

Growing Degree Days (GDD)

By Lyle A. Derscheid, Extension agronomist, and William F. Lytle, associate professor of ag engineering and climatology, Agricultural Experiment Station.

There is a new way of rating the maturity of corn. It is more accurate than the old "days of maturity" ratings. It will help you estimate which hybrids will use all of your growing season and yet produce mature corn.

This new method is called "Growing Degree Days" (GDD) or "Heat Units" because it is based on the number of growing degree days between planting time and physiologic maturity (or first killing frost). Most seed corn companies are now using this rating. This publication will help you determine which hybrids are of the right maturity for you.

Two new terms are being used: Growing Degree Days (or heat units), and the black layer on the tip of the kernel to denote when the seed is mature. It is not necessary for you to understand either term. You can simply use the map, or the table or both to determine the number of growing degrees for your area.

Use Map or Table

Since most corn in South Dakota is planted after May 3 and is physiologically mature before frost, the map was developed to give a rough estimate of the number of growing degree days for this growing season in all areas of the state. If you plant in early May and hope to have mature corn before frost, all you need to do is select a hybrid with a lower growing degree day rating than shown for your area on the map.

For example, if you live in Minnehaha County, you probably plant corn early in May and plan to have it mature by early October. The map shows that you usually have 2,700 to 2,800 growing degree days between May 3 and the first killing frost. So you select a hybrid with a maturity rating of 2,700 or less. By selecting a hybrid that requires fewer GDD, you have a safety factor for years when you get an early frost.

Different Planting Dates

You can use the table to estimate the growing degree days for a different season. You may not plant corn as early as May 3 or you may not ordinarily have the first killing frost until after October 3. It is not necessary to have corn mature before the first killing frost.

For example, you live in Minnehaha County and used the map to help you decide on a corn with a GDD rating of 2,800. But your corn was hailed out in late May. You plan to replant on May 27. You can look in the table at columns for May 23 and May 30 for Sioux Falls and see that you can expect to have between 2,421 and 2,511 growing degree days before you expect to have a killing frost on October 9 (last column of the table). So you select a hybrid with a GDD rating of around 2,400.

Or, you live in Codington County where you may not plan to plant corn until around the middle of May. You ignore the map which shows that you can expect to have between 2,300 and 2,400 GDD, and use the column for May 16 in the table. It shows 2,193 GDD for Watertown so you pick a hybrid with a rating of 2,200 or less.

By using these examples as a guide, you can determine the GDD for your area from the map or table. If you wish to know more about the GDD concept, however, a more detailed discussion of growing degree days and physiologic maturity follows.

Growing Degree Days

A "Growing Degree Day" is not the same as a calendar "day" of 24 hours. The term "Growing Degree Day" or GDD is used to designate calculations based on temperature factors or "heat units." The sum of these "heat units" for each calendar day of the growing season provides a figure ranging from 2,300 to 3,000 in South Dakota that may better pin down the maturity period or rating of corn.

Growing degree days are calculated by subtracting a base temperature from the average of the maximum and minimum temperatures for the day. Corn doesn't grow much at temperatures of 50° to 55° (F). As temperature rises to a range of 80 to 86°, corn grows faster if moisture is plentiful. But at a temperature above 86° the roots have increasing difficulty taking in water fast enough to keep the plant cells turgid (full of water) and working at top speed.

Consequently only temperature extremes of 50° and 86° are used in calculating GDD. The mathematical expression for calculating GDD is:

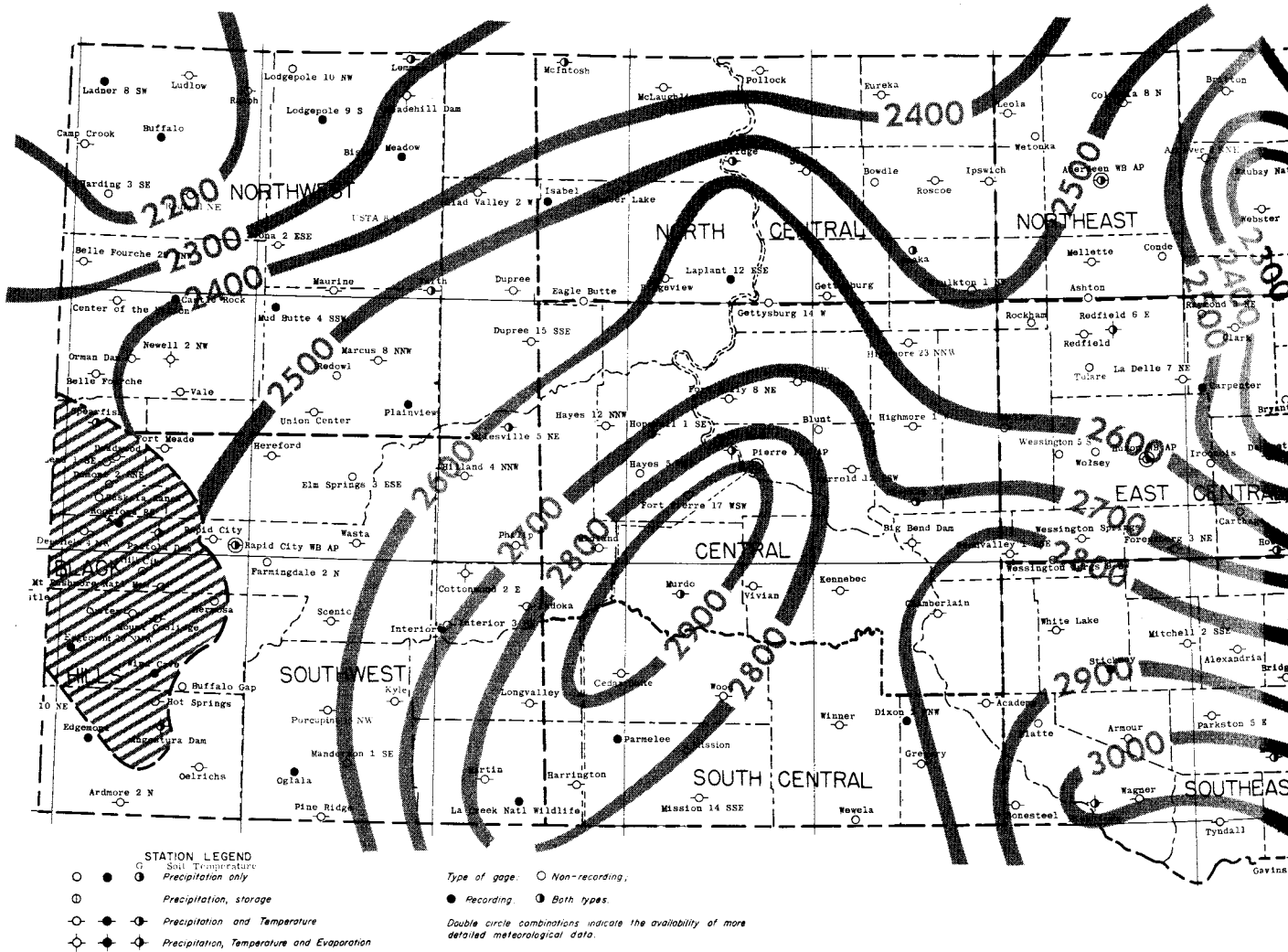
$$\text{GDD} = \frac{\text{Max Temp.} + \text{Min. Temp.}}{2} - \text{Base Temp.}$$

The maximum temperature is the highest temperature for that day and the minimum temperature is the lowest for the day. The base temperature (below which there's very little corn growth) is 50°. The formula is adjusted to correct for extreme high or low temperatures. Minimum temperatures below 50° are counted as 50° and temperatures above 86° are counted as 86°.

For example, if the maximum temperature for the day is 84° and the minimum is 60° so:

$$\begin{aligned} \text{GDD} &= \frac{84+60}{2} - 50 \\ &= 72-50 \\ &= 22 \end{aligned}$$

Adjusted Growing Degree Days in South Dakota—base temperature of 50° F. for period May 3 to first killing frost (last



Then 22 growing degree days occurred on the day. Or, another day the high temperature is 90° and the low is 40°, so:

$$\text{GDD} = \frac{86 \text{ (for } 90^\circ) + 50 \text{ (for } 40^\circ)}{2} - 50$$

2

$$= 68 - 50$$

$$= 18$$

Then 18 growing degree days occurred that day.

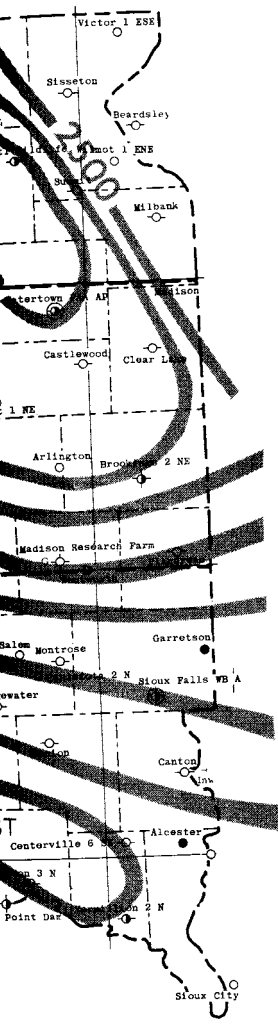
This method is used because temperature is one of the most important environmental factors affecting the rate of plant development. It is recognized that growth is also affected by several other environmental factors such as, moisture, nutrients, length of time temperature is above 50°, and photoperiod. Perhaps some of these environmental factors can eventually be used in a formula to help estimate maturity ratings, but "Growing Degree Days" seems to be the best rating developed to date.

Average Adjusted Growing Degree Days—base temperature of 50° F. for period May 3 to Killing Frost

	Growing Degree days from this date			
	May 2	May 9	May 16	May 23
Aberdeen	2523	2470	2402	2325
Academy	2859	2798	2726	2638
Alexandria	2965	2894	2816	2726
Andover	2429	2376	2309	2334
Ardmore	2913	2791	2715	2625
Armour	2913	2844	2768	2679
Bison	2297	2251	2188	2119
Bonesteel	2901	2837	2763	2677
Bridgewater	2837	2766	2683	2601
Britton	2554	2500	2435	2357
Brookings	2400	2345	2282	2209
Camp Crook	2175	2124	2062	1990
Canton	2851	2781	2707	2621
Castlewood	2450	2396	2329	2254
Centerville	2877	2811	2737	2651

*Date when temperature drops to 28° F. half of the time.

mm in the table).

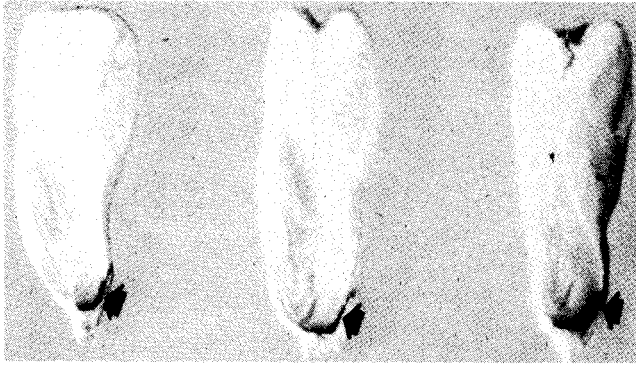


Temperature 50° F.
Killing frost

Date to killing frost*	Date of Killing Frost*		
	May 3	May 30	June 6
2240	2145	Oct. 1	
2548	2450	Oct. 9	
2628	2517	Oct. 10	
2153	2062	Sept. 27	
2531	2424	Oct. 9	
2584	2477	Oct. 10	
2050	1967	Oct. 3	
2584	2480	Oct. 6	
2509	2405	Oct. 9	
2268	2173	Sept. 29	
2127	2037	Sept. 30	
1912	1834	Sept. 24	
2519	2408	Oct. 6	
2169	2080	Sept. 29	
2554	2445	Oct. 9	

	Growing Degree days from this date to killing frost*						Date of Killing Frost*
	May 2	May 9	May 16	May 23	May 30	June 6	
Chamberlain	2852	2784	2707	2618	2521	2416	Oct. 4
Clark	2508	2453	2389	2312	2229	2140	Oct. 3
Cottonwood	2625	2564	2491	2410	2321	2227	Oct. 2
DeSmet	2302	2248	2182	2105	2018	1924	Oct. 13
Dupree	2570	2515	2449	2371	2284	2196	Oct. 5
Eureka	2312	2261	2197	2125	2045	1962	Oct. 1
Faulkton	2492	2436	2371	2294	2212	2126	Oct. 3
Flandreau	2605	2544	2475	2395	2309	2212	Oct. 5
Forestburg	2636	2569	2496	2411	2321	2227	Oct. 2
Gann Valley	2804	2740	2667	2582	2489	2393	Oct. 6
Gettysburg	2631	2577	2509	2432	2348	2257	Oct. 6
Highmore	2564	2509	2446	2369	2287	2200	Oct. 2
Hilland	2682	2626	2562	2488	2405	2318	Oct. 9
Hopewell	2627	2570	2509	2436	2360	2269	Oct. 9
Howard	2561	2501	2433	2355	2270	2179	Oct. 2
Huron	2621	2563	2496	2441	2337	2245	Oct. 7
Kennebec	2651	2590	2520	2433	2354	2263	Sept. 29
La Delle	2581	2523	2454	2376	2289	2197	Sept. 26
Lemmon	2280	2237	2180	2114	2040	1965	Oct. 3
Longvalley	2771	2713	2641	2561	2472	2381	Oct. 8
Ludlow	2148	2105	2047	1982	1911	1838	Sept. 28
Madison	2536	2480	2414	2339	2256	2162	Oct. 5
Marion	2834	2766	2691	2603	2509	2402	Oct. 9
Martin	3017	2947	2862	2771	2666	2557	Oct. 2
Menno	3052	2976	2895	2800	2696	2576	Oct. 7
Milbank	2526	2469	2405	2329	2248	2151	Oct. 8
Miller	2616	2557	2490	2410	2325	2234	Oct. 5
Mission	2682	2616	2544	2464	2387	2278	Oct. 10
Mitchell	2834	2769	2697	2612	2520	2416	Oct. 9
Mobridge	2608	2555	2486	2409	2322	2229	Oct. 3
Murdo	2913	2849	2778	2698	2603	2507	Oct. 12
Newell	2400	2352	2295	2230	2154	2077	Oct. 4
Oelrichs	2465	2405	2337	2260	2177	2090	Sept. 26
Onida	2638	2582	2514	2436	2348	2258	Oct. 4
Oral	2585	2539	2473	2384	2286	2180	Sept. 27
Orman Dam	2506	2449	2385	2310	2225	2139	Oct. 1
Phillip	2614	2559	2488	2411	2329	2239	Oct. 5
Pickstown	3053	2988	2913	2828	2734	2618	Oct. 20
Pierre	2955	2893	2821	2739	2646	2541	Oct. 15
Pine Ridge	2575	2514	2442	2360	2272	2178	Sept. 27
Pollock	2323	2266	2199	2124	2040	1953	Sept. 24
Rapid City	2505	2461	2407	2345	2276	2203	Oct. 13
Redfield 6E	2574	2509	2436	2359	2271	2172	Oct. 4
Redig	2177	2131	2074	2007	1930	1854	Sept. 24
Roscoe	2412	2357	2284	2212	2137	2046	Oct. 3
Shadehill Dam	2333	2273	2205	2134	2058	1974	Sept. 30
Sioux Falls	2721	2659	2591	2511	2421	2318	Oct. 9
Sisseton	2562	2508	2441	2365	2281	2187	Oct. 10
Spearfish	2232	2189	2136	2075	2007	1938	Oct. 6
Timber Lake	2561	2511	2447	2287	2203	2117	Oct. 3
Tyndall	2954	2888	2815	2729	2630	2521	Oct. 11
Union Center	2361	2307	2249	2181	2109	2023	Sept. 29
Vale	2438	2381	2316	2242	2159	2075	Oct. 2
Vermillion	3034	2963	2886	2792	2689	2572	Oct. 18
Vivian	2779	2713	2639	2555	2463	2368	Oct. 4
Wasta	2658	2593	2517	2440	2353	2253	Oct. 2
Watertown	2297	2250	2193	2125	2048	1965	Oct. 3
Webster	2214	2170	2116	2049	1976	1897	Oct. 4
Wentworth	2502	2444	2380	2304	2222	2132	Oct. 6
White Lake	2893	2829	2756	2672	2576	2473	Oct. 10
Winner	2631	2578	2515	2441	2363	2282	Oct. 14
Wood	2811	2744	2679	2588	2494	2399	Oct. 5
Yankton	2972	2911	2843	2762	2670	2536	Oct. 19

*Date when temperature drops to 28° F. half of the time.



Black Layer Denotes Maturity

Cross-sections of corn kernels show the black layer that develops near the tip of the kernel when corn is physiologically mature.

Physiologic Maturity

Physiologic maturity of corn is the stage of development when no more dry matter will be stored in the kernel. Once corn is at this stage it has reached its yield potential. Until recently we have used moisture percentage as a measuring stick. We have said that more dry matter will be produced until the corn kernel dries down to about 35% moisture. Another common guide is that corn reaches maturity 60 to 65 days after silking.

An easier and more accurate method has been discovered. All you need to do is check the tips of the kernels. Just split the kernel and look for a dark, black layer near the tip. If a black layer is visible near the end of the kernel just under the outside layer (see photograph), it indicates the corn kernel has stopped receiving nutrients from the stalk. Unless the plant has dried prematurely from disease or freezing, this means the grain is physiologically mature.

Varying Development

Not all kernels develop this black layer the same day. It is developed at approximately the same time for all kernels in the central portion of the ear. Its appearance is delayed a few days in the larger kernels at the butt of the ear and it appears earliest in kernels at the tip of the ear.

The movement of plant food into the kernels and the development of the black layer seem to be closely related. An environmental stress such as drought, shading, shortage of nutrients, or

intense heat causes a reduction in the supply of plant food being moved to the ear. Kernels on the butt of the ear are nearest the source of supply. They continue to assimilate plant food but there may not be enough for the tip kernels. The black layer forms on the tip kernels and they abort, leaving a barren tip. If the stress occurs shortly after pollination, the tip kernels may abort, those in the central part of the ear may form a layer when only partially filled, and the butt kernels may mature normally. In completely developed kernels, the black layer appears to develop soon after starch granule formation has been completed at the base of the endosperm. The storage capacity of the kernel may diminish to such a level as to trigger the disintegration of translocation tissues in the basal endosperm and black layer formation.

Plant Nutrient Flow Stopped

Regardless of stage of development, formation of the black layer stops the flow of plant nutrients into the kernel. When all kernels on an ear have developed the black layer, that ear has reached its maximum dry weight of shelled corn. Corn is mature at this point. Yield and quality will not be affected by frost, hail or drought and it is ready to pick or cut for silage.

The time required to reach maturity varies by several days, even among corn plants of the same variety in the same field. So for practical purposes, we believe a hybrid is mature when kernels of 75% of the ears have developed the black layer. This black layer is being used by most seed corn companies to determine when the hybrid is physiologically mature. The GDD or "heat unit" rating is based on the number of GDD between planting time and the time that the black layer is formed.

Secure These Fact Sheets for Additional Information on Corn Production

- ▶ Planting Corn in South Dakota
- ▶ Fertilizing Corn in South Dakota
- ▶ Weed Control in Corn
- ▶ Control of Corn Rootworm
- ▶ Control of European Corn Borer
- ▶ Diseases of Corn
 - Stalk Rot, Ear Rot, Smut, Leaf Blight
- ▶ Drying Corn

This publication and others can be accessed electronically from the SDSU College of Agriculture & Biological Sciences publications page, which is at <http://agbiopubs.sdstate.edu/articles/FS522.pdf>



Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the USDA. Larry Tidemann, Director of Extension, Associate Dean, College of Agriculture & Biological Sciences, South Dakota State University, Brookings. SDSU is an Affirmative Action/Equal Opportunity Employer (Male/Female) and offers all benefits, services, and educational and employment opportunities without regard for ancestry, age, race, citizenship, color, creed, religion, gender, disability, national origin, sexual preference, or Vietnam Era veteran status.

FS 522—3M printed by CES at a cost of \$.07 each. February 1981; pdf June 2002.