



Title: Crop Heat Units for Corn and Other Warm Season Crops in Ontario

Division: Agriculture and Rural

History: Replaces Corn Heat Units in Southern Ontario

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Introduction

There is a wide selection of hybrids and varieties for most crops. Most of the warm-season crops have a wide range of maturities. Crop Heat Units (CHU) provide an indexing system to assist farmers to select the most suitable hybrids and varieties for their area. This indexing system was originally developed for field corn and has been in used in Ontario for 30 years. The crop heat unit ratings are based on the total accumulated crop heat units (CHU) for the frost-free growing season in each area of the province. This Factsheet describes the CHU available in different regions of the province and how hybrids and varieties of some warm-season crops are rated.

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Calculating Crop Heat Units

The rate of development of crops from planting to maturity is dependent mainly upon temperature. Cool temperatures slow down the progress to maturity and warm temperatures hasten maturity. Other environmental factors - such as photoperiod (daily period from sunrise to sunset), soil fertility and available water in the soil - can also influence the rate of crop development.

Air temperatures are usually expressed in terms of the daily minimum (min) and maximum (max). Temperatures are measured using calibrated min and max thermometers located in a white, louvered (well-ventilated) shelter, or by using an electronic sensor connected to a recording device.

Daily crop heat units are calculated from these min and max temperatures. There are separate calculations for day and night. The daytime relationship uses 10 °C (50 °F) as the base temperature and 30 °C (86 °F) as the optimum because warm-season crops do not develop when daytime temperatures fall below 10 °C and they develop fastest at about 30 °C. The nighttime relationship uses 4.4 °C (40 °F) as the base temperature and does not specify an optimum temperature because nighttime minimum temperatures very seldom exceed 25 °C in Ontario. The nighttime relationship is a straight line on the graph ([Figure 1](#)), while the daytime relationship is a curve that records greater crop heat units at 30 °C than at higher or lower temperatures. Daily crop heat units are calculated by using the average of the two daily values from the equations given in [Figure 1](#) or they can be read from the matrix in [Appendix I](#).

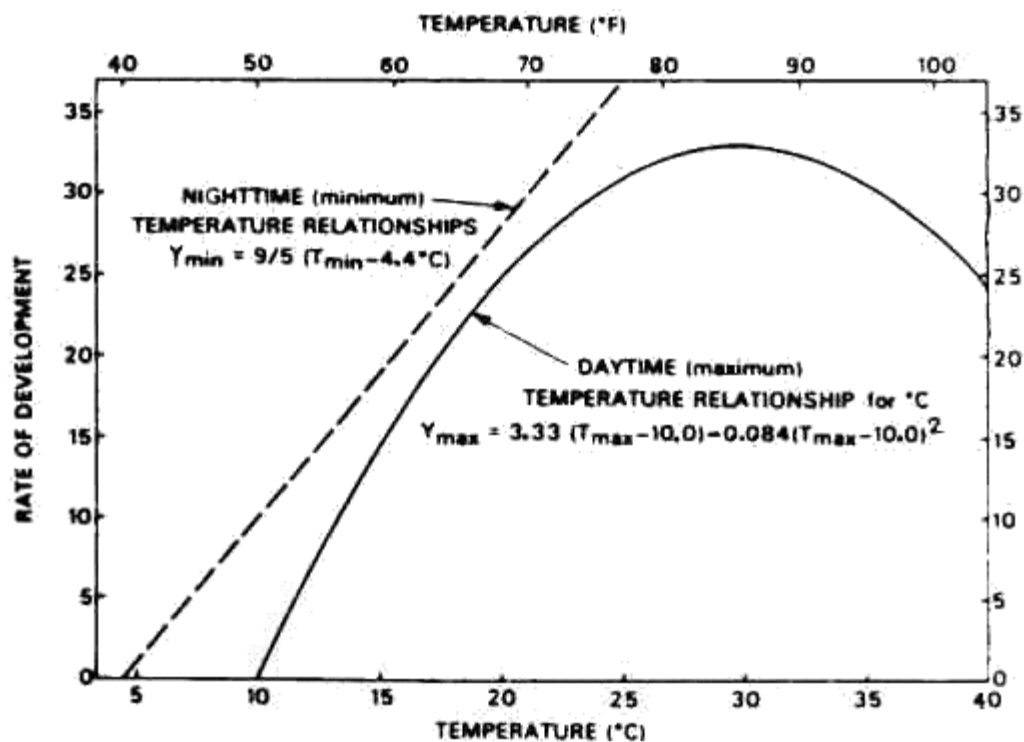


Figure 1. Relationships between daily rate of development of corn and nighttime (minimum) and daytime (maximum) temperatures.

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Geographic Distribution of Crop Heat Units for the Warm Season Crops in Ontario

The accumulated crop heat units that are available for tender crops such as corn, soybeans, tomatoes, etc., are shown in [Figure 2](#). This figure shows the average CHU from the earliest planting to a logical season-ending date. The average CHU are based on the day-by-day accumulations between these dates for each year from 1961 to 1990 for each weather station location.

The spring planting date (date to start accumulating CHU) is estimated as:

1. the last day of three consecutive days, with daily mean air temperatures equal to or greater than 12.8 °C (55 °F), and
2. the starting date for this three-day period each year occurred after the date the 30-year average daily mean air temperature reached 10 °C (50 °F) in spring for each weather station site. (See examples in [table 1](#). Average accumulated Crop Heat Units.)

The season-ending date (date to stop accumulating CHU) is the earlier date of either:

1. the first occurrence of -2 °C (28 °F); or
2. the date when the 30-year average daily mean air temperature dropped to 12 °C (or lower). (See [table 1](#). Average accumulated Crop Heat Units for averages dates for specific locations.)

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Table 1. Average accumulated Crop Heat Units (CHU) and average 10 °C, earliest planting, and season ending dates for locations across Ontario from southwest to northwest.

Location	Average Date $T_{\text{mean}} = 10\text{ °C}$	Average Date of 3 days $T_{\text{mean}} > 12.8\text{ °C}$	Average Season Ending Date	Accum. CHU
Harrow	Apr. 25	May 8	Oct. 11	3560
Woodslee	Apr. 25	May 8	Oct. 9	3410
Ridgetown	Apr. 27	May 11	Oct. 10	3340
London (A)	May 4	May 15	Oct. 2	2900

Brucefield	May 4	May 16	Oct. 3	2820
Woodstock	May 4	May 16	Oct. 2	2890
Delhi	Apr. 30	May 13	Oct. 4	3040
Vineland	May 3	May 17	Oct. 10	3190
Hamilton (RBG)	Apr. 29	May 15	Oct. 8	3210
Guelph	May 7	May 19	Sept. 30	2680
Redickville	May 12	May 24	Sept. 23	2380
Peterborough	May 5	May 19	Sept. 24	2600
Smithfield	Apr. 30	May 18	Oct. 6	2940
Kemptville	May 4	May 17	Sept. 26	2730
Ottawa (CDA)	May 3	May 16	Sept. 29	2890
Petawawa (NF)	May 8	May 21	Sept. 20	2380
Earlton (A)	May 16	May 27	Sept. 10	1930
Kapuskasing	May 23	June 1	Sept. 5	1720
Thunder Bay (A)	May 21	June 3	Sept. 10	1790
Fort Frances	May 11	May 23	Sept. 15	2330

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Method to Calculate CHU's

The method described above and used to calculate the CHU for 1961-90 is a slightly different method from the one used to prepare the previous heat unit map which was based on 1931 -60 temperatures. The map in [Figure 2](#) for the 1961-90 temperatures is however very similar to the previous map. The major differences occur in the Dundalk Upland area and in Eastern Ontario where the CHU are about 100 heat units greater in the map for the 1961-90 period ([Figure 2](#)) using the new criteria for starting and ending dates and calculating CHU by computer for each day in each of the 30 growing seasons.

Latitude, elevation and distance to the Great Lakes all affect daily temperatures and have a marked influence on the accumulated CHU across southern Ontario. Essex County has the highest rating, as it is the farthest south, has an elevation of about 185 metres above sea level, and is situated between Lake Erie and Lake St. Clair. The Dundalk Uplands (located north of Guelph) and the Algonquin Park Highlands have the lowest CHU ratings, as these regions have the highest elevation (mostly over 450 m). The St. Lawrence - Ottawa Lowlands have a higher rating than the Dundalk Uplands because of its lower elevation (most of it lower than 125 m).

The change between isolines on the map in [Figure 2](#) is gradual. The slope and soil type at a site also influence temperature. For example, South-facing slopes receive more heat than north-facing slopes, and sandy soils warm up faster than loam or clay soils. This makes it impossible to estimate the CHU rating closer than 50 heat units for any location.

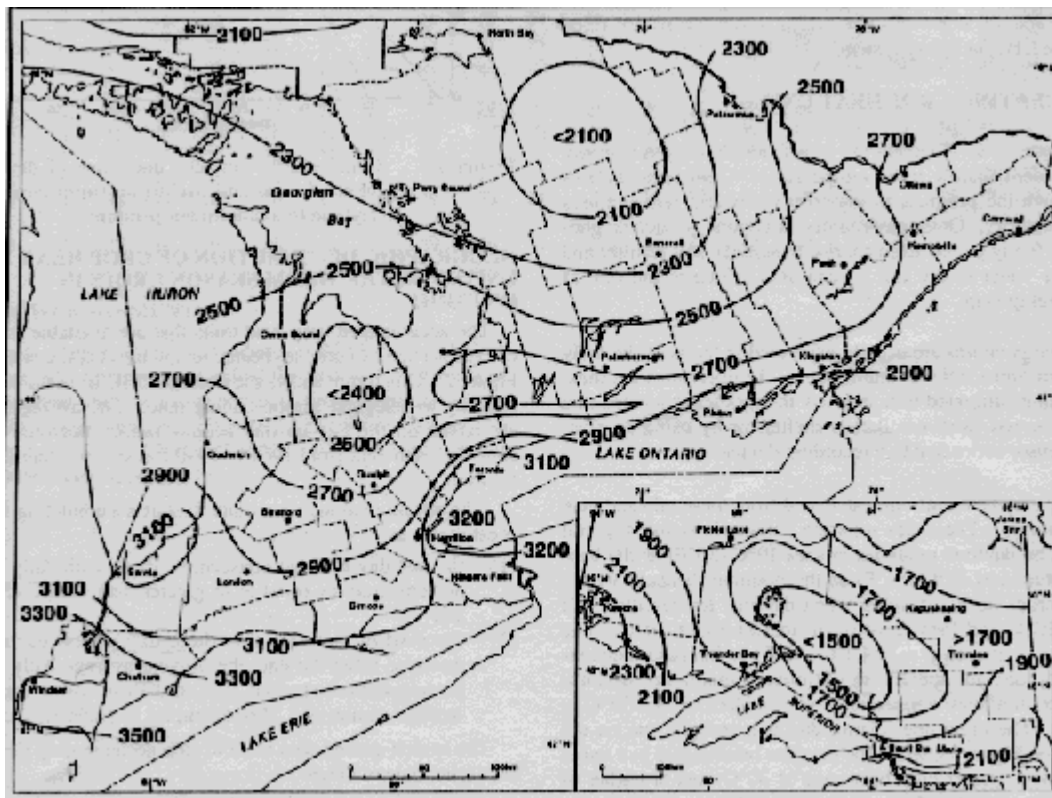


Figure 2. Average accumulated Crop Heat Units (CHU) available for warm-season crops in Ontario.

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Variability in Crop Heat Units from Year to Year

The average CHU, as mapped in [Figure 2](#) provides a value that is exceeded in 50% of years and will not be reached in the other 50% of years. Farmers who wish to choose less risk than one year in two (50% probability) of harvesting a mature crop should select varieties or hybrids requiring fewer CHU than the average in their area as indicated on the map. The number of heat units to subtract from the average CHU to determine specific probability or risk levels is given in [table 2](#). Number of Crop Heat Units to Subtract from Average CHU.

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Table 2. Number of Crop Heat Units to Subtract from Average CHU* to Determine specific probability/risk levels.

Probability %	Risk Level (years)	Crop Heat Unit Adjustment
50	1 year in 2	0
33	1 year in 3	80
25	1 year in 4	115
20	1 year in 5	140
10	1 year in 10	210
5	1 year in 20	280

*Average accumulated CHU provided on the map in [Figure 2](#).

[Table 2](#). Number of Crop Heat Units to Subtract from Average CHU shows that in 20% of the years (1 year in 5), the available CHU are 140 units or more below average. Therefore, for grain corn to reach physiological maturity before the first killing frost in four years out of five, farmers should select their earliest planted hybrids 140 CHU less than the rating given on the map for their area.

Later plantings or early harvests would have fewer crop heat units available. Therefore, crop hybrids and varieties can be selected based on the assumption that accumulated CHU are about 100 CHU per week at the beginning of the growing season (i.e. in May) and near the end of the frost-free season.

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Crop Heat Unit Rating for Hybrids and Varieties (Cultivars)

Hybrids or varieties are rated according to the CHU that are normally accumulated from planting the crop to physiological maturity. For example, corn hybrids are rated based on the CHU required to reach 32% kernel moisture and soybean varieties are rated on the CHU required to have 95% of the pods turn brown on a given variety. Crop specific recommendation pamphlets and publications such as the OMAFRA (Publication 296) Field Crop Recommendations or (Publication 363) Vegetable Crop Recommendations list these ratings for most crops. Farmers can select hybrids and varieties that are suitable for their location and planting dates using the CHU-rating system.

Due to the slight variability that occurs in the response of a given crop hybrid or variety to the environment, and the accuracy of measuring daily maximum and minimum temperatures, it is not possible to rate a hybrid or variety closer than to the nearest 100 heat units. Comparisons of relative maturities allow hybrids and varieties to be assumed to be within 50 crop heat units immediately above or below each other on the list, because of their relative maturity at harvest.

For crops like soybeans and other bean crops that are planted later and mature earlier than corn, the CHU that are available for these crops can be estimated by subtracting about 100 heat units from those given on the map (Figure 2) for each week that the growing season has been shortened. The usual planting and maturity dates for these crops can be compared to the planting season and ending dates given in Table I and used in calculating CHU for the map as indicated in Figure 2.

Appendix I. Daily CHU Values for °C Temperature Recordings

Daily Recorded Maximum Temperature (°C)	Daily Recorded Minimum Temperature (°C)																								
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
10	0	1	1	2	3	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
11	2	2	3	4	5	6	7	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	3	4	5	5	6	7	8	9	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	5	5	6	7	8	9	10	11	11	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	6	6	7	8	9	10	11	12	13	14	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	7	8	9	10	10	11	12	13	14	15	16	17	-	-	-	-	-	-	-	-	-	-	-	-	-
16	8	9	10	11	12	13	13	14	15	16	17	18	19	-	-	-	-	-	-	-	-	-	-	-	-
17	10	10	11	12	13	14	15	16	16	17	18	19	20	21	-	-	-	-	-	-	-	-	-	-	-
18	11	11	12	13	14	15	16	17	17	18	19	20	21	22	23	-	-	-	-	-	-	-	-	-	-
19	12	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	-	-	-	-	-	-	-	-	-
20	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	26	-	-	-	-	-	-	-	-
21	13	14	15	16	16	17	18	19	20	21	22	23	24	25	25	26	27	28	-	-	-	-	-	-	-
22	14	14	15	16	17	18	19	20	21	22	23	23	24	25	26	27	28	29	30	-	-	-	-	-	-
23	15	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	29	30	31	-	-	-	-	-
24	15	16	16	17	18	19	20	21	22	23	24	25	25	26	27	28	29	30	31	32	33	-	-	-	-
25	16	16	17	18	19	20	21	21	22	23	24	25	26	27	28	29	30	30	31	32	33	34	-	-	-
26	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30	31	32	33	33	34	-	-	-
27	16	17	18	18	19	20	21	22	23	24	25	26	27	27	28	29	30	31	32	33	34	-	-	-	-
28	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	29	30	31	32	33	34	-	-	-	-
29	16	17	18	19	20	21	21	22	23	24	25	26	27	28	29	30	30	31	32	33	34	-	-	-	-
30	17	17	18	19	20	21	22	22	23	24	25	26	27	28	29	30	30	31	32	33	34	-	-	-	-
31	16	17	18	19	20	21	21	22	23	24	25	26	27	28	29	30	30	31	32	33	34	-	-	-	-
32	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	29	30	31	32	33	34	-	-	-	-
33	16	17	17	18	19	20	21	22	23	24	25	26	26	27	28	29	30	31	32	33	34	-	-	-	-
34	16	16	17	18	19	20	21	22	23	23	24	25	26	27	28	29	30	31	32	32	33	34	-	-	-
35	15	16	17	18	19	19	20	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	-	-	-
36	15	15	16	17	18	19	20	21	22	23	24	24	25	26	27	28	29	30	31	32	33	34	-	-	-
37	14	15	16	17	18	18	19	20	21	22	23	24	25	26	27	27	28	29	30	31	32	33	34	-	-
38	14	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	29	30	31	32	33	34	-

39	13	13	14	15	16	17	18	19	20	21	22	22	23	24	2	26	27	28	29	3	31
40	12	13	14	14	15	16	17	18	19	20	21	22	23	23	24	25	26	27	28	29	30

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