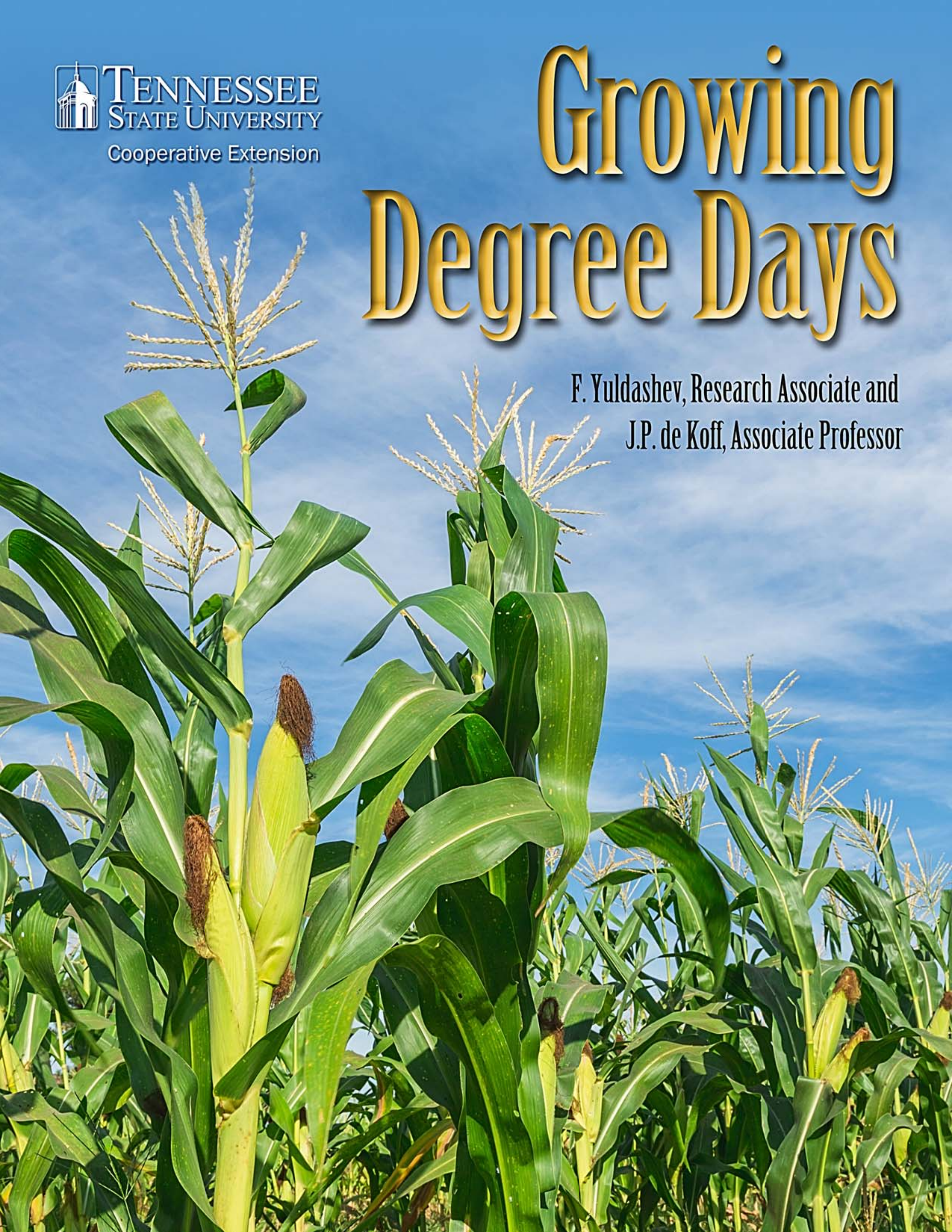
Tennessee State University
Cooperative Extension

Growing Degree Days

F. Yuldashev, Research Associate and
J.P. de Koff, Associate Professor



INTRODUCTION

Growing degree days (GDD), *Growing Degree Units* (GDU)*,* or *Accumulated Heat Units* (AHU) are commonly used terms to assign a heat value to each day that has occurred (Spoden, 2015). The values are added together to give an estimate of the amount of seasonal growth and development of a crop in order to predict crop growth, maturity, or yield (Miller et al., 2001; McMaster and Smika, 1988; Salazar-Gutierrez et al., 2013).

The concept of heat units can also be used to (1) predict weed growth and insect life stages; (2) identify site suitability for growing crops; (3) predict appropriate timing of fertilizer or pesticide application; (4) estimate abiotic stress (heat and drought) on crops; or (5) space planting dates in a crop rotation cycle.

Therefore, the phenological processes ongoing in certain crops are associated with daily air temperature (Hatfield and Prueger, 2015). The concept of heat units will be demonstrated in an example using corn to show how accumulated daily air temperature is related to seasonal growth in Tennessee. Corn in Tennessee will generally require about 2771 GDDs or heat units to reach R6 stage (physiological maturity or blacklayer) (Table 1).

Table 1. *Heat unit accumulation in Tennessee for a corn hybrid (30-Year History, 1981 - 2010).*
https://mrcc.illinois.edu/U2U/gdd/

Corn Stage*	West	Mid	East
Emergence	95	112	115
V2-second leaf	296	290	300
V4-fourth leaf	466	474	464
V6-sixth leaf	631	638	637
V8-eighth leaf	808	810	804
V10-tenth leaf	980	986	977
R1-silking	1452	1441	1459
R6-maturity	2787	2780	2774

* Ciampitti et al., 2011

CALCULATING CORN GROWING DEGREES OR HEAT UNITS

There is an upper and lower threshold temperature, above or below which conditions are not optimal for corn growth**.** For instance, the upper limit for corn is 86°F and the lower limit is 50°F (McClure and Cannon, 2017). Below is an example of how this is calculated. If maximum air temperature is greater than 86°F, 86 is used as Tmax. If minimum air temperature is less than 50°F, 50 is used as Tmin. For example, in Day 2 below, the minimum temperature was <50°F so a value of 50 was used in the calculation.

Day 1: high 82°F, low 52°F
Day 2: high 64°F, low 40°F
[change 40°F to 50°F (Tmin) in the calculation]
Day 3: high 95°F, low 70°F
[change 95°F to 86°F (Tmax) in the calculation]

The equation for calculating GDD is (McMaster and Wilhelm, 1997; Delahaut, 2004):

$$\text{GDD}=\left[\frac{(Tmax+Tmin)}{2}\right]-Tbase,$$

Tmax = *the daily maximum air temperature*;
Tmin = *the daily minimum air temperature*;
Tbase = *minimum temperature for the crop's developmental threshold (50 used for corn)*
Calculations: Day 1: (82 + 52 / 2) – 50 = 17 DD
Day 2: (64 + 50 / 2) – 50 = 7 DD
Day 3: (86 + 70 / 2) – 50 = 28 DD
17 + 7 + 28 = **52 GDD**

This means that over the three days shown above, there were 52 GDDs accumulated toward the 2771 needed in Tennessee.

HISTORICAL CORN GDD ACCUMULATION OVER THE GROWING SEASON

The Midwestern Regional Climate Center developed a decision support tool for predicting corn GDD in the corn belt and mid-Southern states, which puts current conditions into a 30-year historical perspective and offers trend projections through the end of the calendar year (MRCC, 2017). Based on this, in Tennessee, a heat unit accumulation of about 1425 and 2771 GDDs relate to the silking and physiological maturity stages, respectively (Fig. 1).

Figure 1. *Corn at silking (left) and maturity (right)* (Lee, 2011).

The figures below compare how two different planting dates (April 1 or May 1) impact silking and maturity timing based on the heat units accumulated throughout the growing season. Also, within each planting date, the silking and maturity periods can be compared to the 30 year (1981-2010) average temperature. The years 2011 (Figs. 2-4) and 2013 (Figs 5-7) were chosen for comparison because they had some of the greatest differences in temperatures from the 30 year averages and can show how much changing weather patterns and climate can affect corn development (NOAA, 2020). Lastly, relative differences in regions can be compared through the example counties shown.

Figure 2. *Expected accumulation of Corn GDDs in 2011, Gibson County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.

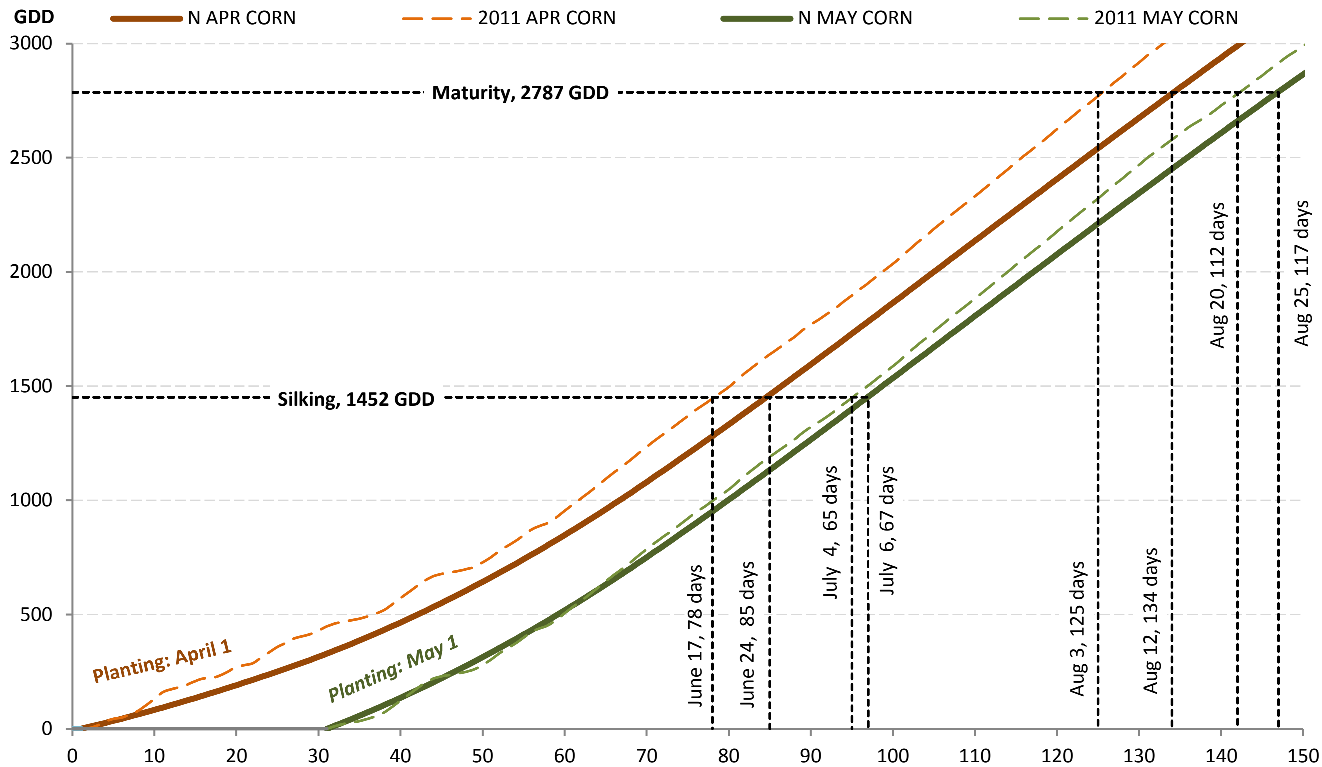


Figure 3. *Expected accumulation of Corn GDDs in 2011, Cannon County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.

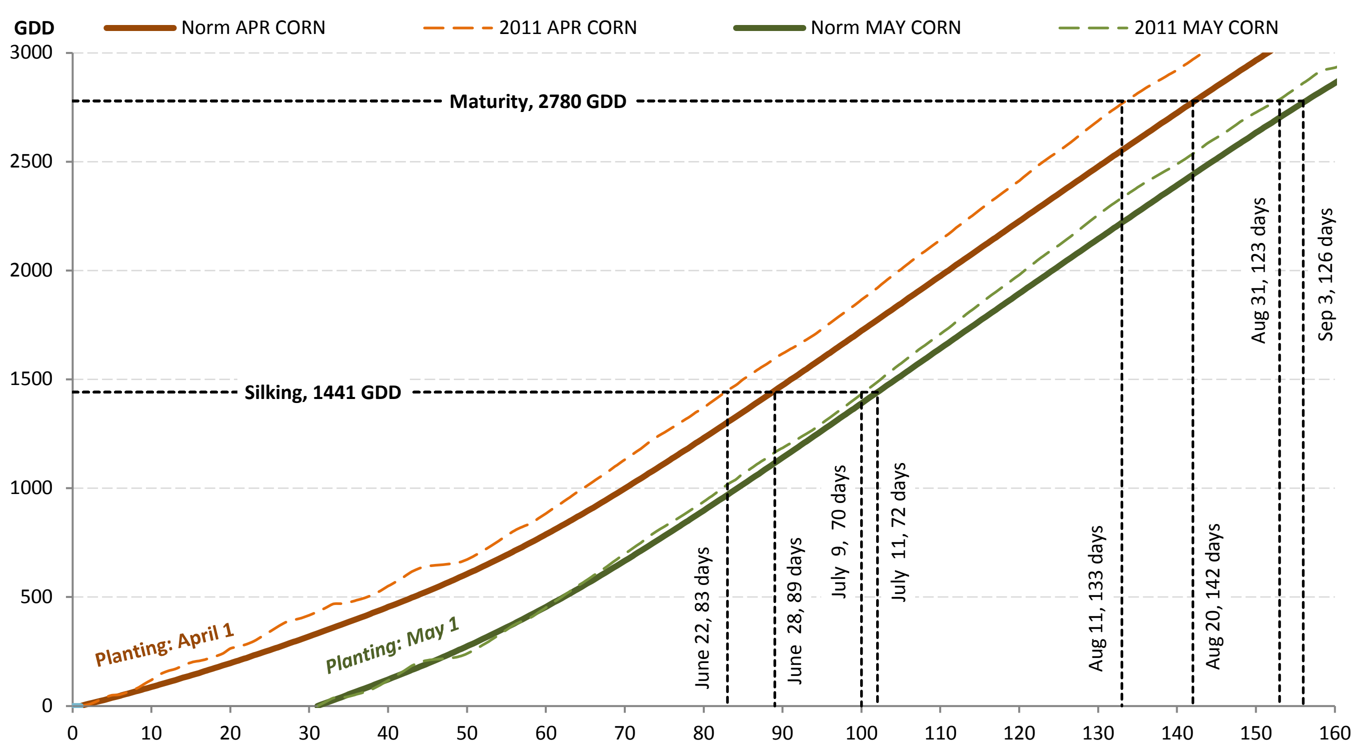


Figure 4. *Expected accumulation of Corn GDDs in 2011, Loudon County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.

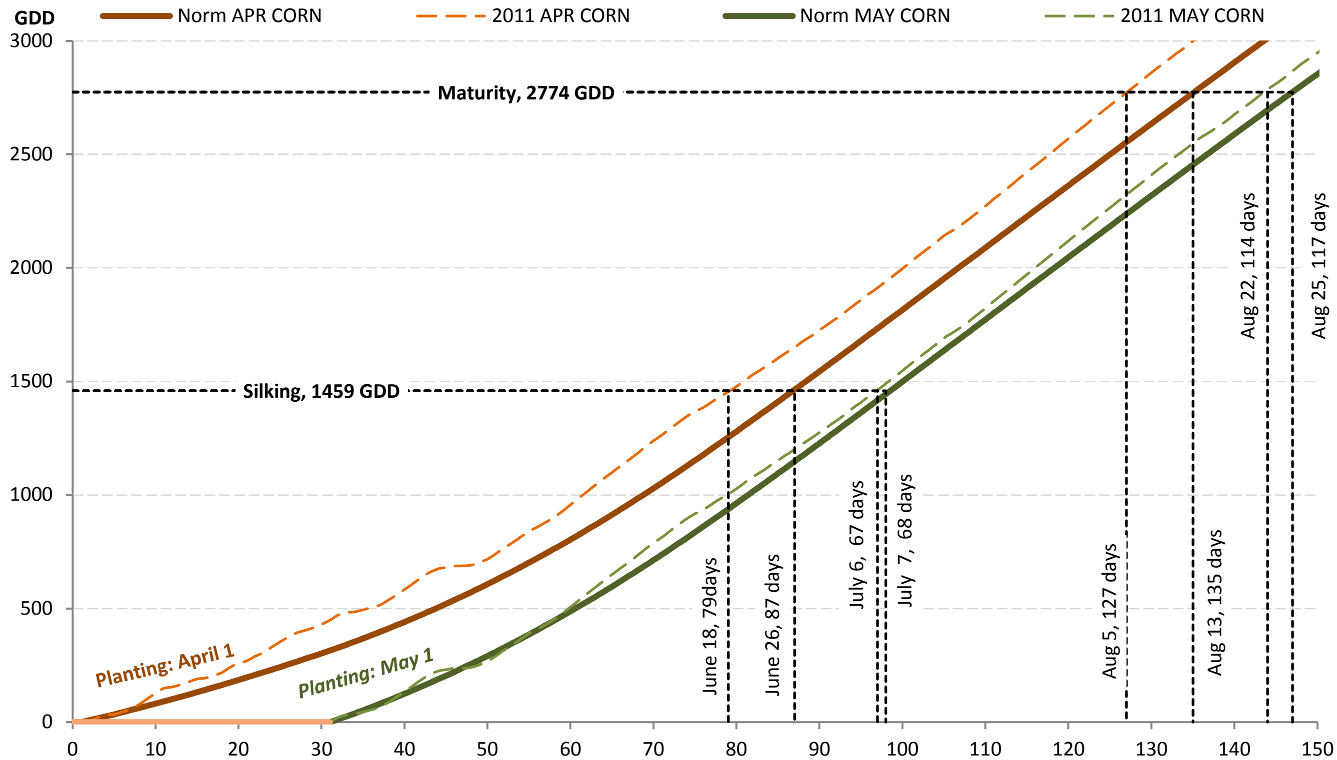


Figure 5. *Expected accumulation of Corn GDDs in 2013, Gibson County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.

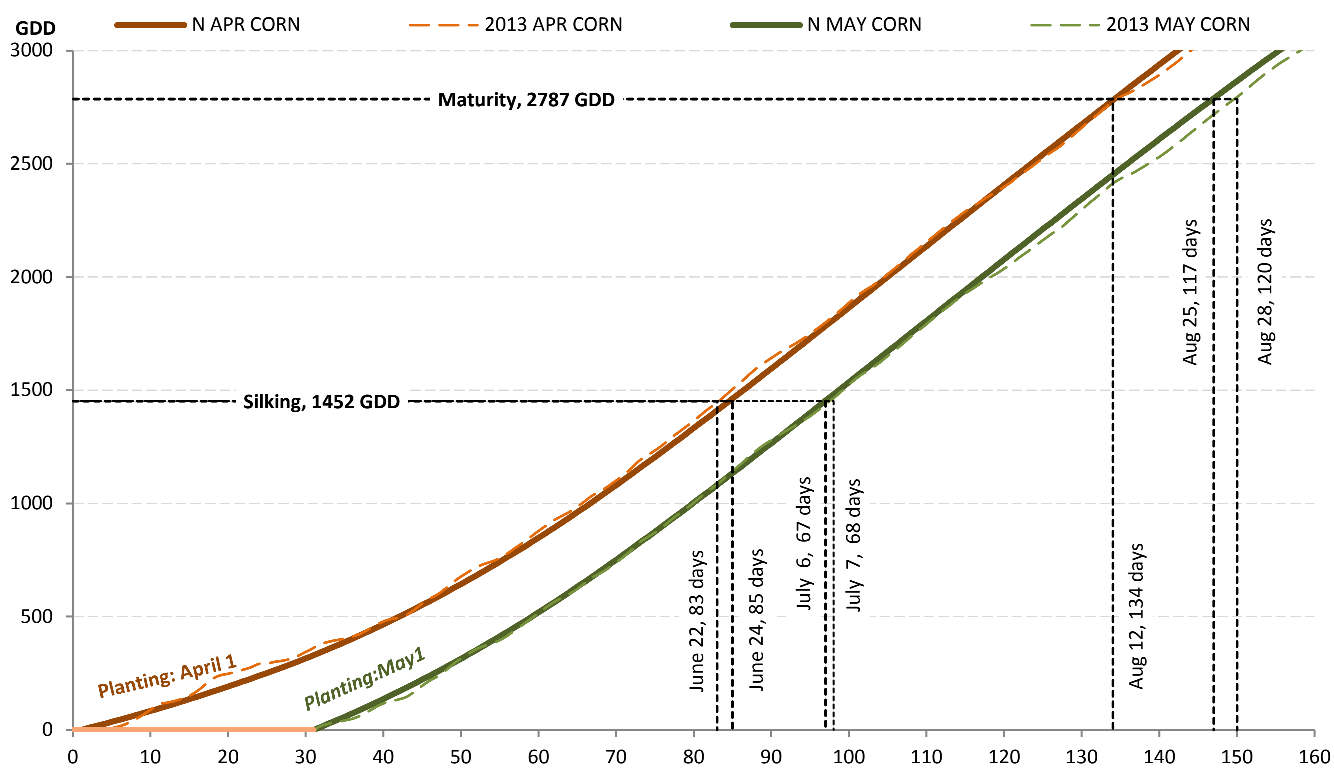


Figure 6. *Expected accumulation of Corn GDDs in 2013, Cannon County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.

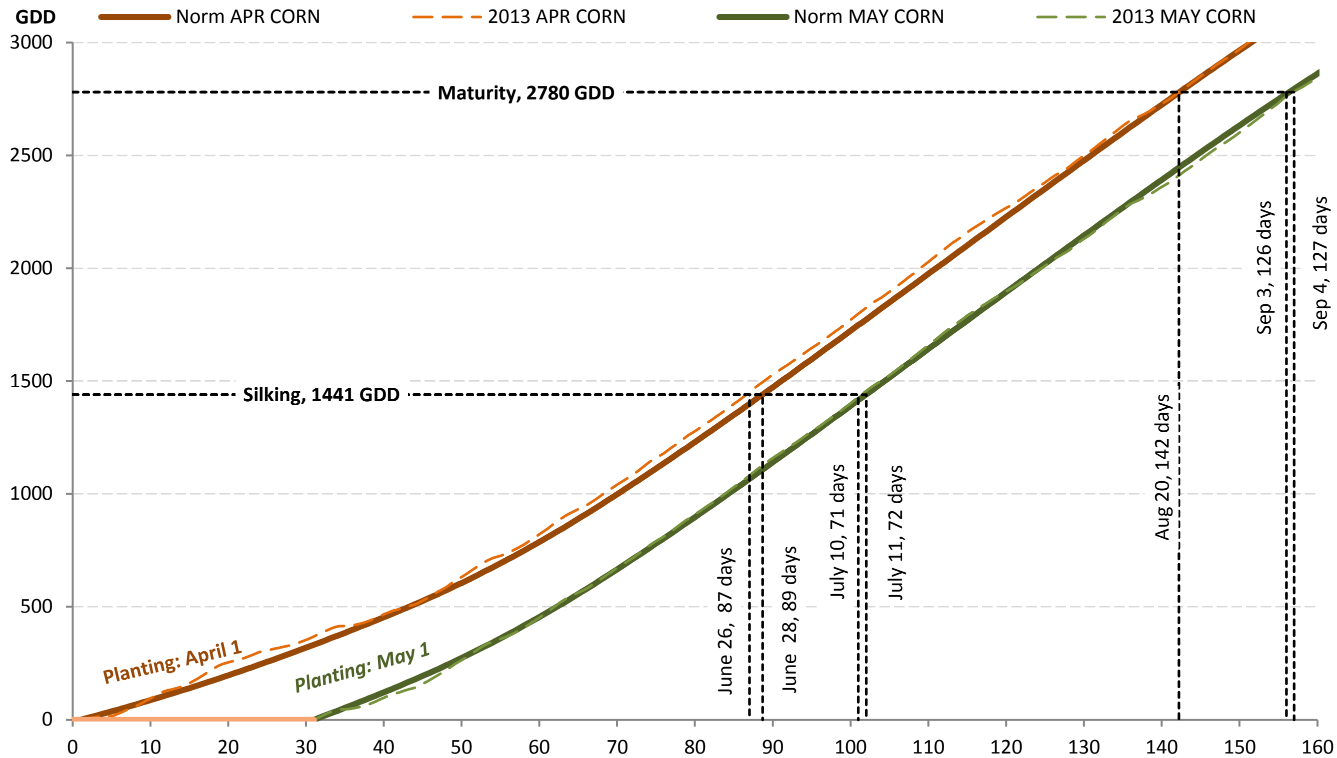
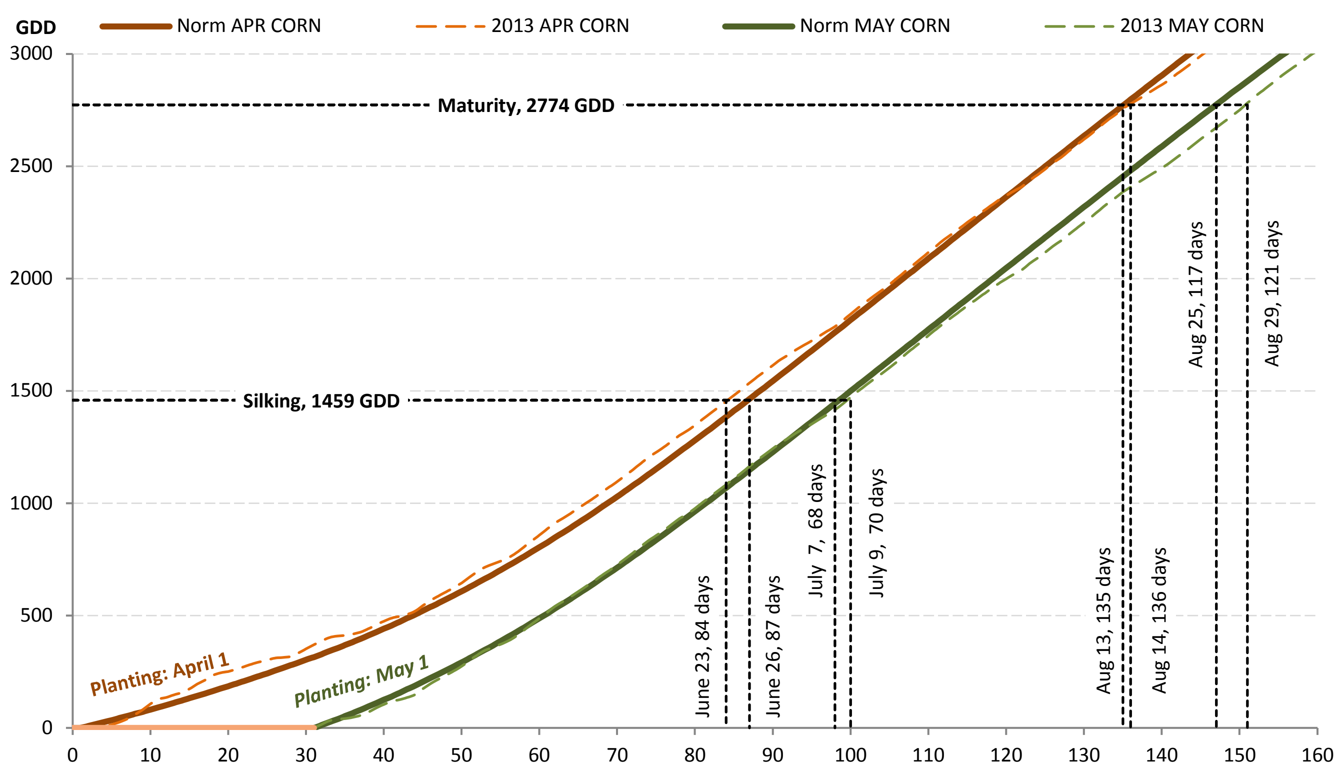


Figure 7. *Expected accumulation of Corn GDDs in 2013, Loudon County.* Red lines represent April 1 planting date and green lines represent May 1 planting date. Dashed lines represent 2011 and solid lines represent the 30 year normal temperatures. Dates followed by number of days represent the relative date for that stage and the number of days from planting.



Corn accumulated heat units more rapidly in 2011 (Figs. 2-4) than 2013 (Figs. 5-7) despite planting dates and locations. For example, when planted on April 1st, corn reached silking at 78-83 days after planting (DAP) in 2011 and at 83-87 DAP in 2013, and maturity at 125-133 DAP in 2011 and at 134-142 DAP in 2013. Also, maturity was estimated to occur 8-9 days earlier in 2011 for an April 1st planting date as compared with estimates based on the 30-year average temperatures while in 2013, it was on time or one day later than the 30-year estimates.

For May 1st planting dates, the differences were not as great. The estimated corn silking stage occurred at 65-70 DAP in 2011 and 68-71 DAP in 2013, and maturity 112-123 DAP in 2011 and 120-127 DAP in 2013. Maturity was estimated to occur 3-5 days earlier in 2011 for a May 1st planting date as compared with the estimates based on 30-year average temperatures while in 2013, it was 1-4 days later than the 30-year estimates.

CORN GROWTH DIFFERENCES BY LOCATION

The daily maximum and minimum air temperatures may vary widely between geographic regions of the state, creating important impacts on plant growth and development.

In our example, and based on temperature averages across 30 years, corn is estimated to mature 134 DAP in Gibson County, 142 DAP in Cannon County, and 135 DAP in Loudon County when planted on April 1st. With a May 1st planting date, and based on 30 year temperature averages, corn is estimated to mature 117 DAP in Gibson County, 126 DAP in Cannon County, and 117 DAP in Loudon County.

In summary, monitoring GDD can be helpful in identifying optimal timing for many agricultural practices. Using average GDD can be a good basis to start from understanding that sometimes large variation can occur between locations and between years due to changes in weather patterns.

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