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# What are Heat Unit or Growing Degree Days (GDDs)

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The term "growing degree days" (GDD) has been around for sometime and most farmers refer to them as "heat units". Scientists know that temperature is the one environmental factor needed for plant growth which can be measured in order to give them an estimation of plant maturity. There is no universal definition for heat unit and its definition can vary from one crop to another. Agronomically, the most commonly used heat unit is for corn. The heat units of various crops are basically similar to one another except for the temperature limits included within a given formula.

A heat unit (GDD) is simply "the average daily temperature to which a crop is exposed within certain temperature limits and above a minimum temperature base". For example:

$$GDD = \frac{(\text{Daily } \textbf{Maximum} \text{ Temp.} + \text{Daily } \textbf{Minimum} \text{ Temp.})}{2} - \textbf{Base} \text{ Temp.}$$

Note this formula defines both a maximum and minimum temperature and a base temperature with no other limitations. The heat unit formula for corn is:

$$GDD = \frac{(\text{Max. Temp. less than } \mathbf{86^\circ} \text{ F} - \text{Min. Temp. greater than } \mathbf{50^\circ} \text{ F})}{2} - \mathbf{50^\circ} \text{ F Base Temp.}$$

Note the formula indicates there is an upper 86° F temperature, a lower 50° F temperature, and a 50° F base temperature. Such limits are necessary because corn grows within a certain temperature range. The upper limit for significant corn growth is 86° F and the lower limit is 50° F. Temperatures above this limit will not hasten growth. There is no significant growth below 50° F. Again, a 50°F base temperature is used since no significant growth occurs below this temperature. By definition only temperatures between **86°** and **50°** F can be used.

To better understand the formula let us practice calculating heat unit values. For example, how many heat GDD's would be generated for a day with a high of 80° F and a low of 52° F. ?

$$GDD's = \frac{(80 + 52)}{2} - 50 = \frac{(132)}{2} - 50 = 66 - 50 = 16$$

Note the maximum (80° F) and minimum (52° F) daily temperatures are both within the temperature limits of 86° and 50° F. Therefore, both values are used in the calculation.

How many GDD's would be generated with a high of 96° F and a low of 48° F.?

$$GDD's = \frac{(86 + 50)}{2} - 50 = \frac{(136)}{2} - 50 = 68 - 50 = 18$$

In this case, 86 is used in the calculation instead of 96, because the upper limit of the equation is 86° F. If 96 was used, the calculated value would be inflated (23, not 18) and the corn would not mature any faster. Likewise, in this case, 50 is used in the calculation instead of 48, because the lower limit of the equation is 50° F.

How many GDD's would be generated with a high of 102°F and a low of 90° F?

$$\text{GDD's} = \frac{(86 + 86)}{2} - 50 = \frac{(172)}{2} - 50 = 86 - 50 = 36$$

In this case, 86 is used for both the maximum and minimum temperatures because the highest a value can be is 86. Since the high and low temperatures are above 86° F we obtain the maximum GDD's possible. This shows how dramatic night temperatures are in accumulating GDD's.

How many GDD's would be generated with a high of 50° F and a low of 44° F.?

$$\text{GDD's} = \frac{(50 + 50)}{2} - 50 = \frac{(100)}{2} - 50 = 50 - 50 = 0$$

In this calculation, we obtain no heat units because none of the temperatures exceed the minimum 50° F needed for growth.

Although we have discussed heat unit calculations it is really the accumulation of daily heat units which is important to the corn grower. The potential GDD's totals that remain from a given spring date to the first killing frost in the fall are shown for several South Dakota sites in Table 1.

How might one use Table 1? If you farm at Marion and usually seed on May 9 you would, on average, have 2,760 GDD's remaining to the average first killing frost on Oct. 9. However, if seeding were delayed until May 30 you have 2,500 GDD's (260 fewer) remaining to the first killing frost.

On average, the GDD requirement for corn, in cornbelt states, decrease about 5 GDD's per day of delayed seeding. In this case if the May 9 seeding was delayed until May 30 you would have 105 fewer GDD's (21 days delay x 5 ) to mature. If you seeded the 2,760 GDD hybrid on May 30 you would be about 100 GDD's short of maturity or at about the 75% milk-line kernel stage with a moisture content of 35% (Figure 1). At this stage you would suffer a yield loss of 2 - 3% but would encounter a relatively high moisture content and associated drying costs. On the otherhand, had you switched to a hybrid rated in the 2,500GDD range (table value on May 30) you would reach full maturity with a lower moisture content and a buffer against an earlier than normal killing frost.

Some growers may select a hybrid with a 200 - 300 GDD rating higher than the number of GDD's remaining in the growing season. In such cases, the hybrid will normally reach the dent to hard dough stages with associated yield reductions of 5 - 15% and moisture contents of 40 - 45%. Under these conditions the first killing frost date will dictate the final outcome. An average killing frost date will result in a 5 - 15% yield reduction and high drying costs or slow field drying conditions with possible high harvest losses. An earlier than normal killing frost will cause an additional yield loss and additional high moisture contents with their associated drying costs. A later than average killing frost will likely result in higher yields, compared to a lower GDD rated hybrid, along with average harvest moisture contents and low harvest losses.

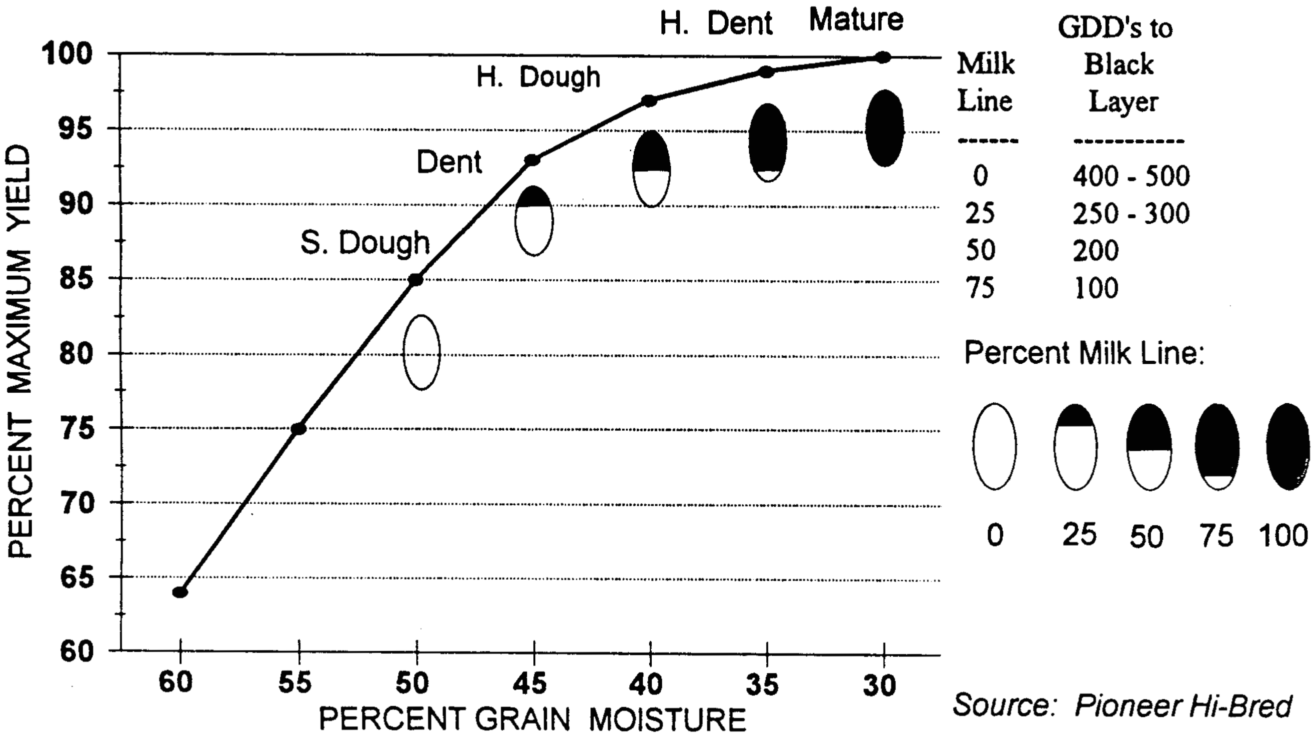
On average, the option to select a GDD rating similar to the number of GDD's remaining to the first killing frost will result in acceptable yields. In addition, test weights and acceptable field drying time will be higher, while, grain moisture levels and harvest losses will be lower compared to options involving higher risks.

Table 1. Average growing degree days ( base 50 degree F. ) for period May 2 to killing frost.

| District | Station | Growing degree days from date to killing frost | | | | | | Frost |
|---|---|---|---|---|---|---|---|---|
| | | May 2 | May 9 | May 16 | May 23 | May 30 | June 6 | Date* |
| N.W. | Camp Crook | 2,175 | 2,124 | 2,062 | 1,990 | 1,912 | 1,834 | Sep. 24 |
| | Dupree | 2,570 | 2,515 | 2,449 | 2,371 | 2,284 | 2,196 | Oct. 5 |
| | Lemmon | 2,280 | 2,237 | 2,180 | 2,114 | 2,040 | 1,965 | Oct. 3 |
| | Newell | 2,400 | 2,352 | 2,295 | 2,230 | 2,154 | 2,077 | Oct. 4 |
| N.C. | Aberdeen | 2,523 | 2,470 | 2,402 | 2,325 | 2,240 | 2,145 | Oct. 1 |
| | Eureka | 2,312 | 2,261 | 2,197 | 2,125 | 2,045 | 1,962 | Oct. 1 |
| | Faulkton | 2,492 | 2,436 | 2,371 | 2,294 | 2,212 | 2,126 | Oct. 3 |
| | Gettysburg | 2,631 | 2,577 | 2,509 | 2,432 | 2,348 | 2,257 | Oct. 6 |
| | Mobridge | 2,608 | 2,555 | 2,486 | 2,409 | 2,322 | 2,229 | Oct. 3 |
| | Pollock | 2,323 | 2,266 | 2,199 | 2,124 | 2,040 | 1,953 | Sep. 24 |
| | Redfield | 2,574 | 2,509 | 2,436 | 2,359 | 2,271 | 2,172 | Oct. 4 |
| | Roscoe | 2,412 | 2,357 | 2,284 | 2,212 | 2,137 | 2,046 | Oct. 3 |
| N.E. | Andover | 2,429 | 2,376 | 2,309 | 2,334 | 2,153 | 2,062 | Sep. 27 |
| | Britton | 2,554 | 2,500 | 2,435 | 2,357 | 2,268 | 2,173 | Sep. 29 |
| | Castlewood | 2,450 | 2,396 | 2,329 | 2,254 | 2,169 | 2,080 | Sep. 29 |
| | Clark | 2,508 | 2,453 | 2,389 | 2,312 | 2,229 | 2,140 | Oct. 3 |
| | Milbank | 2,526 | 2,469 | 2,405 | 2,329 | 2,248 | 2,151 | Oct. 8 |
| | Sisseton | 2,562 | 2,508 | 2,441 | 2,365 | 2,281 | 2,187 | Oct. 10 |
| | Watertown | 2,297 | 2,250 | 2,193 | 2,125 | 2,048 | 1,965 | Oct. 3 |
| | Webster | 2,214 | 2,170 | 2,116 | 2,049 | 1,976 | 1,897 | Oct. 4 |
| W.C. | Cottonwood | 2,625 | 2,564 | 2,491 | 2,410 | 2,321 | 2,227 | Oct. 2 |
| | Rapid City | 2,505 | 2,461 | 2,407 | 2,345 | 2,276 | 2,203 | Oct. 13 |
| | Spearfish | 2,232 | 2,189 | 2,136 | 2,075 | 2,007 | 1,938 | Oct. 6 |
| C. | Gann Valley | 2,804 | 2,740 | 2,667 | 2,582 | 2,489 | 2,393 | Oct. 6 |
| | Highmore | 2,564 | 2,509 | 2,446 | 2,369 | 2,287 | 2,200 | Oct. 2 |
| | Huron | 2,621 | 2,563 | 2,496 | 2,441 | 2,337 | 2,245 | Oct. 7 |
| | Miller | 2,616 | 2,557 | 2,490 | 2,410 | 2,325 | 2,234 | Oct. 5 |
| | Onida | 2,638 | 2,582 | 2,514 | 2,436 | 2,348 | 2,258 | Oct. 4 |
| | Pierre | 2,955 | 2,893 | 2,821 | 2,739 | 2,646 | 2,541 | Oct. 15 |
| | White Lake | 2,893 | 2,829 | 2,756 | 2,672 | 2,576 | 2,473 | Oct. 10 |
| E.C. | Brookings | 2,400 | 2,345 | 2,282 | 2,209 | 2,127 | 2,037 | Sep. 30 |
| | DeSmet | 2,302 | 2,248 | 2,182 | 2,105 | 2,018 | 1,924 | Oct. 13 |
| | Mitchell | 2,834 | 2,769 | 2,697 | 2,612 | 2,520 | 2,416 | Oct. 9 |
| | Sioux Falls | 2,721 | 2,659 | 2,591 | 2,511 | 2,421 | 2,318 | Oct. 9 |
| | Madison | 2,536 | 2,480 | 2,414 | 2,339 | 2,256 | 2,162 | Oct. 5 |
| S.W. | Martin | 3,017 | 2,947 | 2,862 | 2,771 | 2,666 | 2,557 | Oct. 2 |
| | Oelrichs | 2,465 | 2,405 | 2,337 | 2,260 | 2,177 | 2,090 | Sep. 26 |
| S.C. | Kennebec | 2,651 | 2,590 | 2,520 | 2,433 | 2,354 | 2,263 | Sep. 29 |
| | Murdo | 2,913 | 2,849 | 2,778 | 2,698 | 2,603 | 2,507 | Oct. 12 |
| | Winner | 2,631 | 2,578 | 2,515 | 2,441 | 2,363 | 2,282 | Oct. 14 |
| | Bonesteel | 2,901 | 2,837 | 2,763 | 2,677 | 2,584 | 2,480 | Oct. 6 |
| S.E. | Armour | 2,913 | 2,844 | 2,768 | 2,679 | 2,584 | 2,477 | Oct. 10 |
| | Canton | 2,851 | 2,781 | 2,707 | 2,621 | 2,519 | 2,408 | Oct. 6 |
| | Centerville | 2,877 | 2,811 | 2,737 | 2,651 | 2,554 | 2,445 | Oct. 9 |
| | Marion | 2,834 | 2,766 | 2,691 | 2,603 | 2,509 | 2,402 | Oct. 9 |
| | Menno | 3,052 | 2,976 | 2,895 | 2,800 | 2,696 | 2,576 | Oct. 7 |
| | Pickstown | 3,053 | 2,988 | 2,913 | 2,828 | 2,734 | 2,618 | Oct. 20 |
| | Tyndall | 2,954 | 2,888 | 2,815 | 2,729 | 2,630 | 2,521 | Oct. 11 |
| | Vermillion | 3,034 | 2,963 | 2,886 | 2,792 | 2,689 | 2,572 | Oct. 18 |
| | Yankton | 2,972 | 2,911 | 2,843 | 2,762 | 2,670 | 2,536 | Oct. 19 |

* 50% chance of 28 degrees F.

Figure 1. The relationship of grain moisture to yield and kernel maturity and kernel milk line to growing degree days remaining to black layer formation in corn.




| Milk Line | GDD's to Black Layer |
|---|---|
| ------ | ----------- |
| 0 | 400 - 500 |
| 25 | 250 - 300 |
| 50 | 200 |
| 75 | 100 |

*Source: Pioneer Hi-Bred*

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