Become familiar with problems associated with under or over-irrigating crops.
Understand & demonstrate how to use irrigation equipment for effective (corn and soybean) irrigation management.



Why did irrigation first start? (supplement the crop with needed water so it wouldn't die)

What is the economic impact irrigation has on Nebraska?

(The University of Nebraska's Bureau of Business Research conducted an Economic Impact Study* in 2003, a drought year, to determine the impact of irrigated agriculture on Nebraska's economy. The actual net total economic impact was computed as more than $4.5 billion; adjusted to $3.6 billion for normal precipitation conditions.)

How do most producers decide when to irrigate?

What tools are they using to decide when to irrigate? Do you think those are pretty accurate?

Let's define some key irrigation terms to first understand how and what irrigation does.

Irrigation, (defined by Britannica) is 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.

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)

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What do you want?

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

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

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

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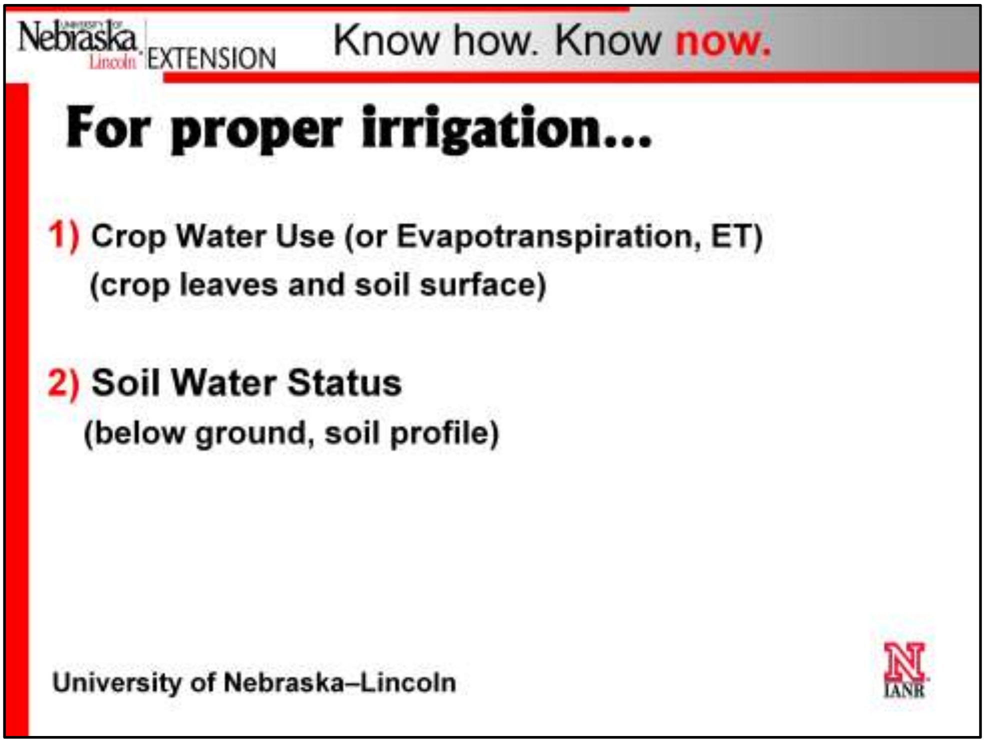
Proper **irrigation management** is required to maintain adequate soil moisture in the crop root zone for healthy plant growth and optimum yield. The objective of irrigation management is to establish proper timing and amount of irrigation for greatest effectiveness. It also helps reduce the potential for runoff and reduce soil erosion and pesticide movement into the surface and groundwater.



In order to understand irrigation management, there are two important concepts to understand in regards to crops: 1) Crop Water Use, also called Evapotranspiration and 2) Soil Water Status.

Crop Water Use (Evapotranspiration)The evapotranspiration (ET) process is a key variable in many disciplines including,

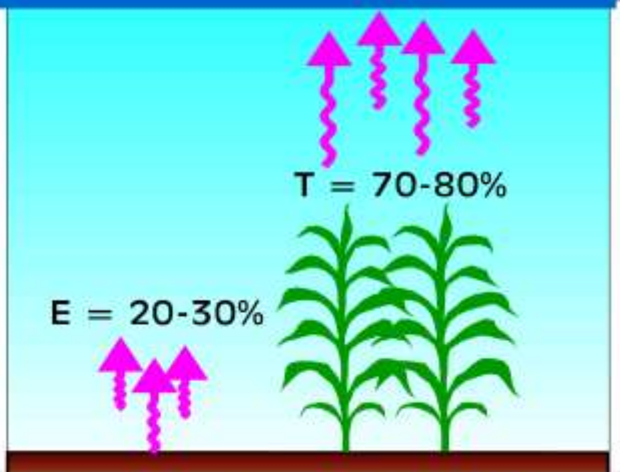
irrigation management,
crop growth,
hydrologic cycle,
plant physiology,
soil-plant-water-atmosphere relationships,
microclimate and surface interactions, and
drainage studies.

ET can be defined in a broad definition as the combined process of both evaporation from soil and plant surfaces and transpiration from plant canopies through the stomates to the atmosphere.

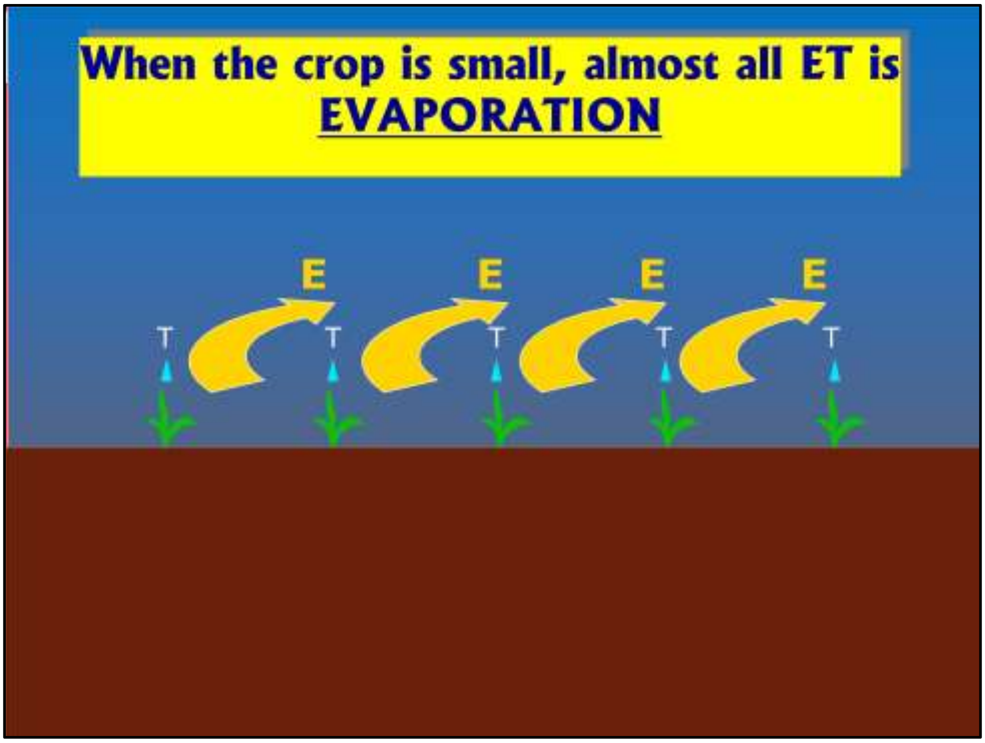
In the ET process, water is transferred from the soil and plant surfaces into the atmosphere in the form of water vapor.

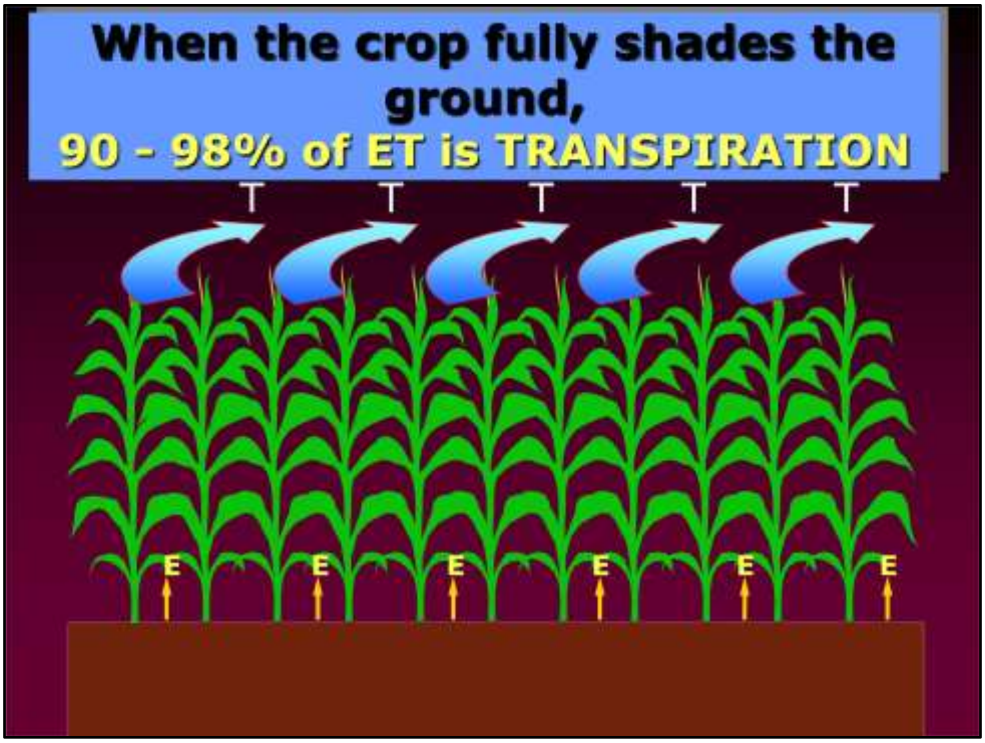
Crop ET can be measured directly using advanced techniques. However, in practice, the most commonly used method of estimating the ET rate for a specific crop requires first calculating reference ET and then applying the proper crop coefficients to estimate actual crop ET.

Crop Water Use = Evapotranspiration (ET)



ET = Evaporation + Transpiration

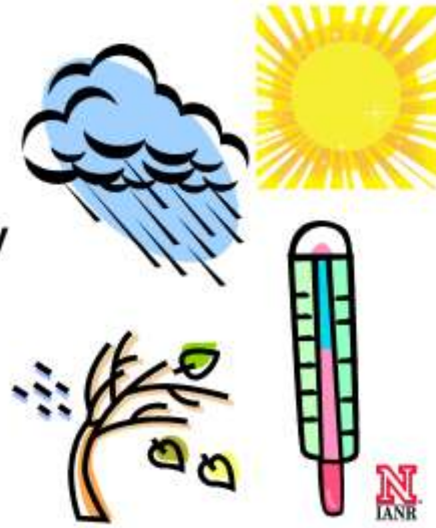

When the crop is small, almost all ET is
EVAPORATION
E
E
E
E
T
T
T
T
T

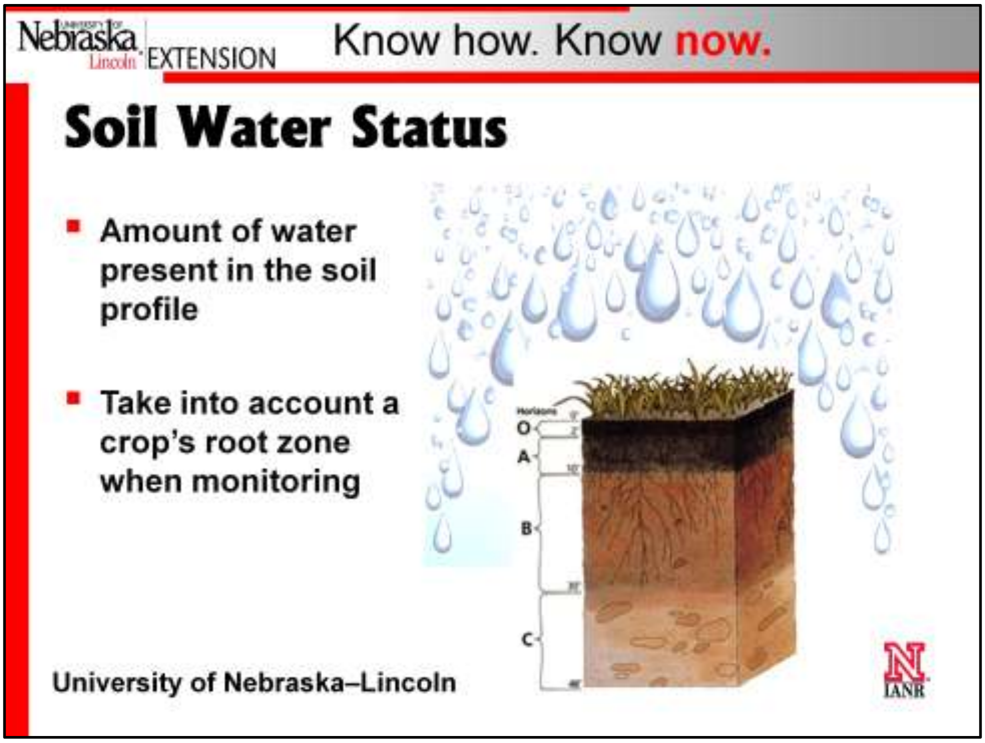

When the crop fully shades the ground,
90 - 98% of ET is TRANSPIRATION
T
T
T
T
T
E
E
E
E
E
E

What affects a crop's ET?

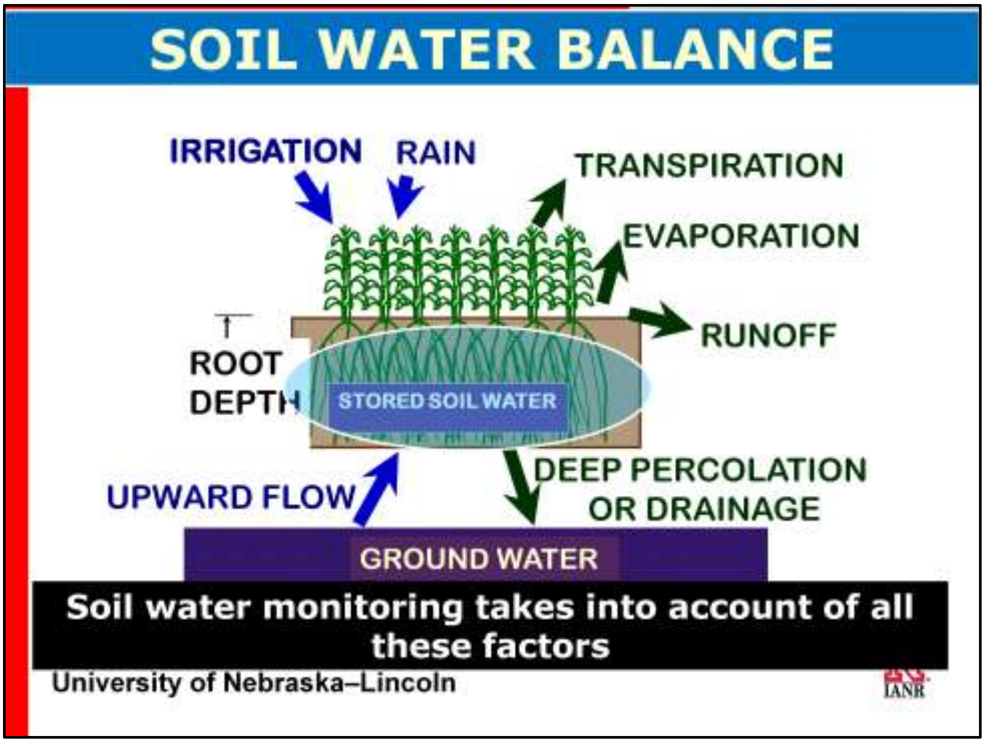
Weather data:

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

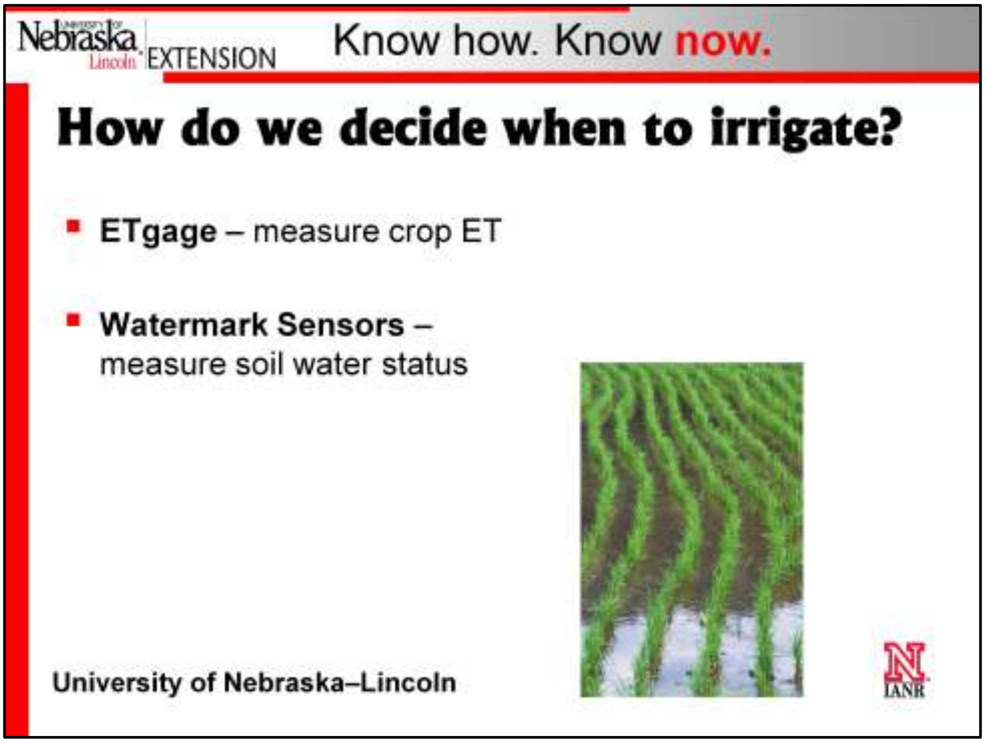




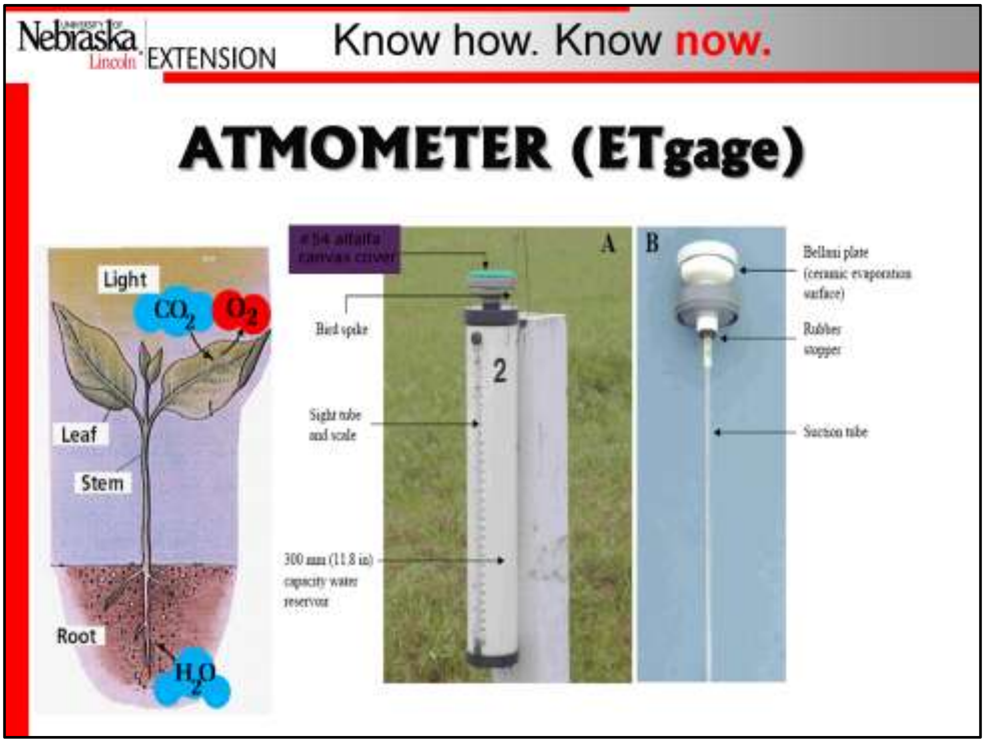
Soil water status is an indication of the amount of water present in the soil profile and can be described in two ways: 1. Soil water content and 2. Soil water potential. Soil water potential determines availability of water to plants is is a direct indication of the energy required for plants to obtain water from the soil.



The soil water balance slide shows that several factors are involved in determining how much water the crop has to use and when more irrigation is needed. Soil water monitoring gives the irrigator the net effect of all of the factors so they can directly determine how long until irrigation is needed and how much water the soil will hold. Knowing how much water is in the root zone is also critical in determining when to stop irrigating for the season.



As water is removed from the soil, the remaining water molecules are bonded to soil particles and to other water molecules, and are not readily and easily removed from the soil by plants. Matric potential indicates the energy that must be available in the plants to extract water from the soil.
In general, more clay content in a soil, the greater the water content at any given matric potential.



In order to measure a crop's ET, an **atmometer** or **ETgage** can be used.

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Actual crop water use = ETr x Kcr

From ETgage

From ETgage NebGuide

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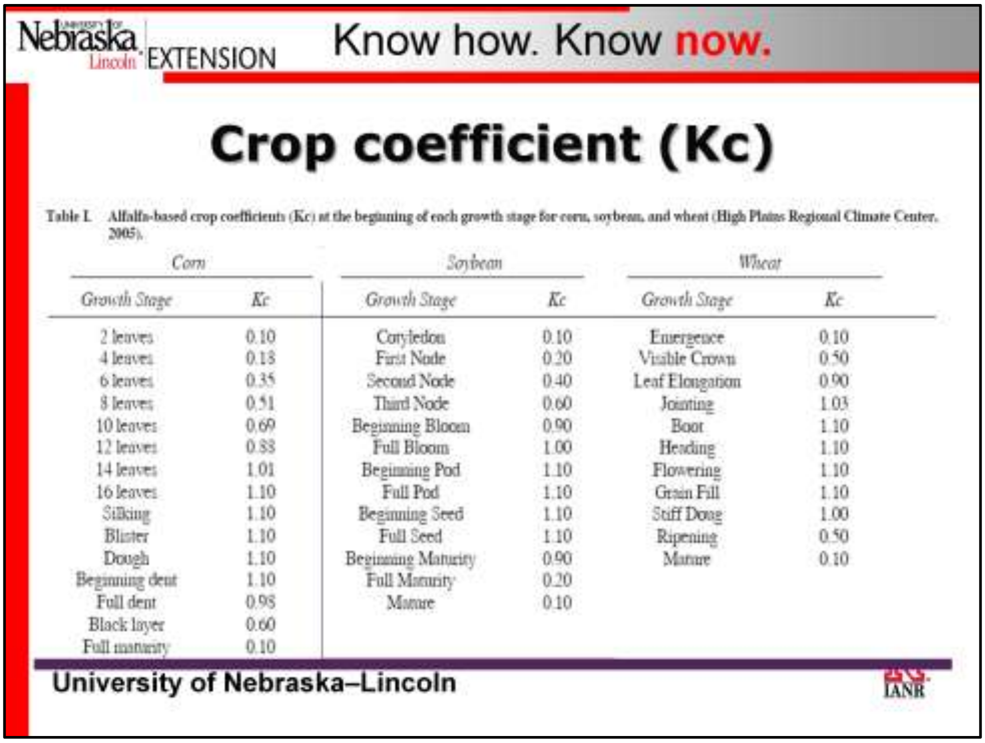
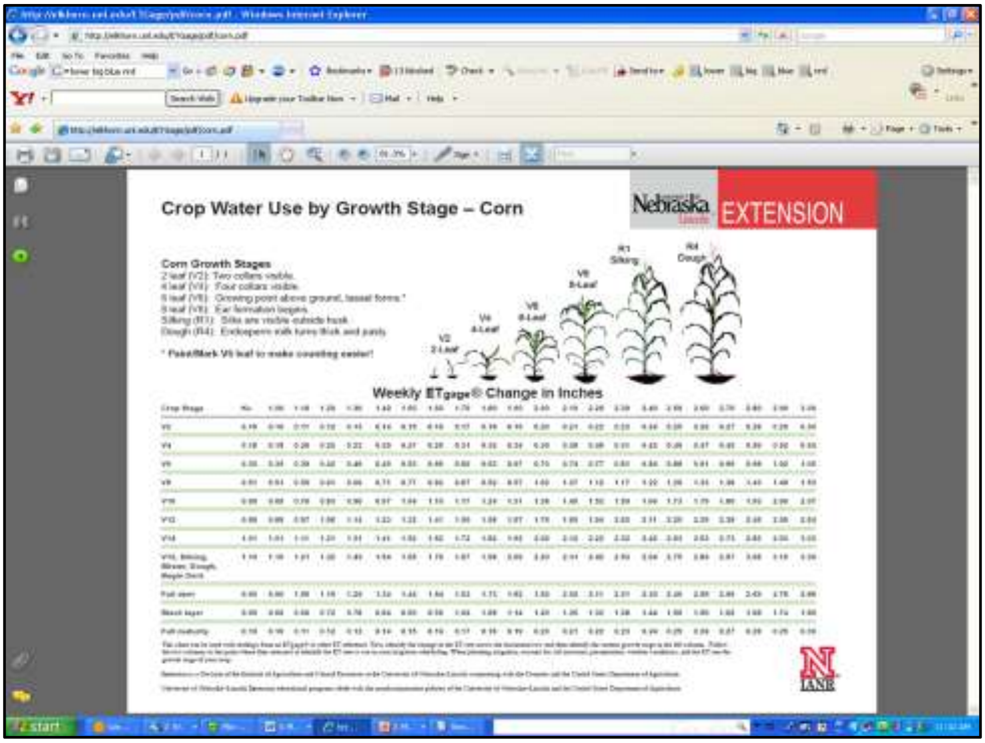


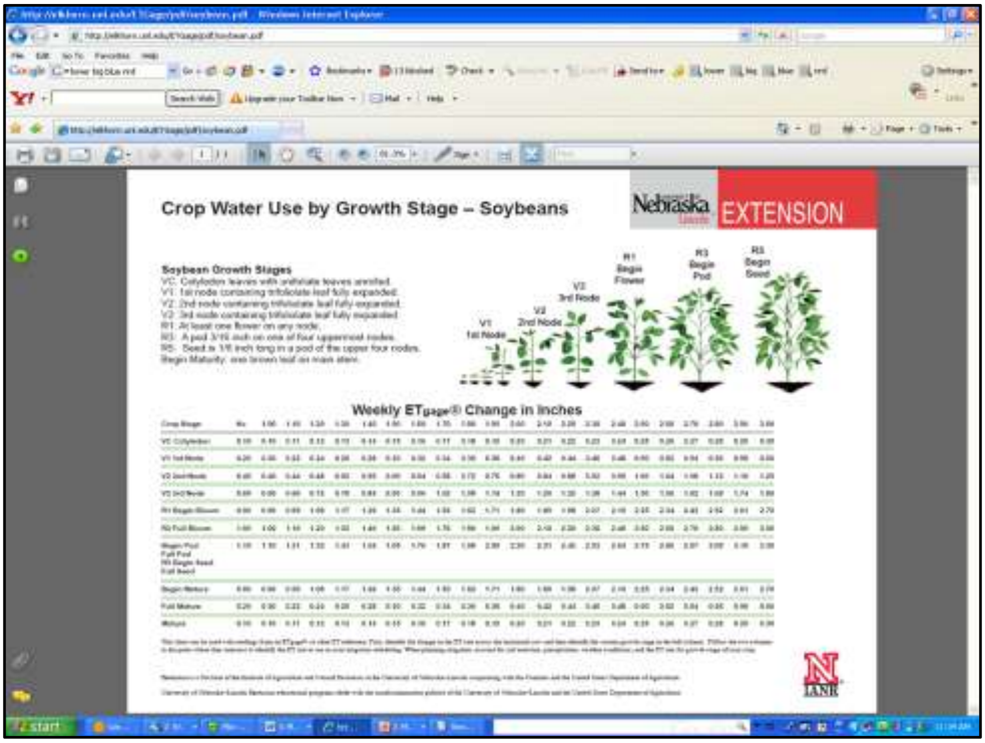
Crop coefficient (Kc)

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 Dough	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 ET can be measured directly using advanced techniques. However, in practice, the most commonly used method of estimating the ET rate for a specific crop requires first calculating reference ET and then applying the proper crop coefficients to estimate actual crop ET.


Crop Water Use by Growth Stage – Corn
Nebraska
EXTENSION
Corn Growth Stages
R1
Silking
R4
Dough
Weekly ETgage® Change in Inches


Crop Water Use by Growth Stage – Soybeans
Nebraska
EXTENSION
Soybean Growth Stages
V1
1st Node
V2
2nd Node
V3
3rd Node
R1
Begin
Flower
R3
Begin
Pod
R5
Begin
Seed
Weekly ETgage® Change in Inches

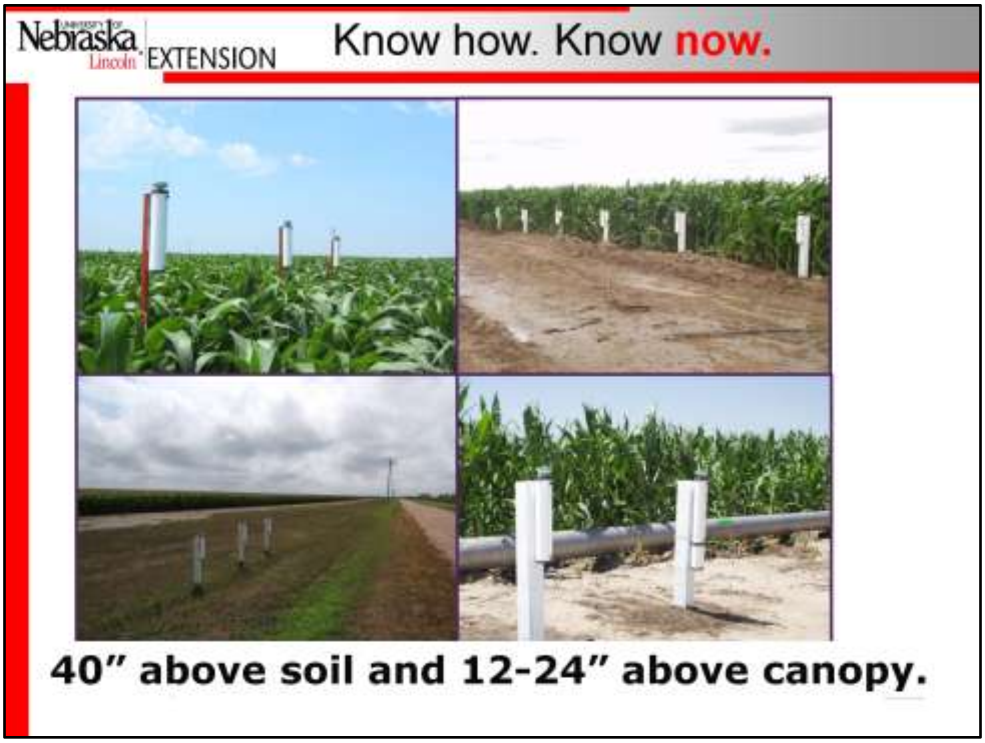
Example

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**



Different locations… best location is open area above the crop canopy!

More information on how to use an ETgage for irrigation management

NebGuide

Nebraska Lincoln

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.

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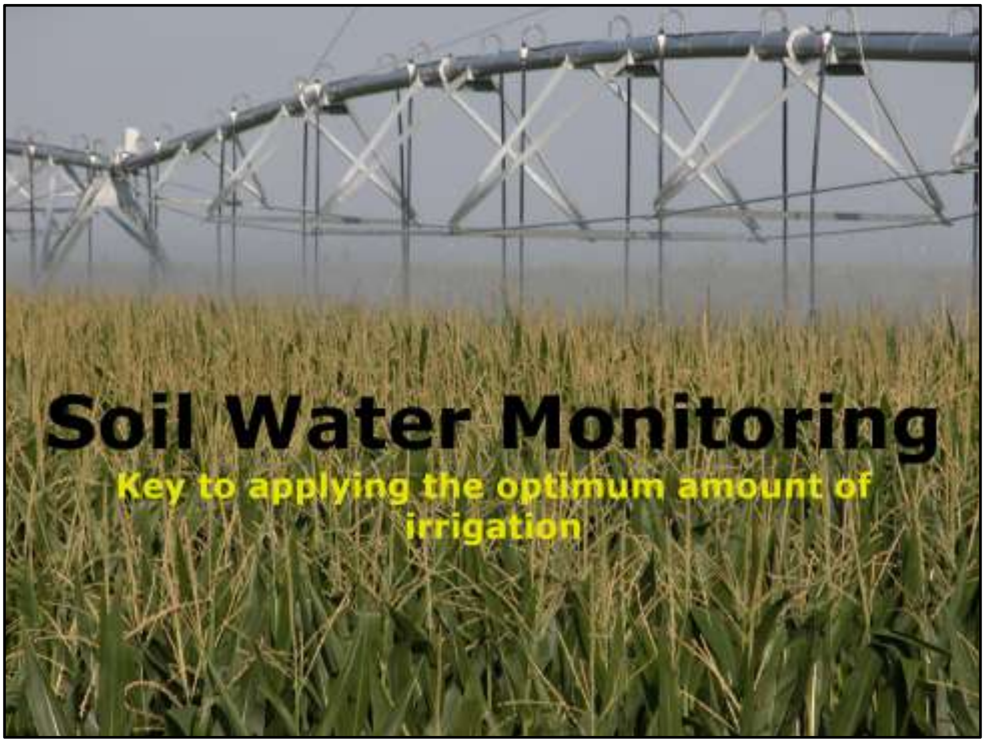
Soil Water Monitoring
Key to applying the optimum amount of irrigation

Know how. Know **now.**

For effective irrigation, must know water applied

Watermark sensors are used to measure soil moisture to determine irrigation timing and amount

One of the simple, economical, durable, and accurate sensors to monitor soil water status is the Watermark Granular Matrix sensor.

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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 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	0.08	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	0.90	0.80	0.80
80	0.65	0.55	0.70	0.60	1.20	1.00	0.93	1.00
90	0.75	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	0.88	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	0.99	0.88	1.08	1.20	N/A	N/A	N/A	N/A
200	1.00	0.95	1.28	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	30-35	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.

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							
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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
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(*) 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**.*

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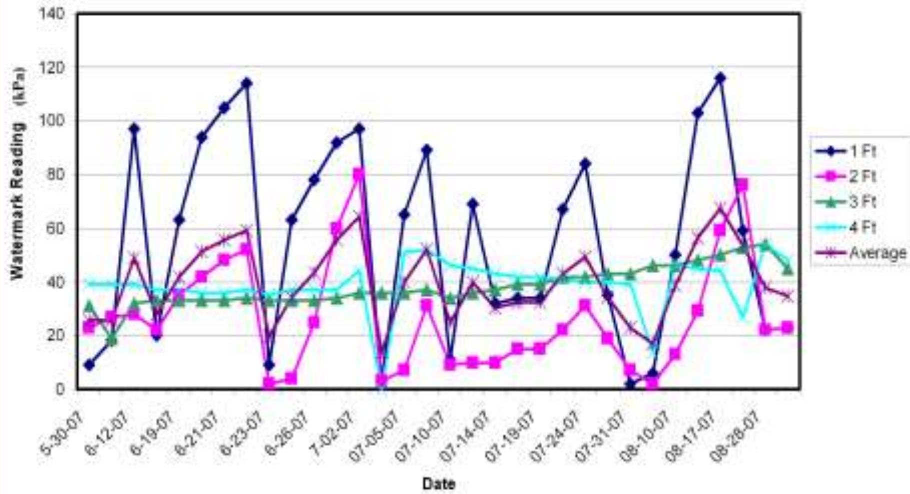
Example: change in soil water status



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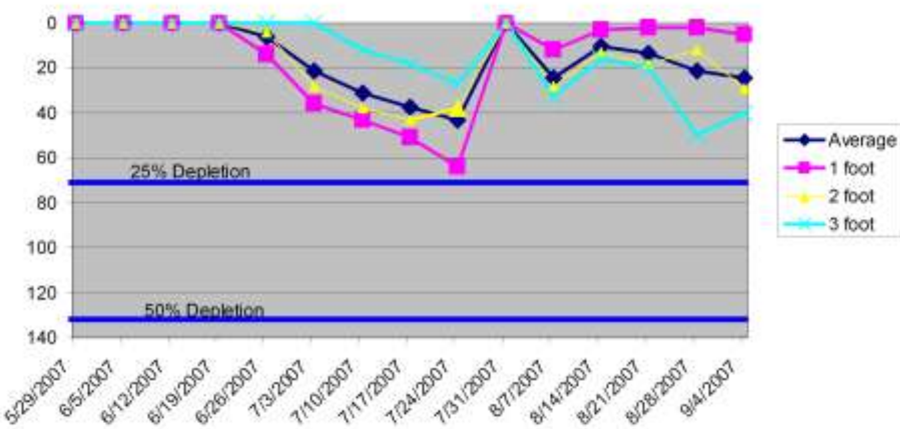
Example: change in soil water status



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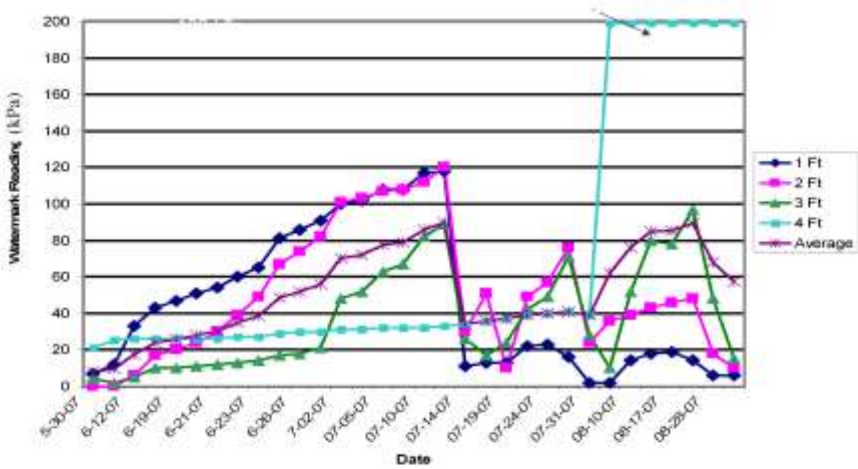
Example: change in soil water status



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

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EC783

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

Suat Irmak, Irrigation and Water Resources Engineer; Jose O. Payero, Irrigation Engineer; Dean E. Eisenhauer, Hydrologic and Irrigation Engineering; William L. Kranz, Irrigation Specialist; Derrel L. Martin, Irrigation and Water Resources Engineer; Gary L. Zoubek, Extension Educator; Jennifer M. Rees, Extension Educator; Brandy VanDeWalle, Extension Educator; Andrew P. Christiansen, Extension Educator; Dan Leininger, Water Conservationist, Upper Big Blue NRD

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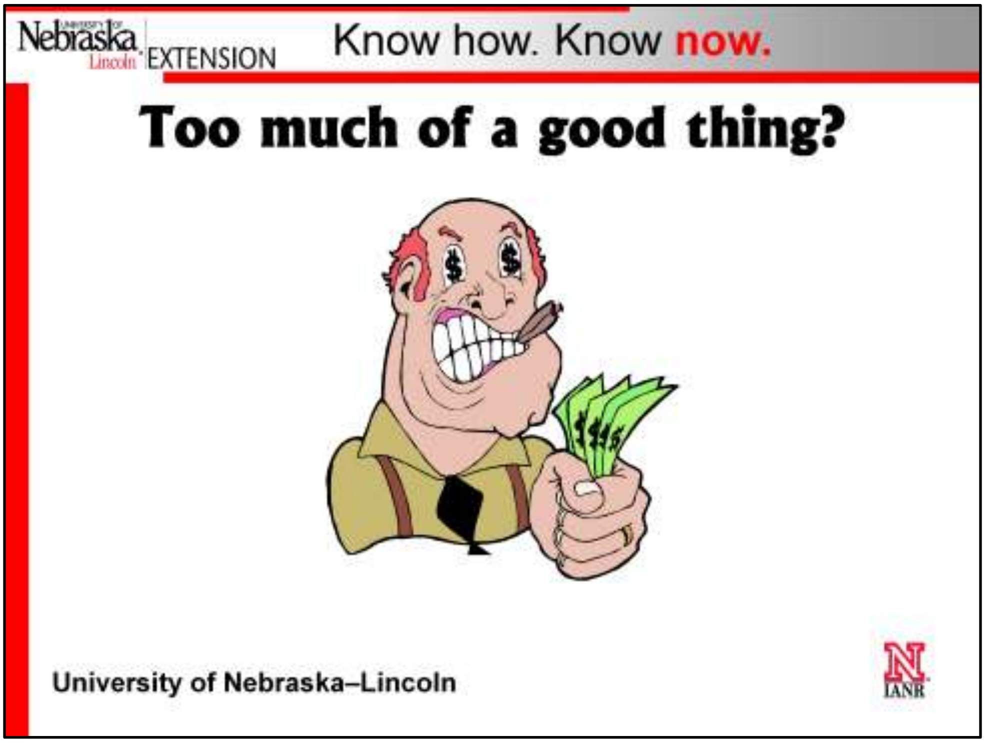

Ask youth if too much of a good thing can happen, whether its that they eat too much of a healthy food. i.e. apple, etc. (Everything needs to be in balance; think back to the demonstration at the beginning of lesson with over water, underwater, etc. plants)

The impact of excess water on crop growth and yield is influenced by crop type, soil characteristics, duration of excess water or flooding, initial soil water and nitrogen status of the soil before flooding, crop stage, air temperature, etc.

What happens to crops that receive excess water? (they will “drown” out b/c they need oxygen to survive)

Adopting proper irrigation management strategies can reduce negative impacts of over-irrigation and provide a balance between the crop water requirements and available water. Over-irrigation leads to water loss, increases energy use for pumping, causes leaching of nitrogen and other micronutrients and wastes time.

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Plants need O2 also!!!

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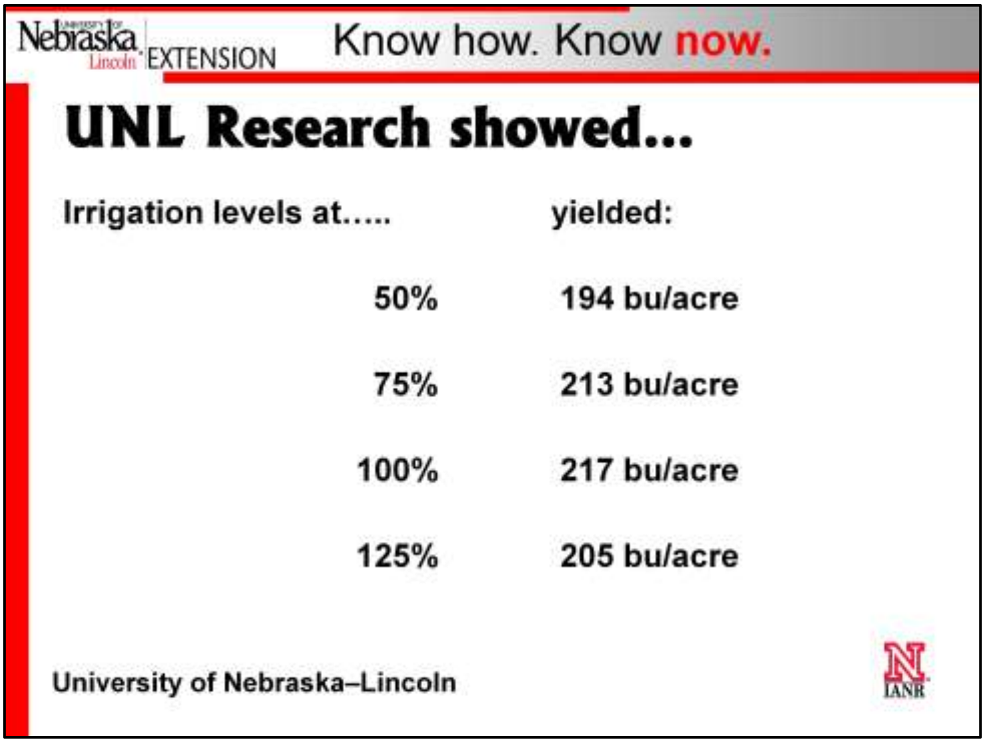

Research conducted in 2006 and 2007 at the University of Nebraska South Central Agricultural Laboratory near Clay Center by Dr. Suat Irmak included corn plots irrigated at 50%, 75%, 100% and 125% of actual crop water use or evapotranspiration. In both years, the over irrigated fields (125%) yield less than the optimum or fully irrigated field (100%).

Yields were:
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*.

Started in 2005 with UNL Extension and UBBNRD, spread to Little Blue NRD and others across the state.
NRCS has served as a great supporter and provided grants to expand the network.
Producers and crop consultants make this program work! Producers have been very great to work with as they have provided input and helped us improve the workings of the network.

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NAWMDN Website

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


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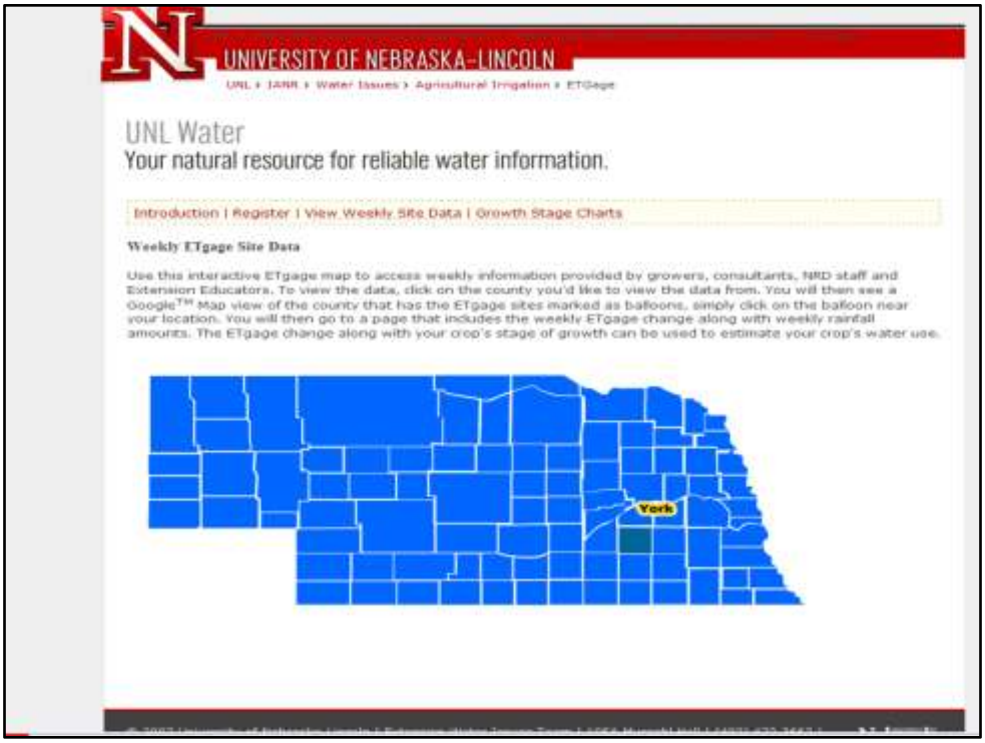
UNL Water
Your natural resource for reliable water information.
NAWMDN - Enabling producers to use water and energy resources efficiently.
What is an ETgage?
ETgage data information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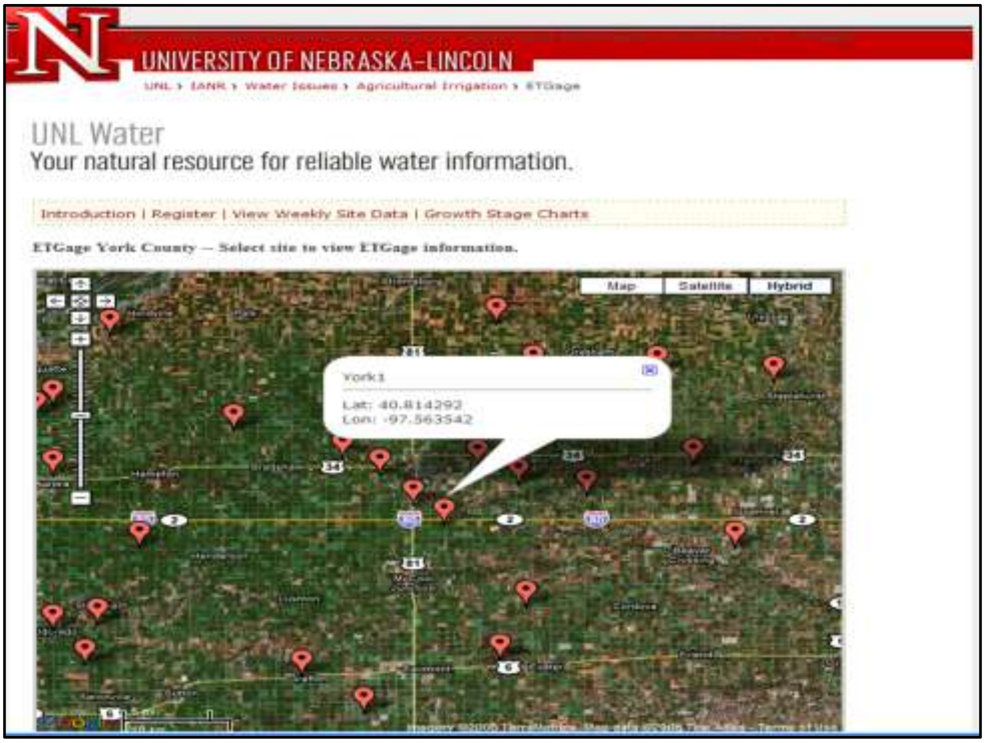
UNL Water
Your natural resource for reliable water information.
Introduction | Register | View Weekly Site Data | Growth Stage Charts
Weekly ETgage Site Data
Use this interactive ETgage map to access weekly information provided by growers, consultants, NRD staff and Extension Educators. To view the data, 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.
York



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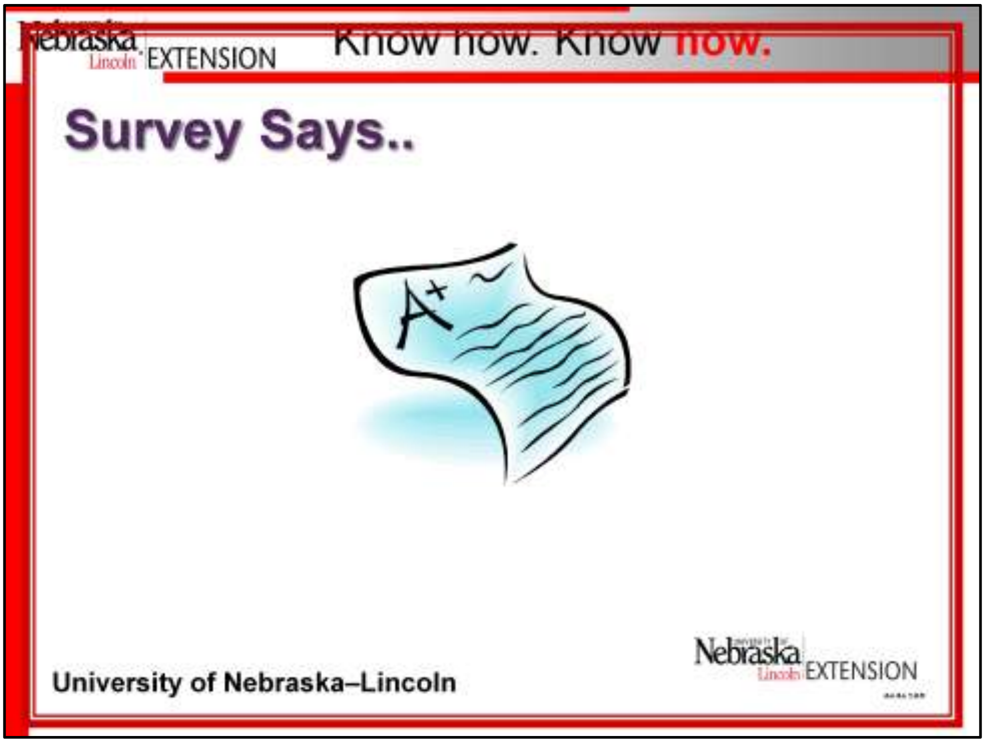
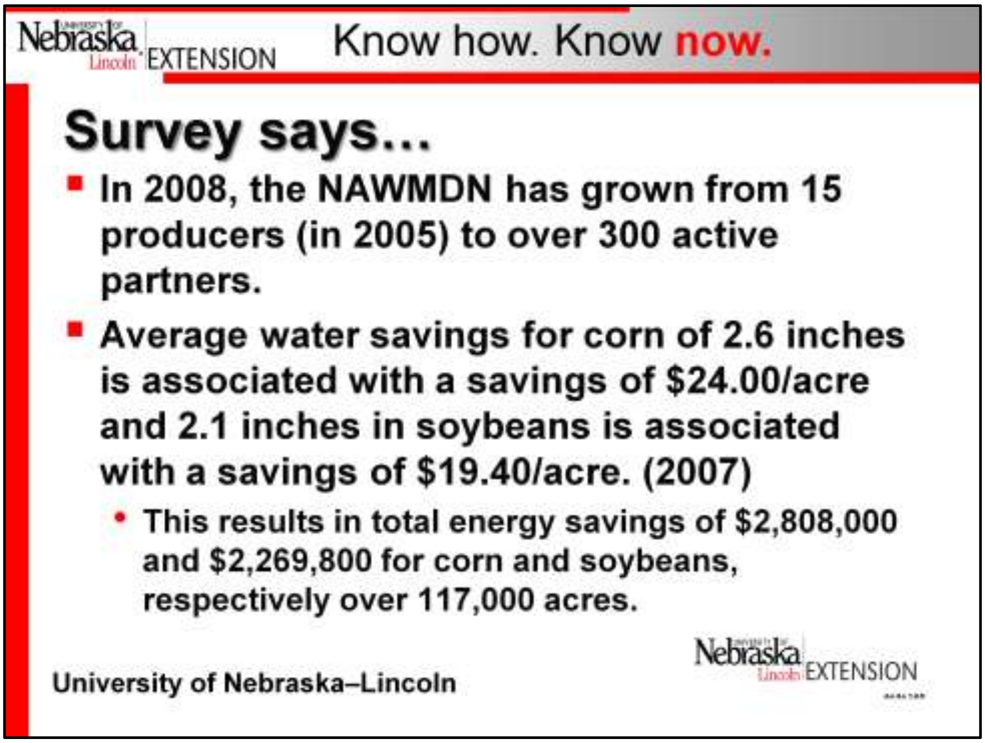
UNL Water
Your natural resource for reliable water information.
Introduction | Register | View Weekly Site Data | Growth Stage Charts
ETGage York County -- Select site to view ETGage information.
Map
Satellite
Hybrid
York1
Lat: 40.814292
Lon: -97.563542



Each year we have been working on this project, we sent surveys to producers to get their input.
Most of the surveys returned from 2006 and those coming in from 2007 have been very favorable.
We also have meetings throughout the growing season and at the end of the year for support and ideas, hence the development of quick charts and other materials received.

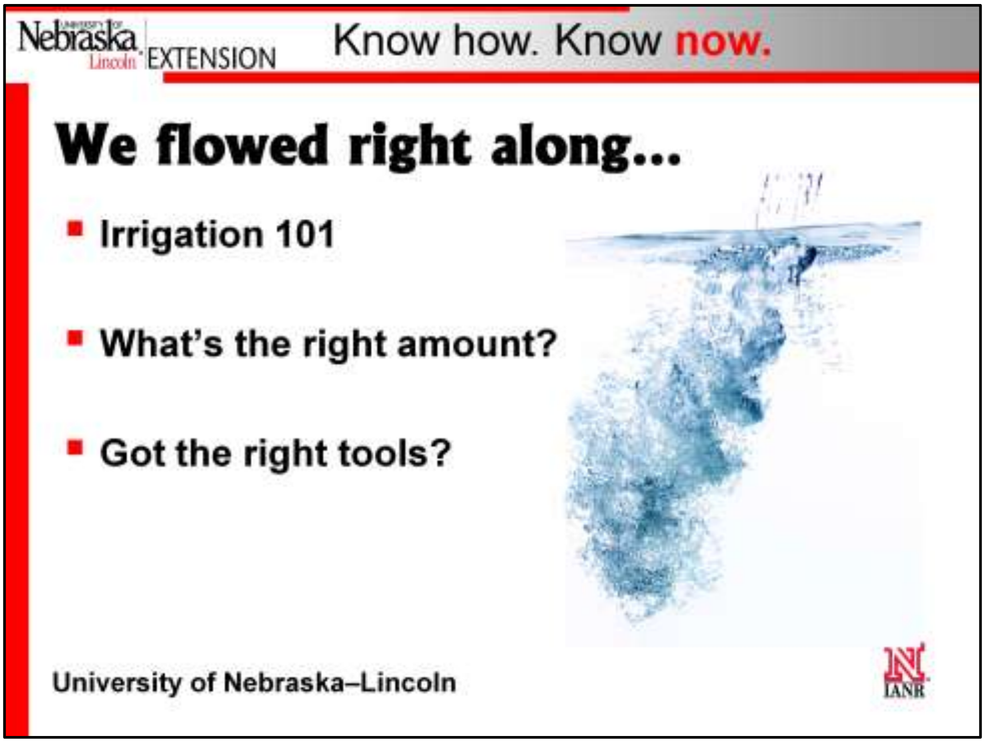


The NAWMDN has expanded State-wide this year with over 120 cooperators. This is twice the amount of cooperators from last year.
Last year producers that responded indicated that they reduced irrigation applications by 2-3" per acre as a results of the new technologies.
Preliminary survey results (N=12) indicate an average water savings of 2.5 inches. We anticipate more surveys after harvest.
One producer in the LBNRD reported "Those moisture sensors have paid for themselves about ten times over for one pivot".

2008 Survey data is being tabulated.

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.



Now you should….
Define and understand basic irrigation terminology.
Become familiar with problems associated with under or over-irrigating crops.
Understand & demonstrate how to use irrigation equipment for effective (corn and soybean) irrigation management.
Summary (Closure) – Conclusion to the Problem:
What is the importance of irrigation in Nebraska and when should I irrigate?
Review:
What is a definition of irrigation management?
Why is it important to irrigate efficiently and how can you be effective?
Define and understand basic irrigation terminology.
What are problems associated with under or over-irrigating crop?
What are two tools used to irrigate crops/soybeans?

Ask youth to answer…. When and how much should they irrigate?

Nebraska Lincoln EXTENSION Know how. Know **now.**

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