Factors Affecting Crop Water Use, ET

University of Nebraska Lincoln EXTENSION

Know how. Know **now.**

By Dean Yonts, Simon van Donk and Chuck Burr

IANR

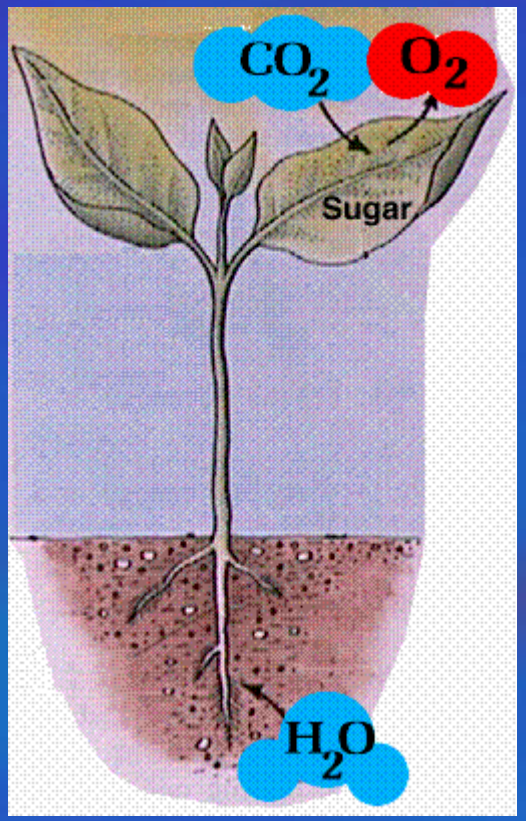
Why Do Plants Need Water

- Maintain Cell Turgidity for Structure and Growth
- Transport Nutrients and Organic Compounds
- Comprising Much of the Living Protoplasm in Cells
- Raw Material for Chemical Processes
  - Photosynthesis
  - Transpiration
  - Temperature Buffering Agent

Photosynthesis

- $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$

Know how. Know **now.**



Evapo-Transpiration (ET)

Transfer of water in form of water vapor from:

- **Soil Surface**
- **Body of Water**
- **Vegetative and other Surfaces**

To the Atmosphere

Unless: The Air is Saturated

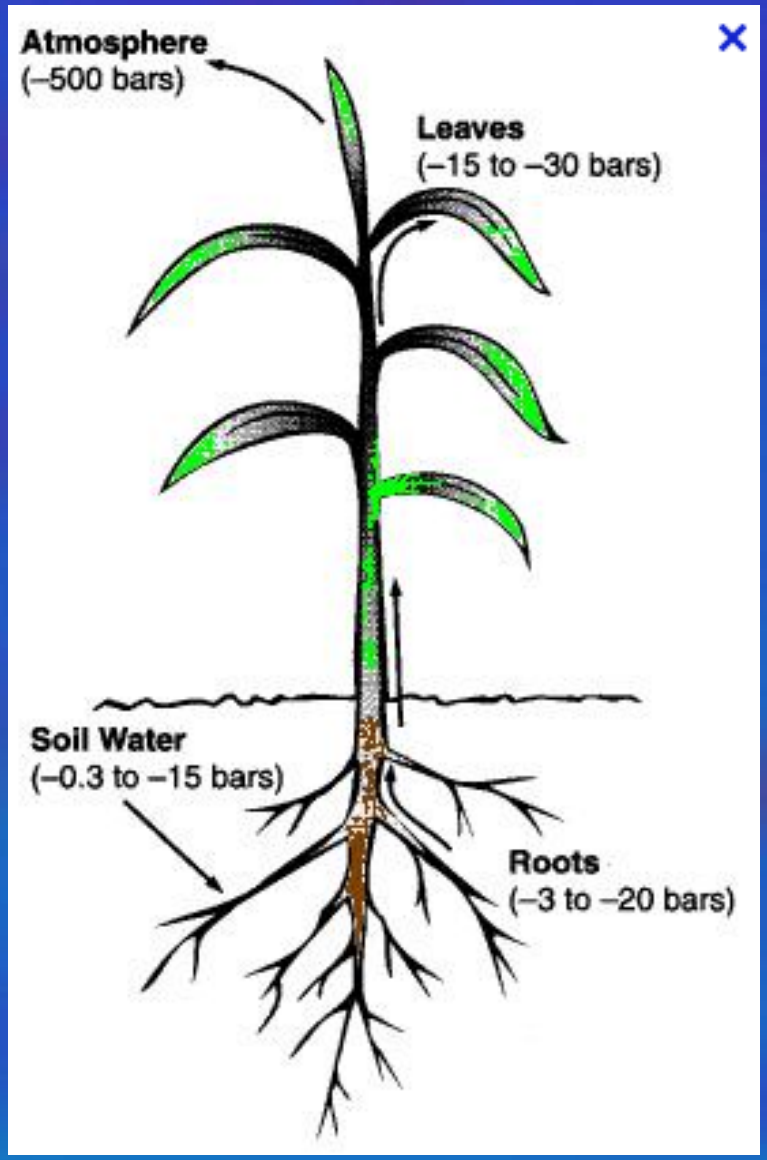
Agro-ecosystems: ET

(E)

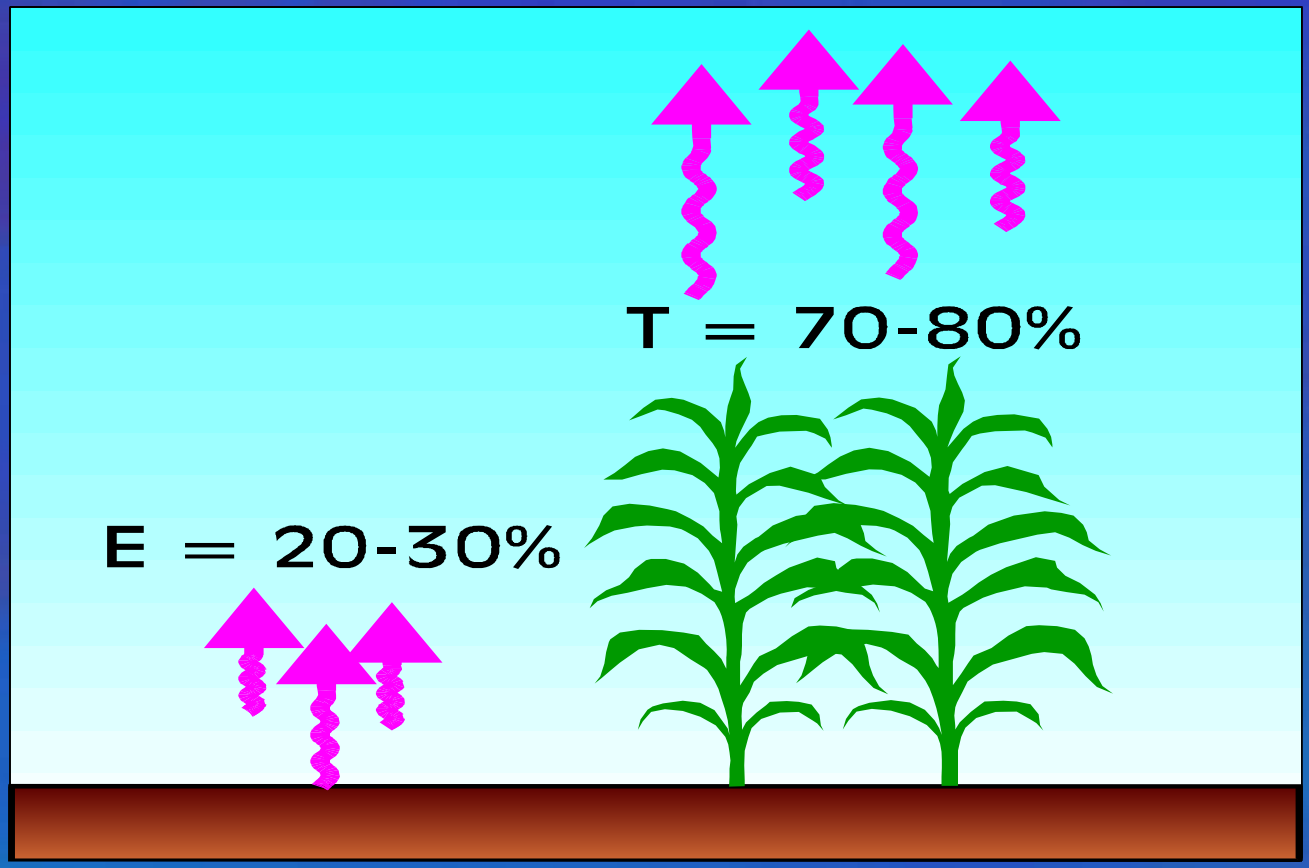
Evaporation From Soil, Water or Plant Surfaces

(T)

Transpiration From Plants


Atmosphere
(–500 bars)
Leaves
(–15 to –30 bars)
Soil Water
(–0.3 to –15 bars)
Roots
(–3 to –20 bars)

ET Components Over a Growing Season



Evapo-transpiration is Primarily Driven by Climatic Conditions:

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

Evapo-transpiration is Primarily Driven by Climatic Conditions:

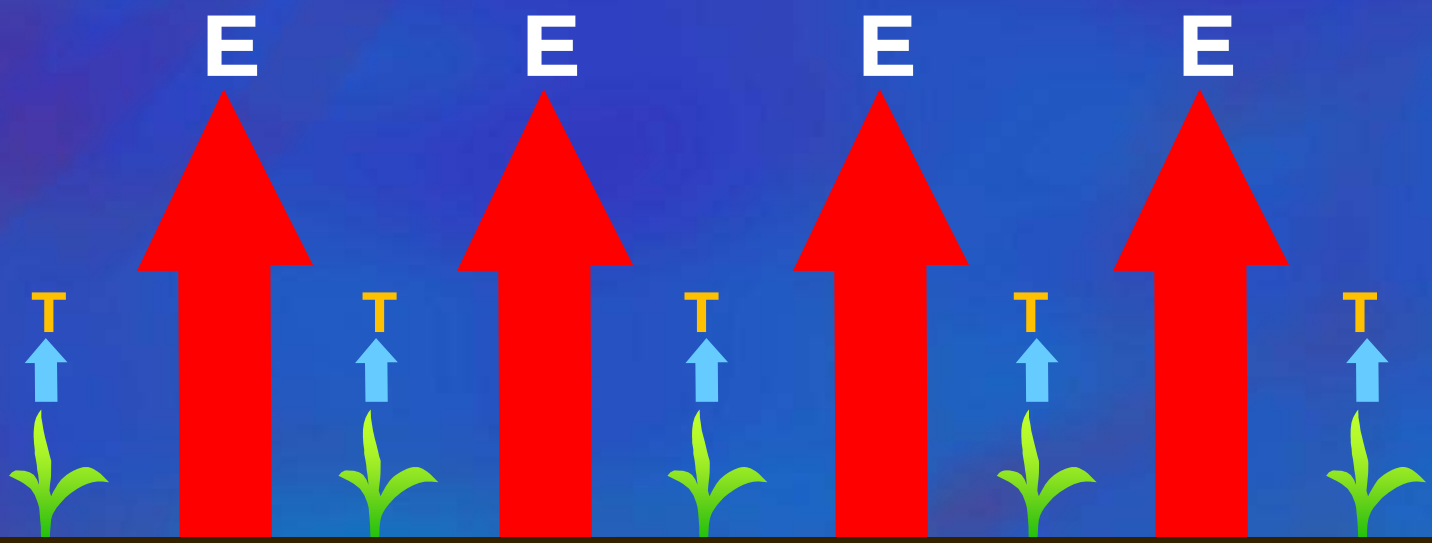
- ET Increases with an Increase in Air Temperature and Solar Radiation – Two Primary Drivers of ET
- ET Usually Increases with an Increase in Wind Speed
- Above a Certain Wind Speed, the Stomata Close, Reducing Transpiration

Evapo-transpiration is Primarily Driven by Climatic Conditions:

- A Reduction in Relative Humidity Increases ET because Low Humidity Increases the Vapor Pressure Deficit between the Leaf Surface and the Air

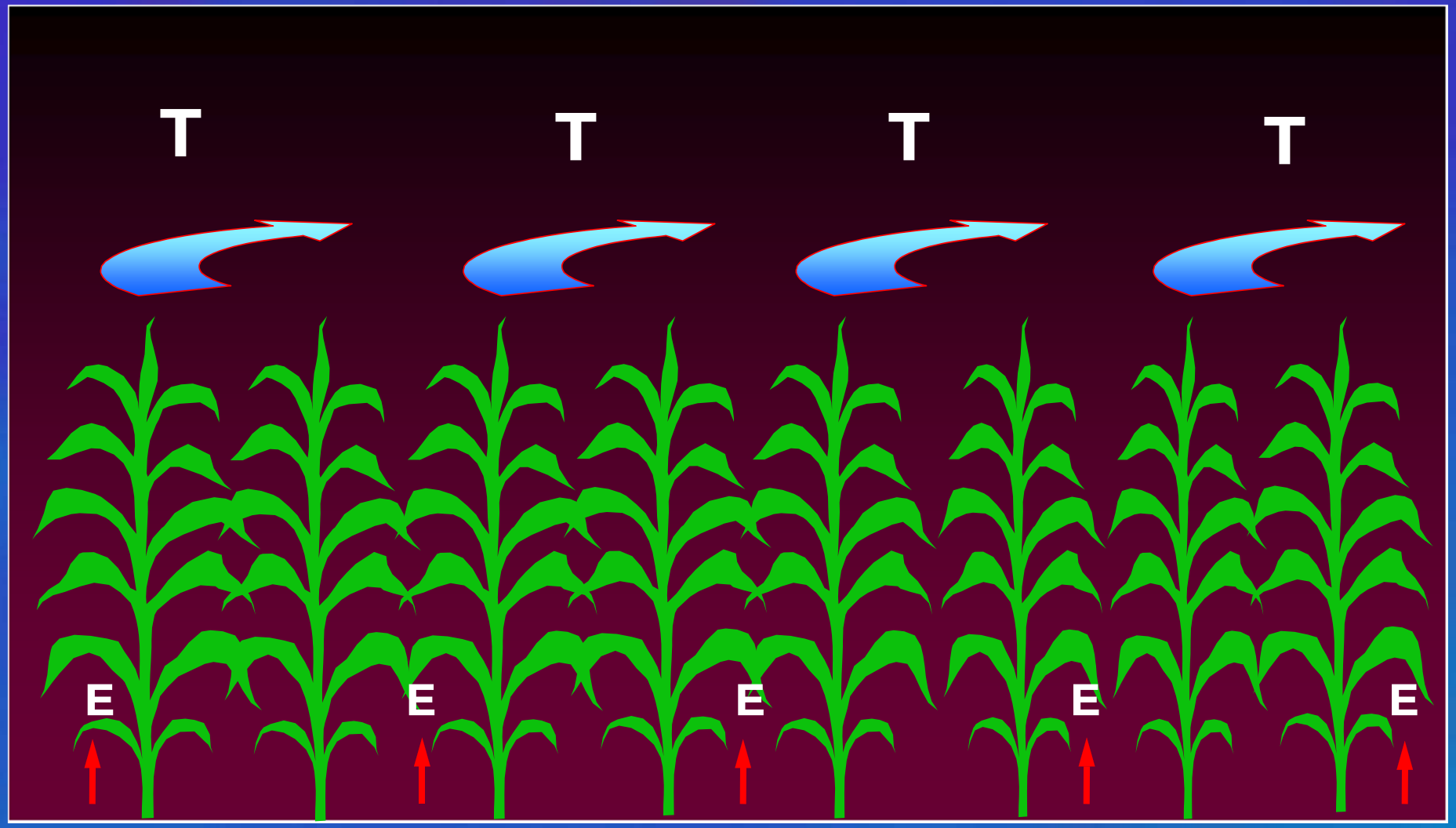
- Generally the Top Leaves Are More Active in Transpiration – Receive More Solar Radiation

When the crop is small, almost all ET is E



Nebraska University of Lincoln EXTENSION

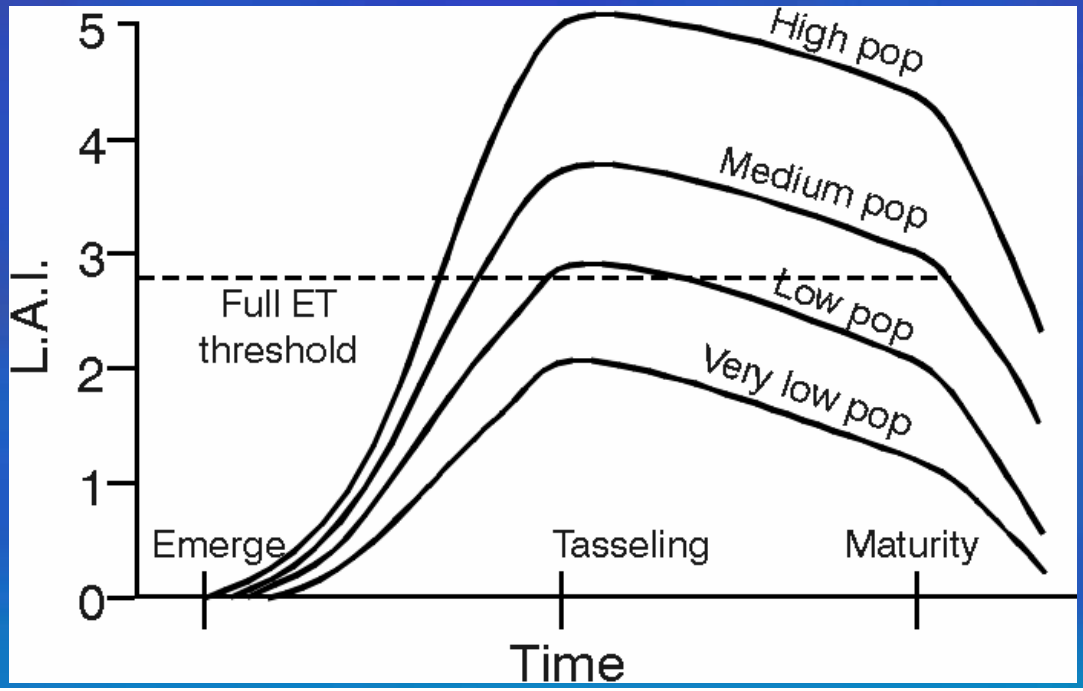
Know how. Know **now.**



IANR

When the Crop Fully Shades the Ground, 90-98% of ET is Transpiration

- LAI - Ratio of Leaf Surface (one side) Area to Land Surface area
  - Ex. 15 ft^2 leaf surface area for 5 ft^2 land = 3.0
- 2.7 Leaf Area Index – Full Canopy – 5-6 ft tall



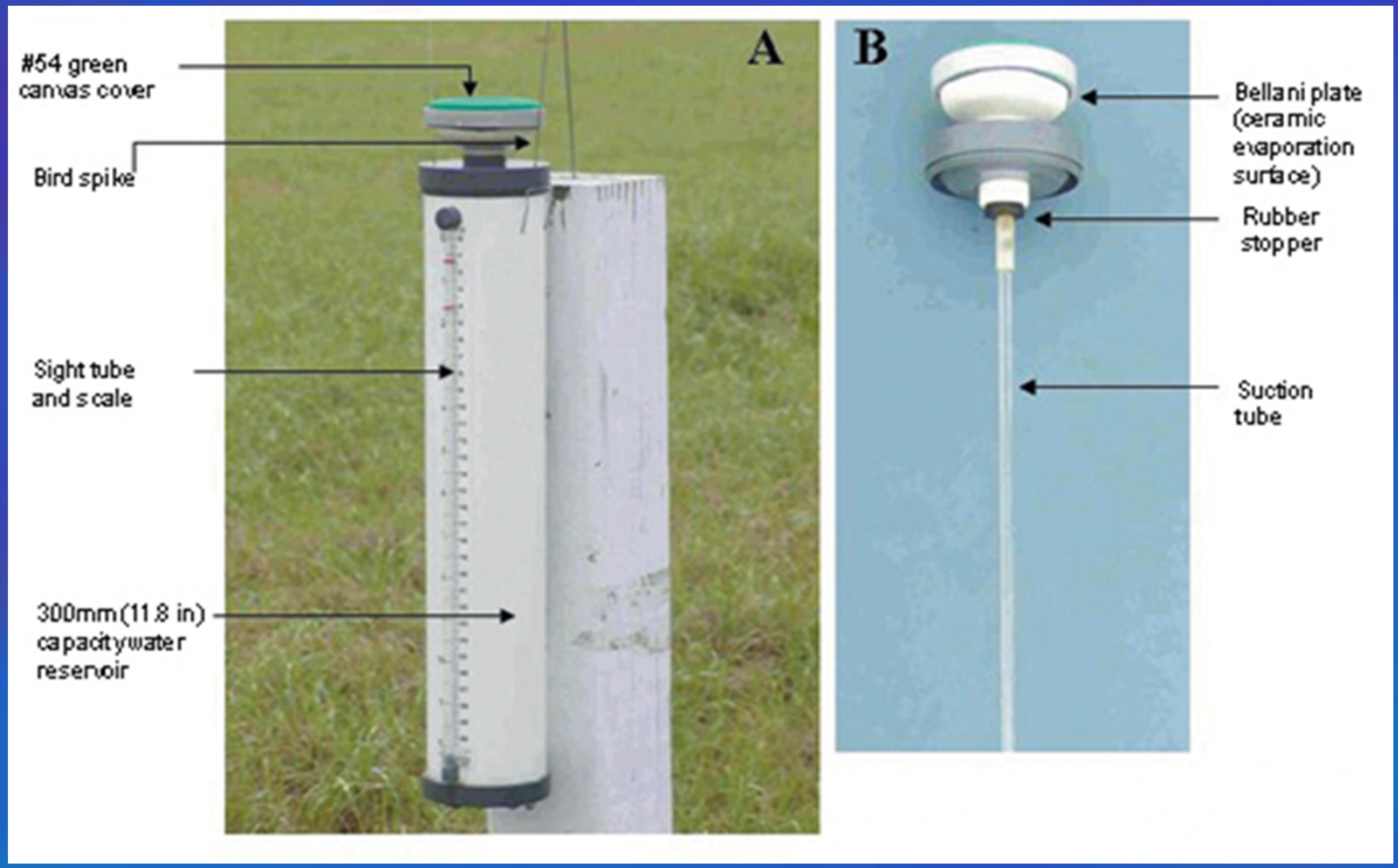
Factors Which Affect ET

Plant Species, Canopy Characteristics, Plant Population, Degree of Surface Cover, Plant Growth Stage, Irrigation Regime, Tillage Practices, Planting Date, Maturity Group of Plant Variety, Soil Water Availability.

In Nebraska Crop ET is Calculated (Estimated) From Weather Data by the High Plains Climate Center (HPCC) or with the use of an Atmometer

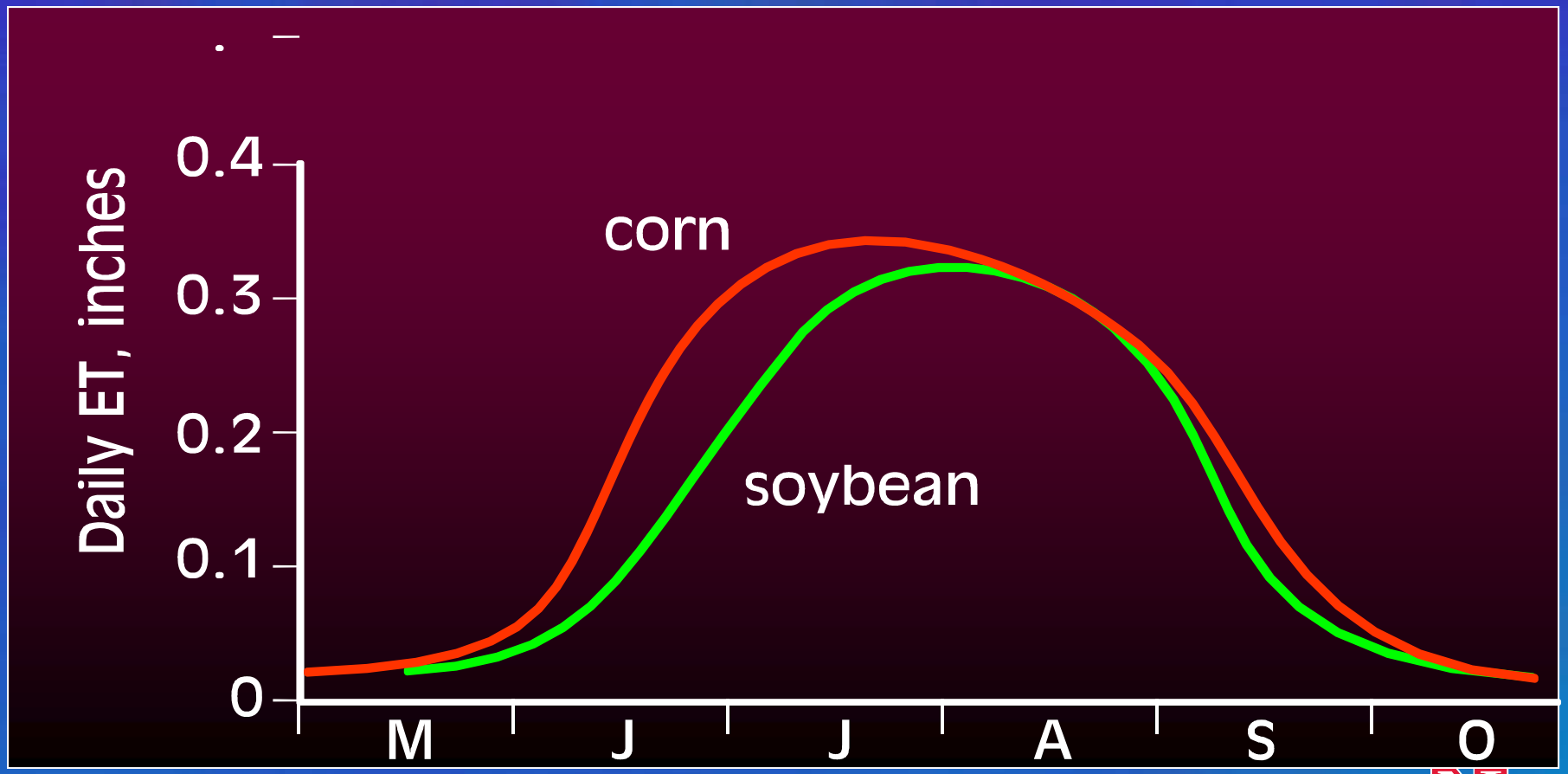
Weather Station Data - http:/www.hprcc.unl.edu/

Atmometer (ET Gauge) – NAWMDN – http://water.unl.edu/cropswater/nawmmdn



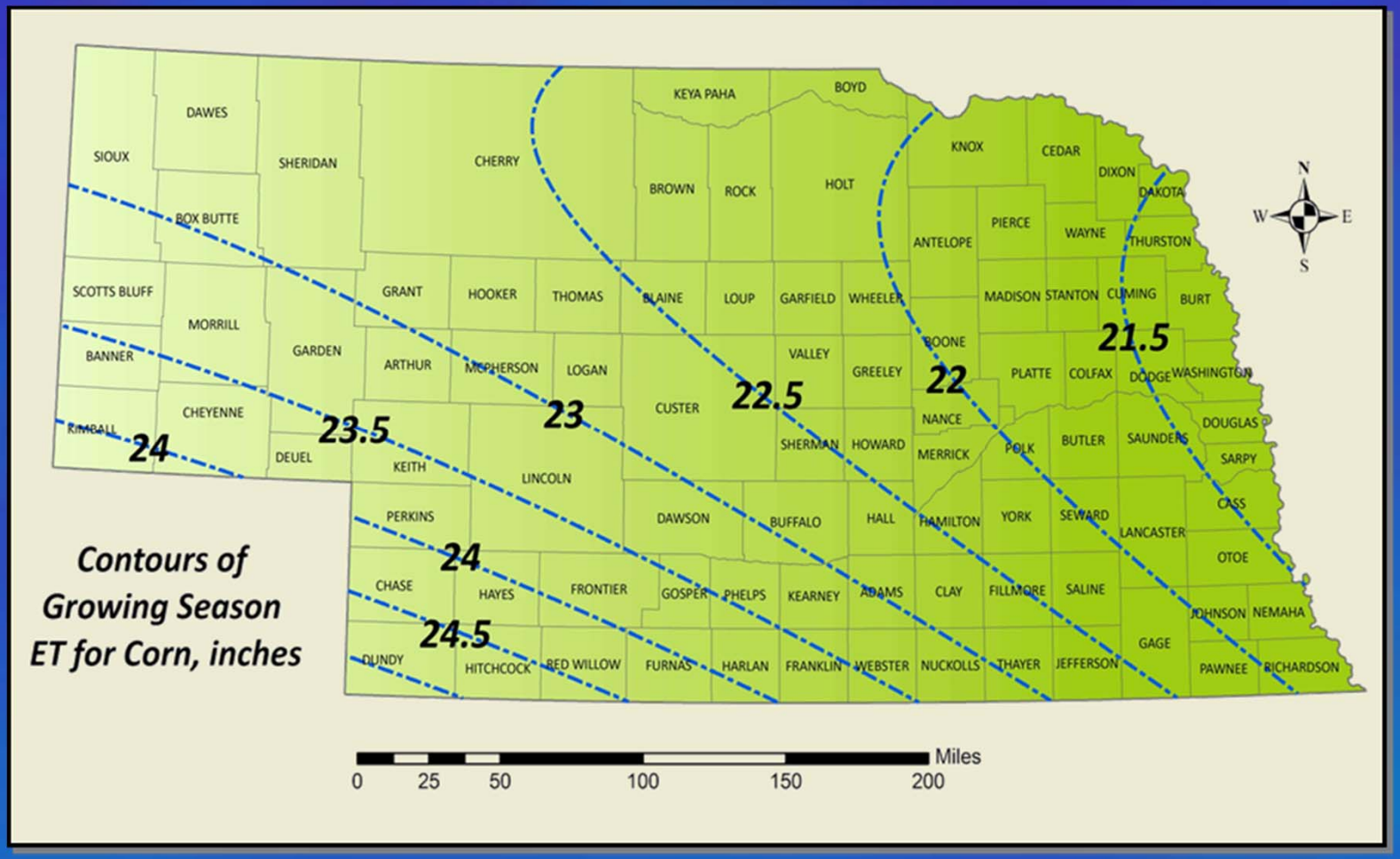
IANR

Average Crop ET for Multi-year Period



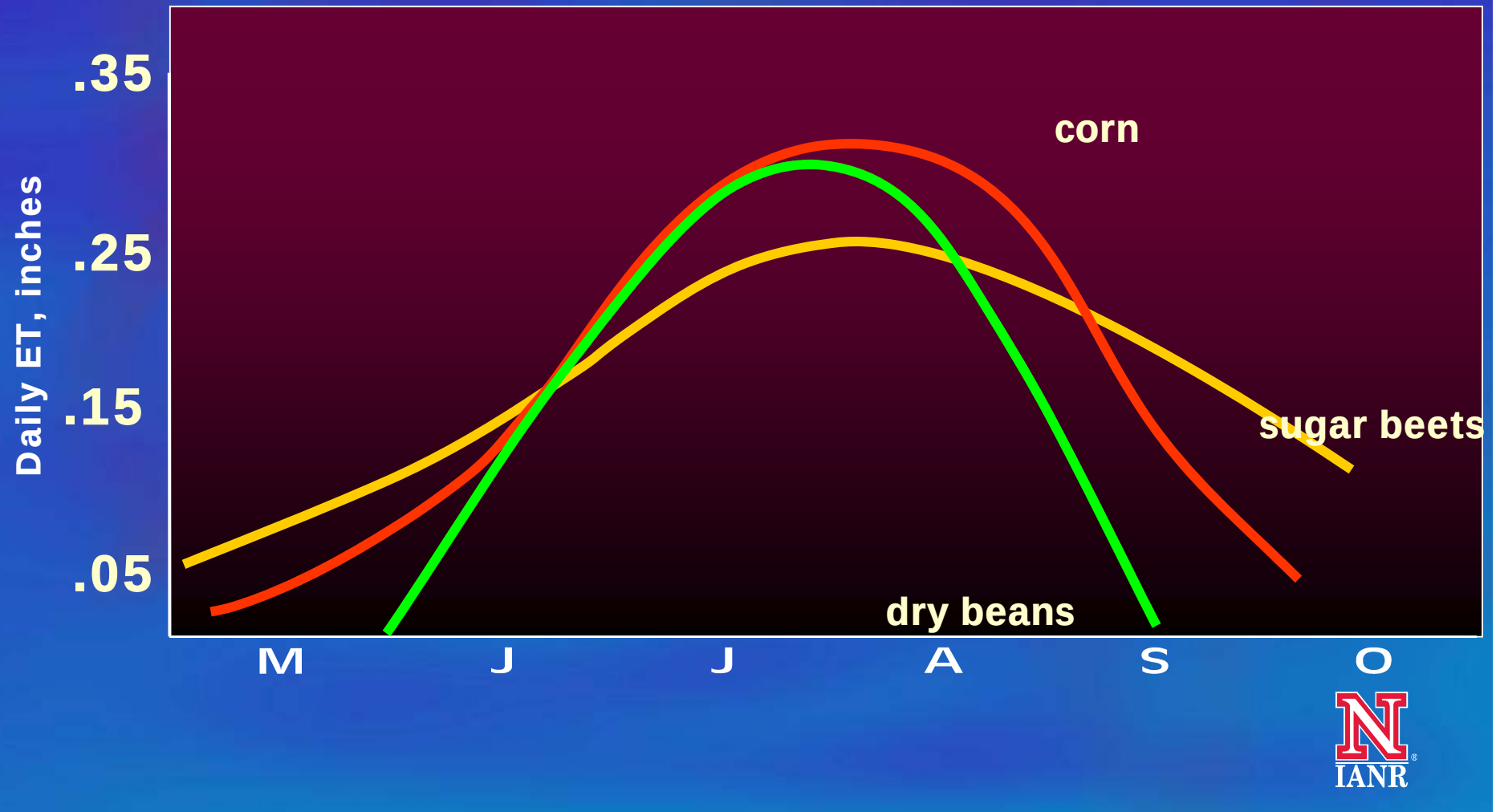
IANR

Growing Season ET for Corn (May 1- September 15)

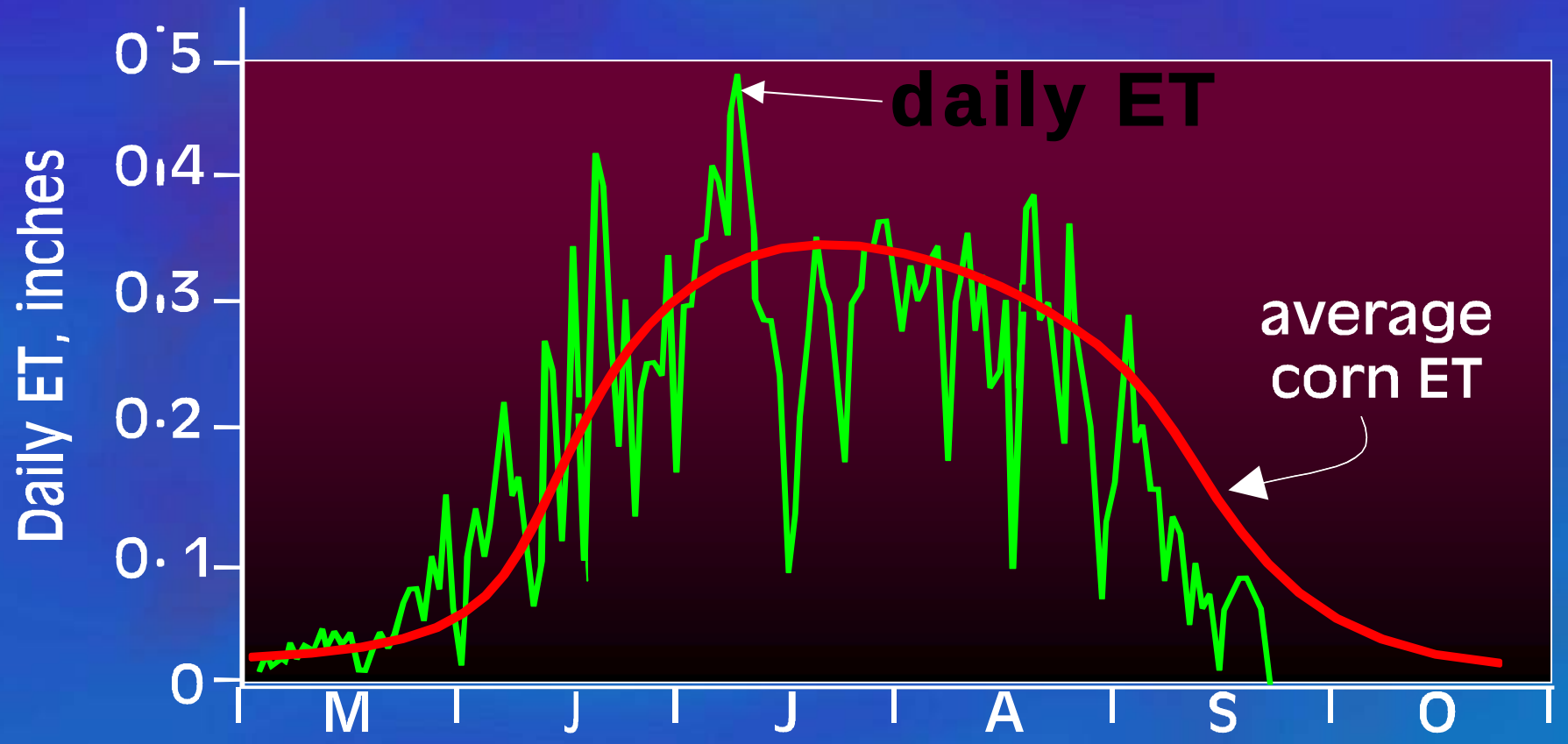


IANR

Ave ET for Corn, Sugar Beets & Edible Beans



Crop ET Varies With Weather



IANR

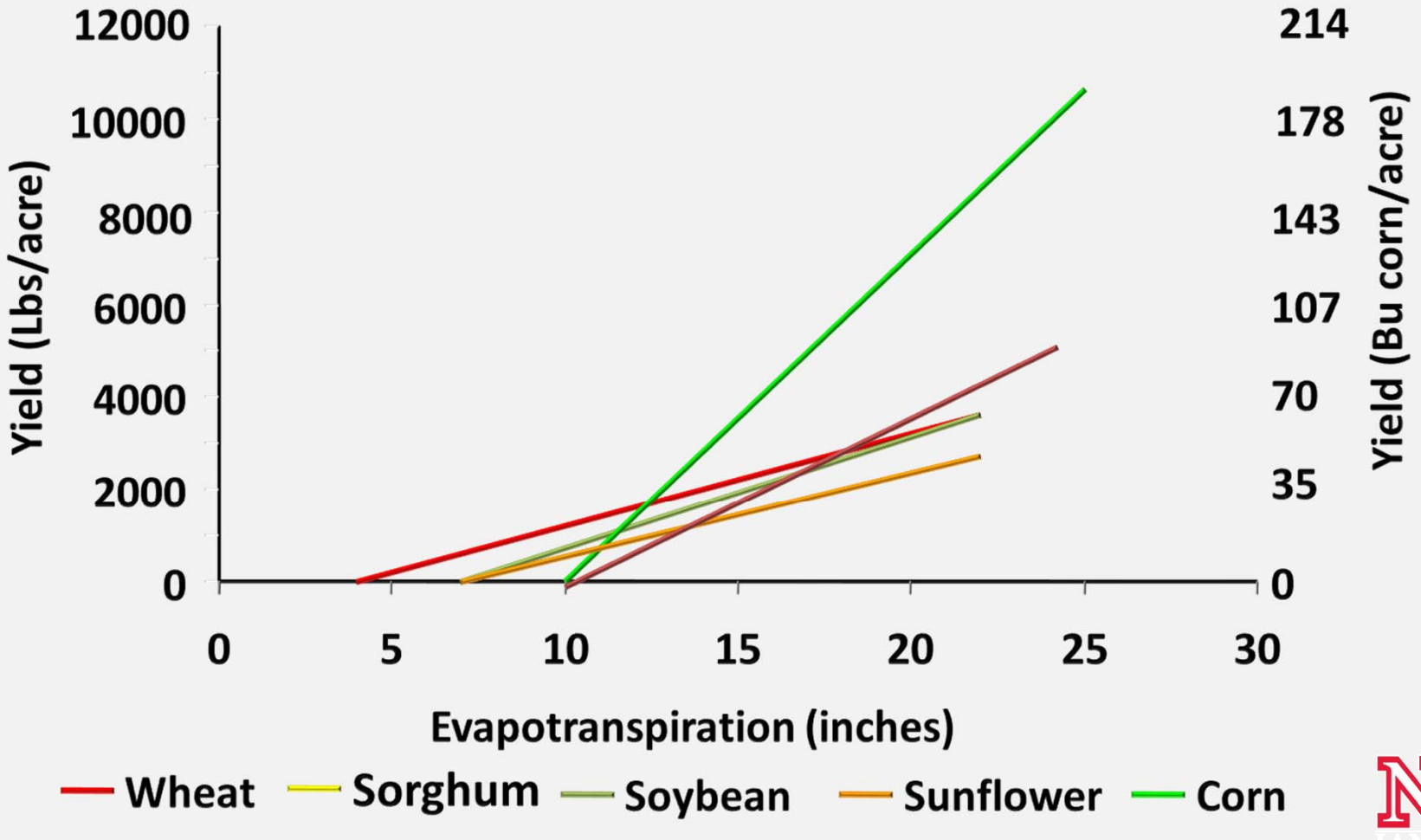
Daily ET Varies with Weather Conditions and Crop Growth Stage

ETc= ETref X Kc

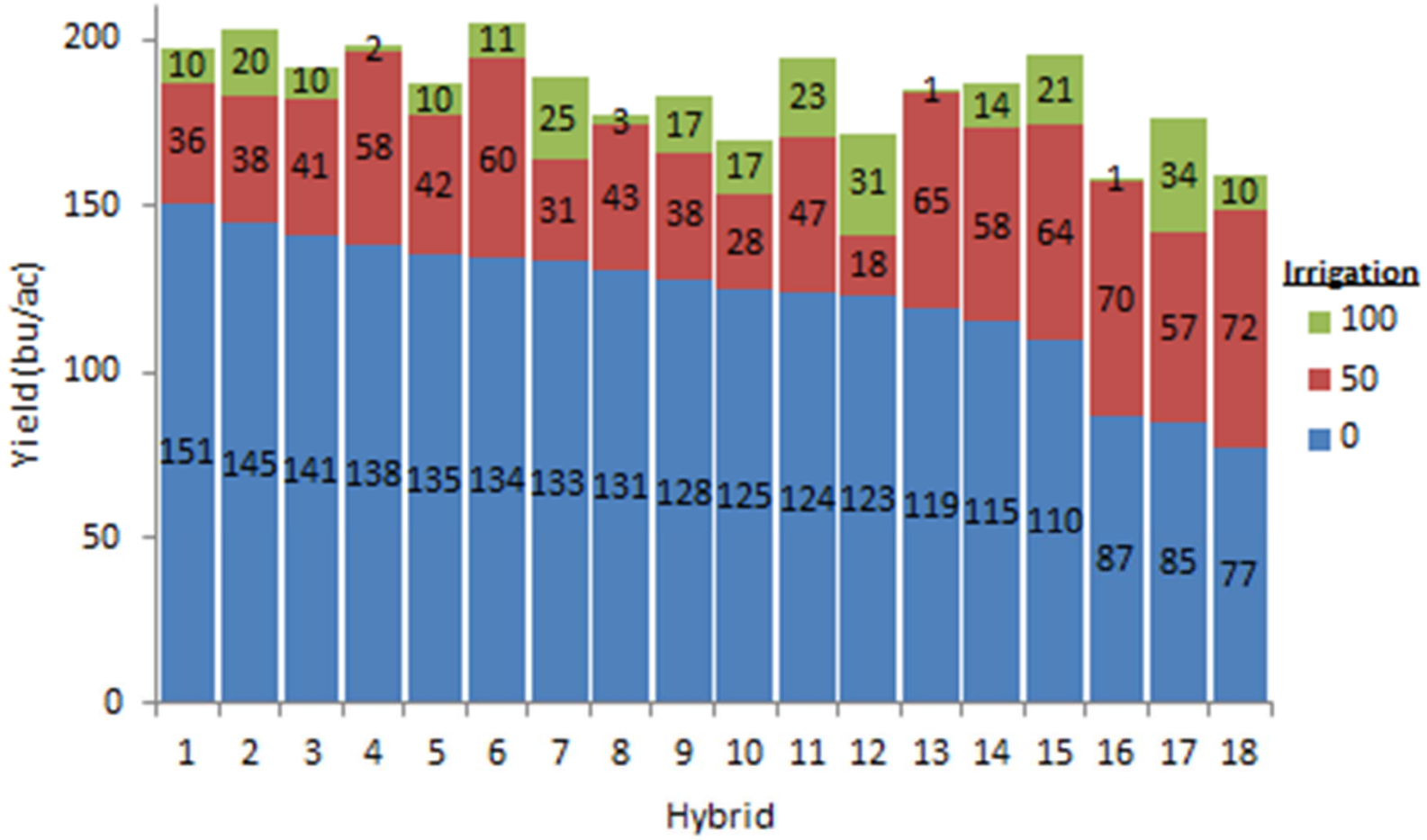
Crop Coefficients to be used with Alfalfa Reference Crop

Stage	Corn	Kcb	Soybean	Kcb	Wheat	Kcb
1	2 leaves	0.10	Emergence	0.10	Emergence	0.10
2	4 leaves	0.18	Cotyledon	0.10	Visible crown	0.50
3	6 leaves	0.35	Fist node	0.20	Leaf elongation	0.90
4	8 leaves	0.51	Second node	0.40	Jointing	1.04
5	10 leaves	0.69	Third node	0.60	Boot	1.10
6	12 leaves	0.88	Begin bloom	0.90	Heading	1.10
7	14 leaves	1.01	Full bloom	1.00	Flowering	1.10
8	16 leaves	1.10	Beginning pod	1.10	Grain fill	1.10
9	Silking	1.10	Full pod	1.10	Stiff dough	1.00
10	Blister	1.10	Beginning seed	1.10	Ripening	0.50
11	Dough	1.10	Full seed	1.10	Mature	0.10
12	Beginning Dent	1.10	Begin maturity	0.90		
13	Full Dent	0.98	Full maturity	0.20		
14	Black Layer	0.60	Mature	0.10		
15	Full Maturity	0.10				

Water Needed For Crops



Hybrid by Water Interactions

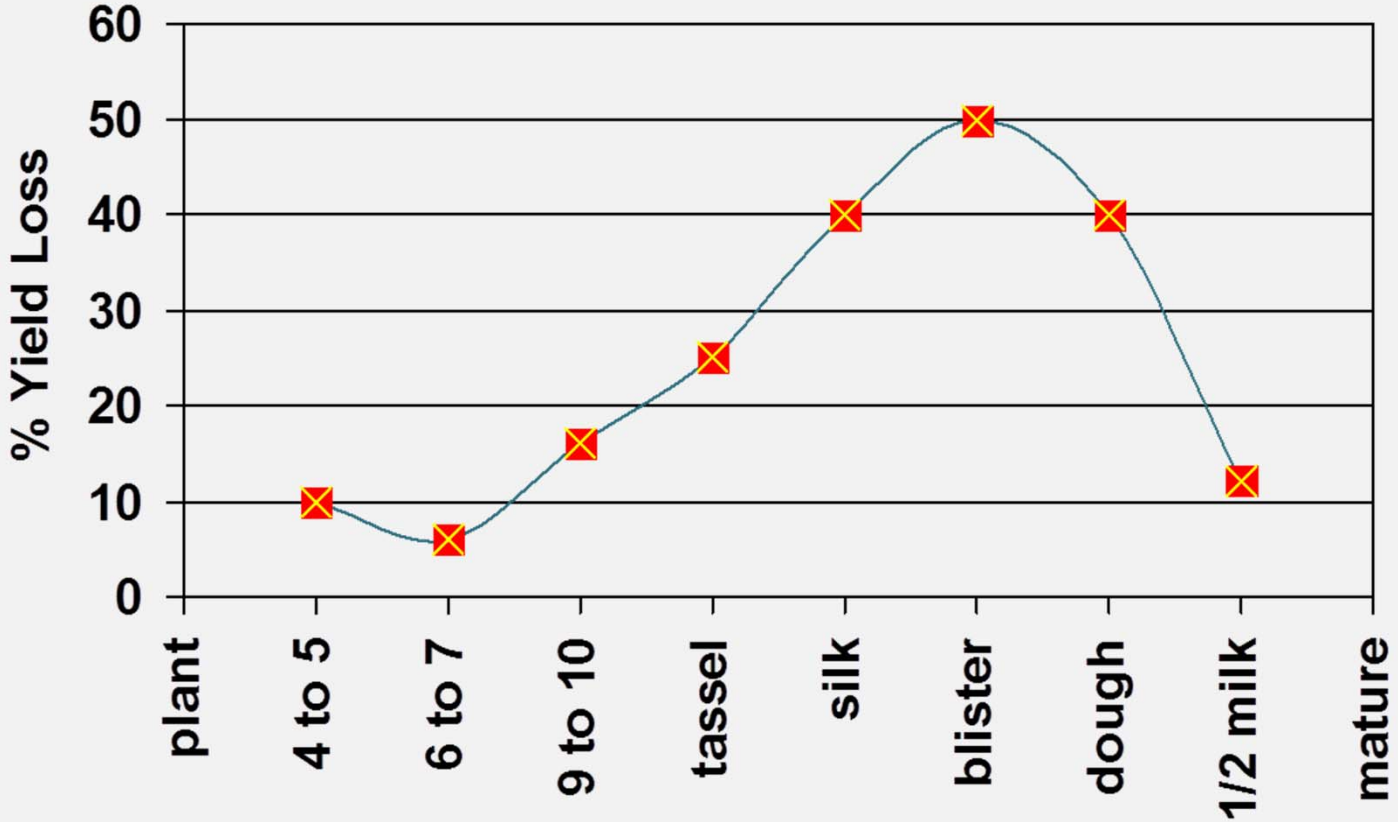


* Data collected in 2011 from Gothenburg and Brule.

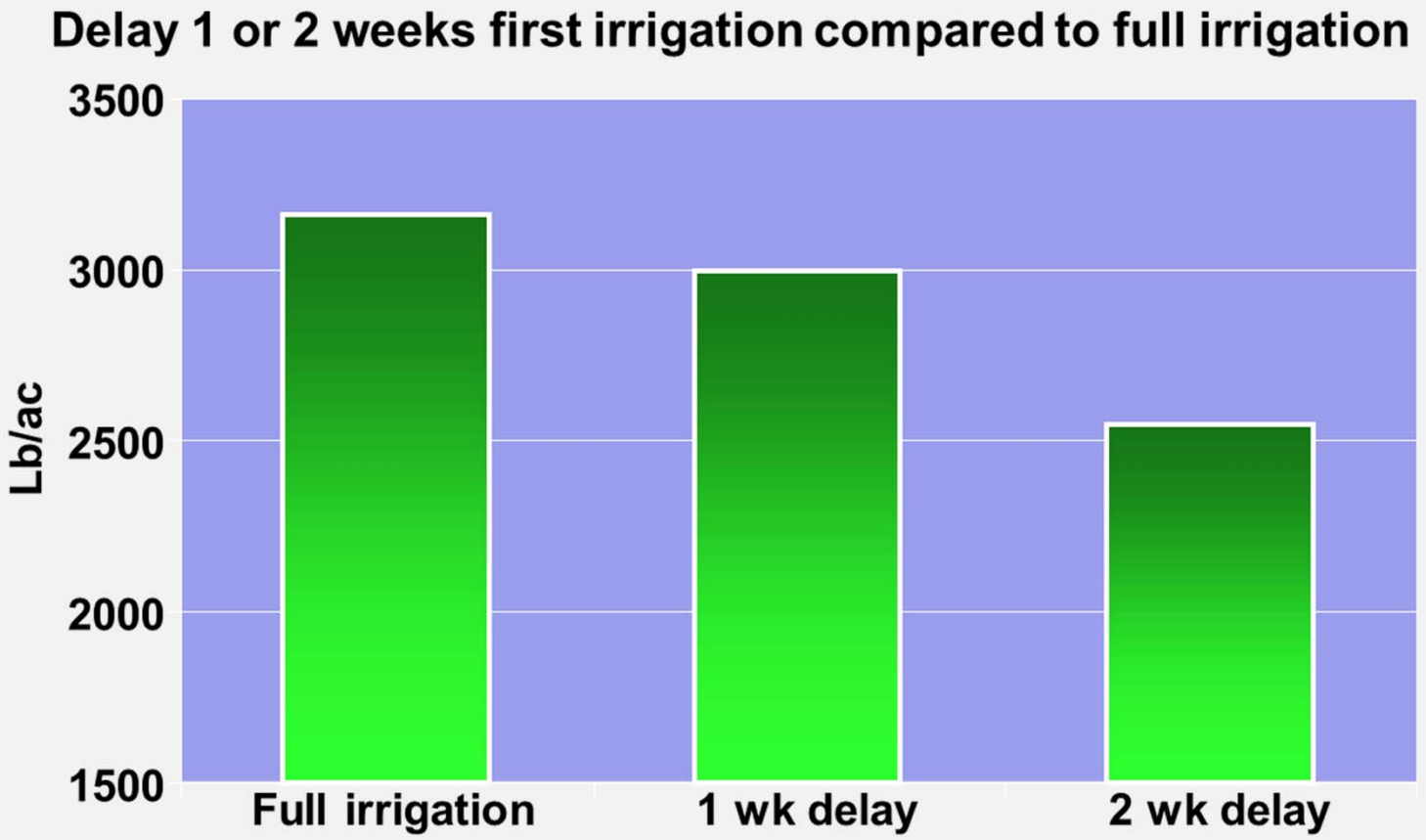
Effect of stress on yield

Growth Stage	% Yield Loss/Day
10 leaf	1-2
tassel/silking	5-15
blister	3-6
dough	3-4
dent	2-3
black layer	0

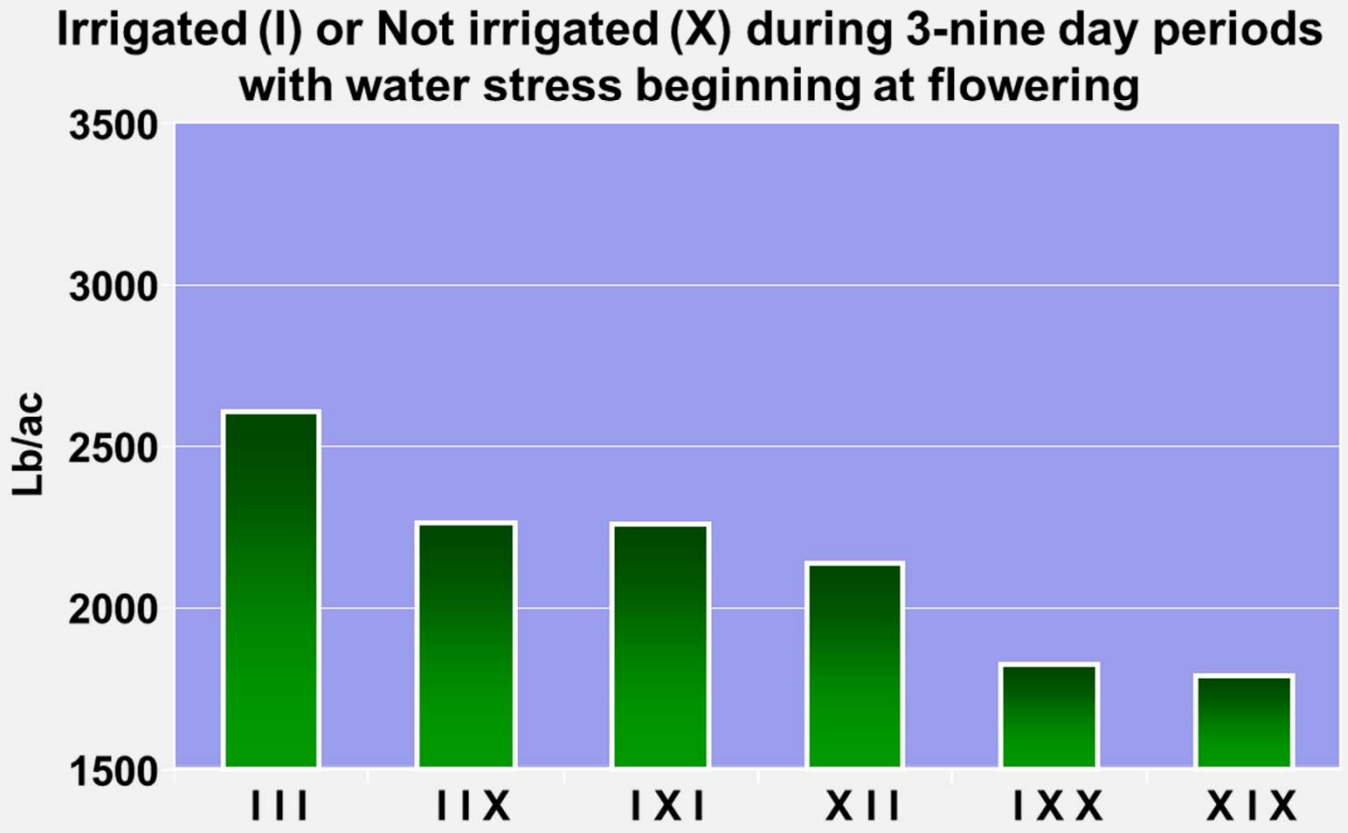
Effect of 4 days of stress on yield



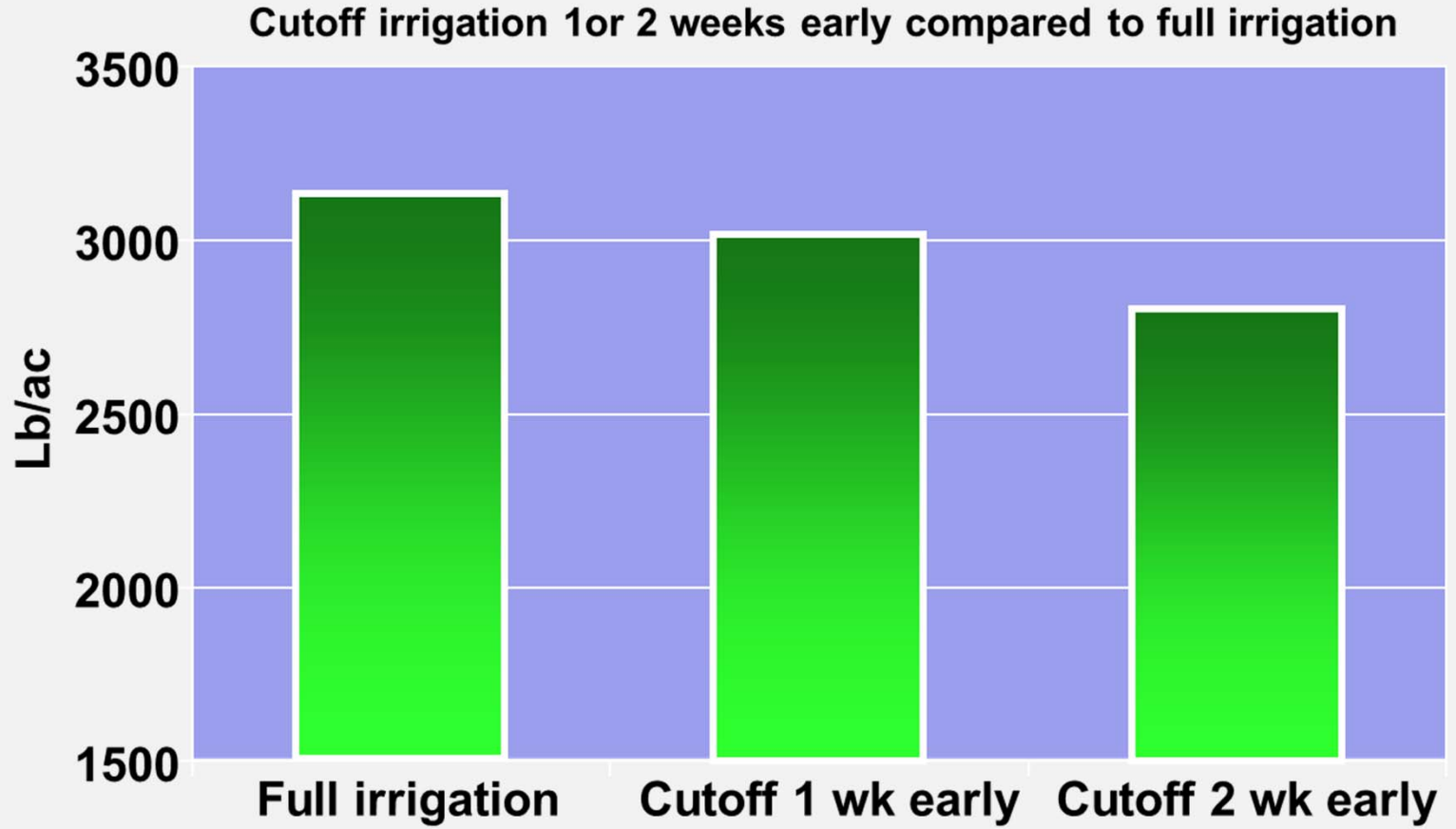
Effect of Early Season Water Stress on Drybean Yield(bu/ac)



Effect of Mid Season Water Stress on Drybean Yield(lb/ac)



Effect of Late Season Water Stress on Drybean Yield(lb/ac)



- **Plant Population . . .**
- **May or may not affect ET**
- **For Typical 115 Day Maturity**
- **Populations must be below 18,000 plants per acre before ET is reduced very much**
- **Higher populations may mean more yield, but higher ET is not likely**

Development of season long deficit irrigation strategies for sugar beets

C. Dean Yonts

Extension Irrigation Engineer

University of Nebraska

University of Nebraska Lincoln

Irrigation Treatments

- 100% of full early/50% of full late
- 50% of full early/100% of full late

- 75% of full early/25% of full late
- 25% of full early/75% of full late
- 'Late' began early to mid-August

4-year averages

% ET	Irrigation	Sucrose
100% ET	17.4	9600
75% ET	13.2	8990
100%&50%	13.0	8810
50%&100%	13.4	8200
50% ET	9.0	8575
75%&25%	8.8	8670
25%&75%	9.2	7530
25% ET	4.7	7350

Sugar Beet Summary

- Less water produces less sugar, but….
  - 25% less = 10% loss
  - 50% less = 25% loss
  - 75% less = 45% loss
- Early water for good stand essential
- Starting with a full soil profile makes a significant difference in final yield
- Yield reflects a full profile each year

Nebraska Lincoln EXTENSION

Know how. Know **now.**

Extension is a Division of the Institute of Agriculture and Natural Resources at the University of Nebraska–Lincoln cooperating with the Counties and the United States Department of Agriculture.

University of Nebraska–Lincoln Extension educational programs abide with the nondiscrimination policies of the University of Nebraska–Lincoln and the United States Department of Agriculture.

IANR