Managing Heat and Water Stressed Corn in the Texas Panhandle

Brent Bean and Nich Kenny[1]

Thus far in 2011 the Texas Panhandle has experienced record drought and record air temperatures. In a period of three days last week the all time record for maximum air temperature was shattered not once, but twice, reaching temperatures of 109° on June 24th and 111° on June 26th. During that time daily corn water use for a May 1st planting date reached 0.65 inches on June 24th. This compares to an average corn water use of 0.3 inches for that day. **From the period of May 1st to June 26th, total corn water use has been 13.2 inches, or 3.9 inches more than the previous six year average.** Compounding the increased water demand is the absence of the historical precipitation amounts during the same period, of approximately 3 inches. Through June much of the corn in the Texas Panhandle has experienced up to a 7 inch water deficit compared to a typical season.

Practically all of the corn grown in the region is irrigated, typically requiring 18 to 24 inches of annual irrigation water to fully meet the water demand of the crop. Assuming a producer had the irrigation capacity to meet the increased water demand of 7 inches through June, increased pumping cost alone would add up to an additional $35 per acre.

Heat Stress

Heat and moisture stress tend to go together. Heat stress alone typically does not affect yield much if adequate moisture is present. In time's of severe heat, it is important to understand that corn reaches its maximum growth rate at 86°. Heat accumulated at temperatures above 86° increases crop water demand to maintain crop vigor and yield. Warm night time temperatures cause the corn plant to consume additional energy (respiration) just to maintain itself. This is energy that is ideally stored to be used during grain fill. During the grain fill period, increased night time temperatures may cause the corn plant to cannibalize itself by mobilizing sugars from the stalk and leaf tissue to the kernels, resulting in weakened stalks and increased lodging potential.

Early Season Corn Stress

Fortunately corn can withstand significant stress from weather early in the season without overly affecting grain yield. During the early vegetative stage, from emergence to 6 leaf stage, heat and drought stress primarily reduces potential plant height and has little effect on yield if good crop production conditions are present for the remainder of the season. Water and heat stress effect on yield becomes more significant as corn reaches the 6 to 8 leaf stage and enters a period of rapid stem elongation. At the beginning of this time period the number of kernel rows on the primary ear is determined. Maximum kernel row number is genetically controlled and severe stress during this time

[1] Texas AgriLife Extension Agronomist and Irrigation Specialist, respectively.

can reduce the number of kernel rows present. The number of kernels along the length of the ear will be affected through about the 12 to 13 leaf stage. This is important because **number of kernels per ear contributes about 85 percent of the final grain yield** with the remaining 15 percent being the weight of the individual kernels. The location along the length of the ear that potential kernels are aborted depends on the duration and intensity of the stress (primarily from lack of moisture). If moderate stress occurs over a long period of time, aborted potential kernels will be primarily at the ear tip. If the stress period is short but very intense, then potential aborted kernels may be located anywhere along the length of the ear. High temperatures alone, when adequate moisture is present, will not normally lead to significantly reduced grain yield. High temperatures early in the season will cause the corn plant to advance through its growth stages in fewer days due to a more rapid accumulation of heat units. This, coupled with moisture stress, will result in shorter plants. **Reduction in height will only have a minimum effect on yield, primarily due to a reduction in light interception and associated reduction in photosynthesis.** Agronomists generally anticipate a yield reduction of 2 to 3 percent per day if severe stress is present during the late vegetative stage (8 leaf to tassel emergence).

Critical Corn Stage

The most critical time for yield determination is approximately two weeks prior to and after silk emergence. During the two weeks prior to silk emergence, yield loss can be as much as 3 to 4 percent per day if corn is severely stressed (continuous visible wilting). During pollen shed, severe stress many reduce yield 8 percent per day. After silking, yield can be reduced 6 percent per day when severely stressed. Moisture stress (lack of moisture) is generally more damaging than heat stress. Moisture stress can cause a delay in silking, increasing the time required for pollination. Under severe conditions, all the pollen may be shed before silks emerge. The other risk is that silks may emerge but may dry out too rapidly to effectively receive pollen. This is especially true when moisture stress and high temperatures compound to lead to rapidly desiccating silks. Additionally, high temperatures can impact pollen viability, fertilization, and grain formation. Pollen viability begins to decrease when temperatures reach 95° and pollen may become completely sterile at 104° when accompanied by moisture stress. **Fortunately, since pollen is generally released from the anthers between 9:00 and 11:00 in the morning, temperatures are seldom high enough to affect pollen viability**.

What to Do?

When examining corn water use during the two weeks prior to and following silking over the last six years, average daily water use has been 0.34 inches at the ARS Conservation and Production Research Laboratory near Bushland TX. However, 2011 has certainly not been an average year. If weather conditions remain extreme, average water use during this time is expected to exceed 0.4 inches per day for extended periods. Producers should keep this in mind as they determine their irrigation strategy during this critical time period. Historically, producers have relied on stored soil moisture to get through the high water use period during July and August. Drought and the abnormally high water demand during May and June, have left many corn fields with less than ideal soil moisture storage as the crop is approaching its peak physiological water use period**. Producers basically have two corn management options if soil moisture is currently lacking and irrigation capacity is not sufficient to meet average daily water use of at least 0.34 inches (6.5 GPM/acre).** The options are 1) Irrigate acres at less than full water use demand or 2) strategically abandon a portion of corn acres to allow the remaining acres to be adequately irrigated. To aid in making this decision the following should be considered:

1. Research and field experience has shown that expected corn yield when irrigating to meet 75 percent of full water demand is 95 percent of fully irrigated corn (approximately 250 bu/acre). In most years, irrigating to meet 75-80 percent of full crop water demand has shown to be the most profitable management strategy. At a 50 percent irrigation level, corn yield is expected to be 60 percent of fully irrigated corn. This would be a potential yield reduction of up to 100 bu/acre, and is generally not advised. Yield reduction is expected to be even greater during 2011 if drought conditions persist and temperatures remain at historical highs**. An irrigation system capacity of 4.7 GPM / acre is necessary to meet 75 percent of typical corn water demand from mid-May through August, <u>assuming zero precipitation</u>.**

2. When deficit irrigation (applying less water than physiologically required) is practiced under a center pivot sprinkler it is **best to apply between 1 – 1.25 inches per irrigation**. Larger irrigation applications increase irrigation efficiency by reducing the percentage of water that is evaporated from the soil and plant surface. In situations where a pivot is windshield wiping, application of 0.75 – 1.0 inch in each direction is a good compromise to eliminate long periods without irrigation and minimize run-off. In the severe drought and high temperature conditions this season, it may be advisable to use the sprinkler to provide micro-climate cooling to the crop during the 7 days of active pollination by making daily, high-speed, low-volume applications. This would help ensure viable pollen and receptive silks. **Some soil moisture is necessary to sustain the crop if this micro-climate cooling is attempted.**

   Two important technical points to understand about corn water use is that corn has shown to use water luxuriously when easily extractable water is available and can limit transpiration when water is not freely available. In practical use, this has shown that consistent, intermittent irrigation applications allow for corn to survive in relatively drastic deficit scenarios due to crop adaptations, albeit with an associated yield reduction. During the 2010 season, this was experienced in a Texas AgriLife Extension Service Case Study in Sherman County where two fields yielded approximately 250 bushels/acre on 30 inches of total water (combination of soil, precipitation, and irrigation water) while a neighboring field yielded 240 bushels on 39 inches of total water. The same case study also demonstrated that 200 bushels/acre was realistic on 25 inches of total water (13 inches from irrigation and 12 from rainfall and soil storage)

3. **If the decision is made to abandon some corn acres, the abandoned corn does have a value for silage or hay**. In a trial conducted in 2010 at Bushland, the nutritional value of just tasseled corn was similar to headed sorghum/sudangrass. It is recommended that pricing of the abandoned forage be secured prior to making the decision to abandon grain and that economics be heavily

considered in the final decision. Also, corn tends to be high in nitrate. Be sure and have it tested before feeding. If the forage is ensiled, nitrate levels will typically be reduced by 50 percent.

Corn yield and nutritional comparison to sorghum/sudangrass harvested 67 days after planting.

Type	Yield, DM Ton/acre	Moisture	% C. Protein	% NDF	% IVTD
BMR Sorghum	2.9	78	12.8	54.7	84
NonBMR Sorghum	3.5	76	12.1	55.8	82
Corn	2.8	81	14.4	55.8	83

4. **In areas with moderate irrigation capacity, corn and cotton has become a very common and desirable rotation, often including seasonal water splitting**. During multiple conversations this season, considerations for abandoning the riskier corn crop to ensure a more water and heat stress tolerant cotton crop have been expressed. This is a difficult decision since both crops offer exceptional economic benefits under current market conditions. In areas north of the Canadian River where cotton has been successfully established, water should exclusively be applied to the corn crop and the decision to abandon should be deferred until early to mid-July while the cotton crop is developing. If no significant rainfall occurs prior to mid-July, serious consideration should be given to abandoning some corn acres for cotton or reduce overall corn target yields and focus on cotton. This decision is much more difficult in areas South of the Canadian River where heat and water stresses are more prevalent and irrigation capacities are generally lower. It may be wise to begin splitting water earlier and targeting lower grain yields and/or abandoning crops.

5. **<u>Corn should likely not be abandoned</u> if irrigation system capacity dedicated to the corn crop meets or exceeds 4.5 GPM/acre**. GPM/acre is determined by dividing the total irrigation system water flow by the amount of acres that it covers (ie. 625 GPM into a 125-acre pivot provides an irrigation system capacity of 5 GPM/acre). 4.5 GPM/acre is the amount of water required to deliver 75 percent of the water needed for a fully irrigated corn crop during the month of July. Producers should keep in mind that **this is the minimum pumping capacity needed** under conditions where little stored soil water is available to sustain the crop if a well goes down or weather conditions are such that water demand is higher than the historical norm. This figure should be <u>honestly</u> evaluated during this season in cases where significant early pumping has led to premature aquifer drawdown. Through June 2011, many producers are already experiencing substantially reduced well production compared to previous years.

References

Hatfield, J.L. et. al. 2011. Climate impacts on agriculture: Implications for crop production. Agron. J. 103: 351-369.

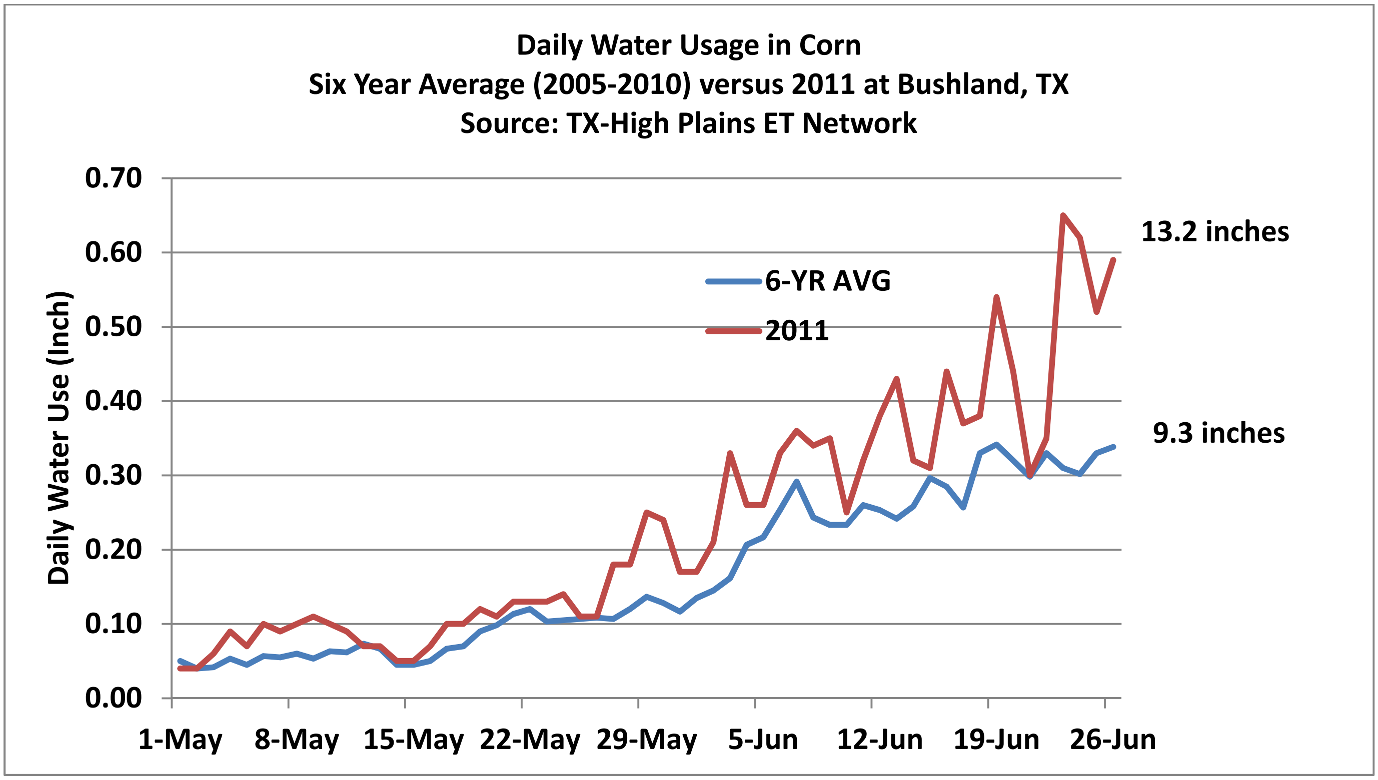
Strachan, S.D. 2009. Corn grain yield in relation to stress during ear development. Pioneer Growing Point Wdbsite.

Shaw, R.H. and J.E. Newman. Weather stress in the corn crop. National Corn Handbook.

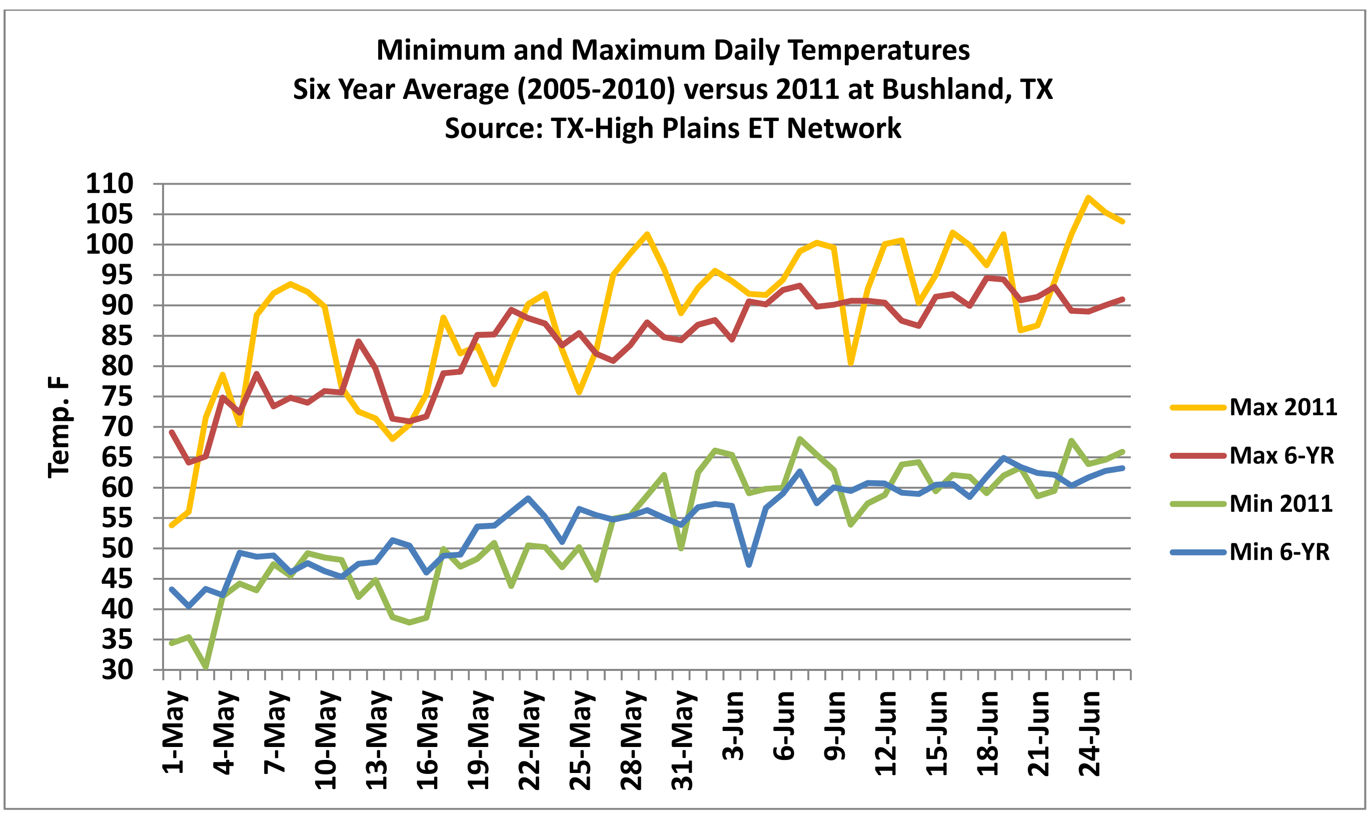
Nielson, R.L. 2007. Drought and heat stress effects on corn pollination. www.agry.purdue.edu/ext/corn/pubs/corn-07.htm.

Nielson, R.L. 2009. Effects of stress during grain filling in corn. www.kingcorn.org.

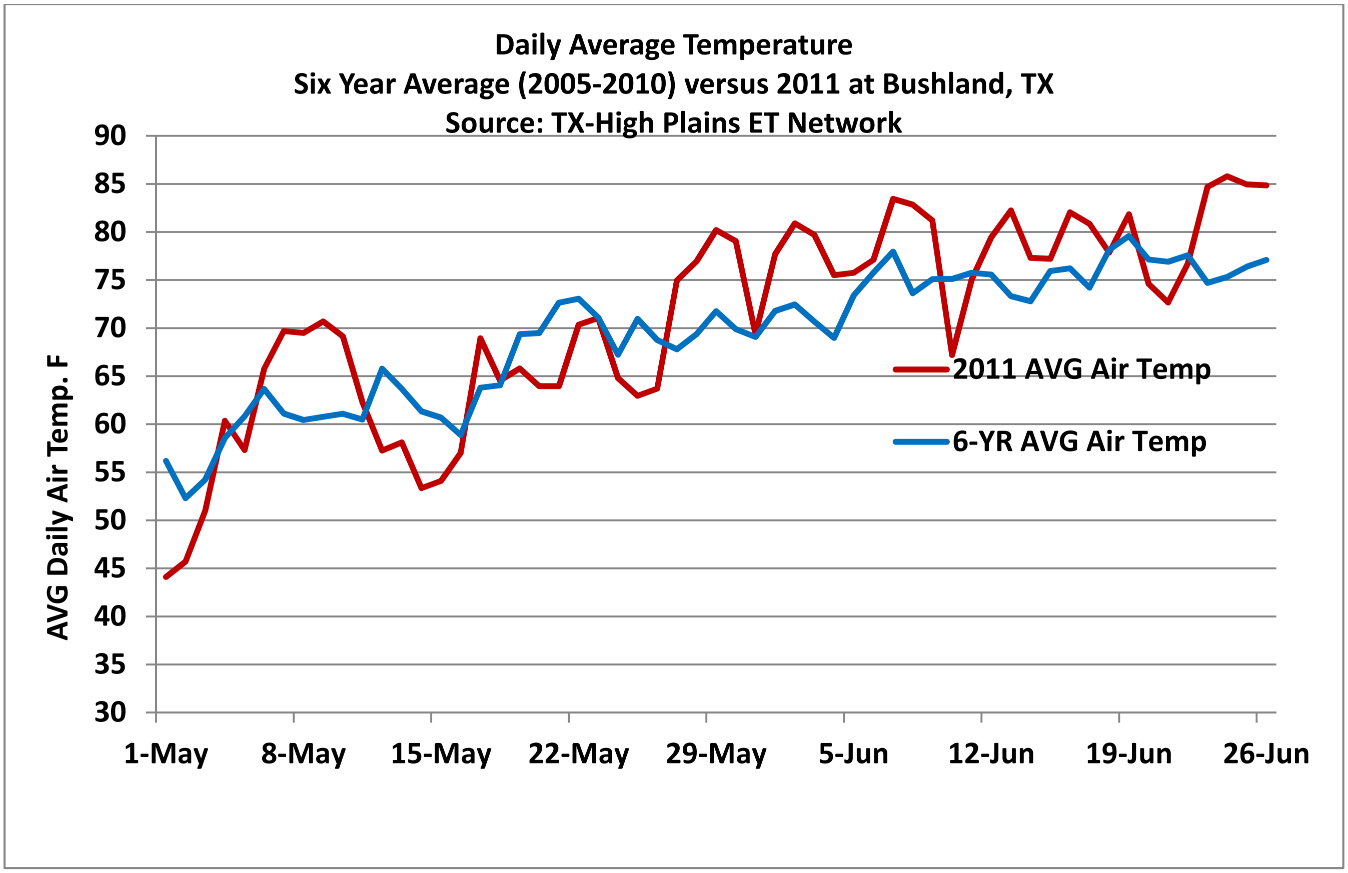
Thomison, P. 2010. Can warm nights reduce grain yield in corn? C.O.R.N. Newsletter 2010-22.

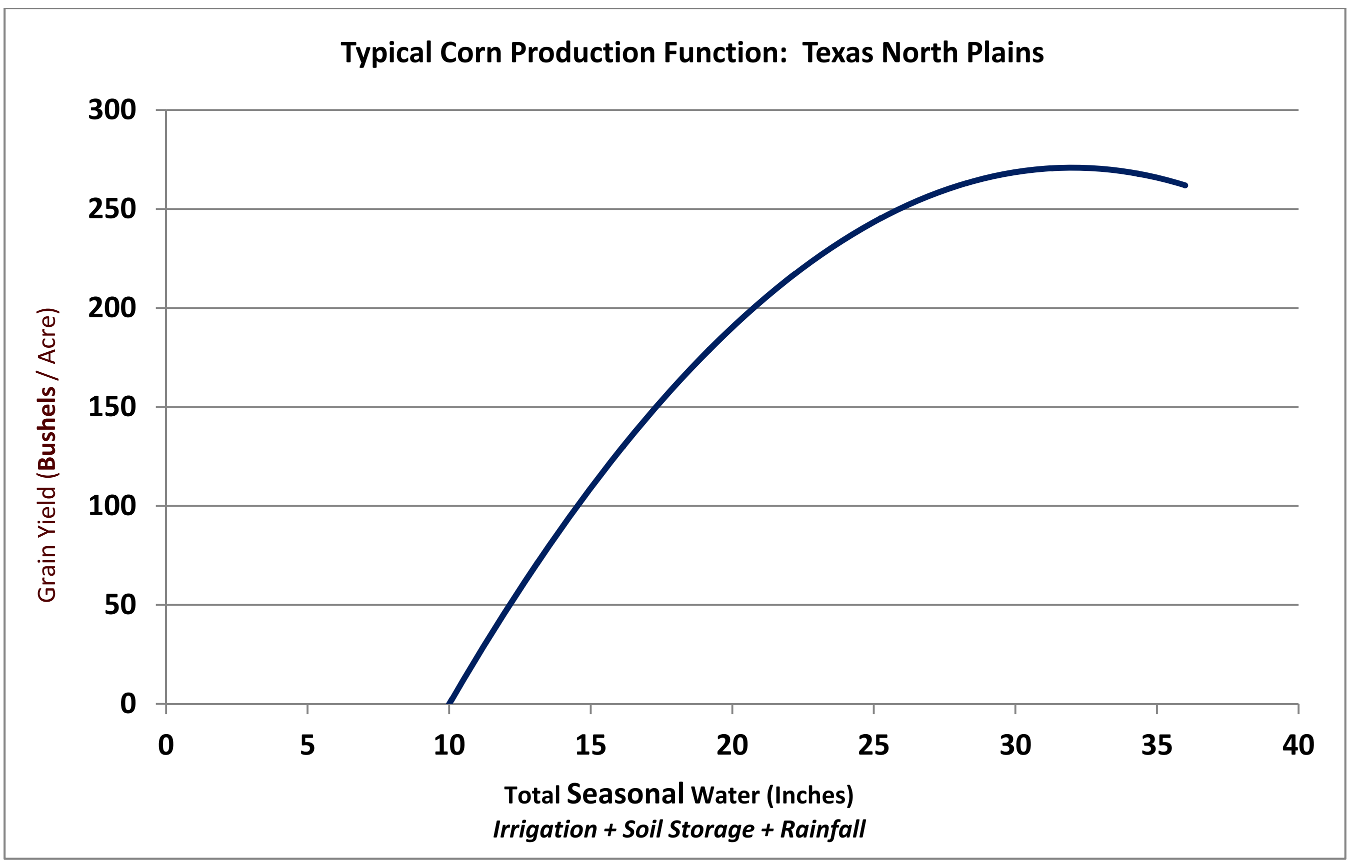


Daily Water Usage in Corn
Six Year Average (2005-2010) versus 2011 at Bushland, TX
Source: TX-High Plains ET Network
Daily Water Use (Inch)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1-May
8-May
15-May
22-May
29-May
5-Jun
12-Jun
19-Jun
26-Jun
6-YR AVG
2011
13.2 inches
9.3 inches



Minimum and Maximum Daily Temperatures
Six Year Average (2005-2010) versus 2011 at Bushland, TX
Source: TX-High Plains ET Network
Temp. F
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
1-May
4-May
7-May
10-May
13-May
16-May
19-May
22-May
25-May
28-May
31-May
3-Jun
6-Jun
9-Jun
12-Jun
15-Jun
18-Jun
21-Jun
24-Jun
Max 2011
Max 6-YR
Min 2011
Min 6-YR


Daily Average Temperature
Six Year Average (2005-2010) versus 2011 at Bushland, TX
Source: TX-High Plains ET Network
AVG Daily Air Temp. F
90
85
80
75
70
65
60
55
50
45
40
35
30
1-May
8-May
15-May
22-May
29-May
5-Jun
12-Jun
19-Jun
26-Jun
2011 AVG Air Temp
6-YR AVG Air Temp


Typical Corn Production Function: Texas North Plains
Grain Yield (Bushels / Acre)
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
Total Seasonal Water (Inches)
Irrigation + Soil Storage + Rainfall