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# Kansas Corn: Growing Degree Days

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# Kansas Corn: Growing Degree Days

## Grade Level: Middle School and High School

### Overview

Driving through Kansas, it is difficult to miss fields of corn in the spring and summer. In an average year, more than 500 million bushels of corn are harvested in Kansas. That's a lot! With numbers like that, one might believe it is easy to grow corn in Kansas. It goes well beyond just planting and watering though. There's a science behind knowing when to plant corn, when to expect different stages of growth, and when to harvest – it's called *growing degree days* (GDD).

In the spring, there are many important factors to consider when a farmer is thinking about planting corn. Are we done with freezes for the season? Is there moisture on the way? How much light is hitting my plants? While these are in the forefront of a farmer's mind, another major factor is going to be temperature. We are not only talking air temperature, but also ground temperature.

According to the Kansas State University Department of Agronomy, if a farmer plants corn from when the ground temperature is between 50°F and 55°F, it can take 18 to 21 days to see emergence. If the farmer plants corn when the ground temperature is between 60°F and 65°F, it might only take 8 to 10 days to see emergence. What a difference!

Iowa State University's Department of Agronomy adds that corn will not grow below 50°F. Corn grows best in conditions between 50°F and 86°F. Between 86°F and 93°F, corn continues to grow, but the increase in temperature does not give additional benefit to the plant. Above 93°F, there can be a negative impact on the growth of corn. Above 110°F, true heat stress can occur on the plant. In general, warmer weather helps corn grow and cooler weather slows growth.

It is recommended that students complete the *Kansas Corn: Explore Corn* lab prior to completing this lesson. This will help the students understand the growth stages of corn as they complete this lab.

### Kansas College and Career Ready Standards

#### Science

- **LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

#### Language Arts

- **RI.3.1.** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- **RI.3.7.** Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).

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### *Language Arts (continued)*

- **SL.3.1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.

### *Math*

- **HSS.MD.A.1.** Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.
- **HSS.MD.A.2.** Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.

### **Learning Objectives**

- Students will gain an understanding of ideal growing conditions for corn.
- Students will be able to make calculations to determine what stage of growth corn is in.
- Students will use their knowledge of corn life stages to determine when it will mature.

### **Materials**

- Growing Degree Days PowerPoint (available online at [www.kscorn.com](http://www.kscorn.com))
- Growing Degree Days Student Packet (pg. S1-S3, or available online at [www.kscorn.com](http://www.kscorn.com))
- Growing Degree Days Student Worksheet (pg. S4-S5, or available online at [www.kscorn.com](http://www.kscorn.com))
- Answer Key – Growing Degree Days Student Worksheet (pg. T10)
- Computer and internet access

### **Procedures for Instruction**

Length of Time for Preparation: 30 minutes

Length of Time for Classroom Teaching: 1.5 hours

**Note:** It is recommended that students complete the Kansas Corn: Explore Corn lab (available online at [www.kscorn.com](http://www.kscorn.com)) before completing the Kansas Corn: Growing Degree Days lab.

### **Classroom Discussion**

The *Growing Degree Days* PowerPoint is available at [www.kscorn.com](http://www.kscorn.com). Open it and show the students the slide with the United States (Slide 2). Have them identify all of the states from the map that are major corn producers.

**(Note: The numbers on the states are the percent of total corn production contributed to the U.S. supply.)**

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There must be a reason why corn is grown in these areas!

To gauge student knowledge, have students make a list of everything that can impact the growth of corn. Give them one minute. At the end of that minute, have them turn to a shoulder partner to compare lists. Encourage them to talk through the lists. From those lists, the partners will create a new list of the top five factors that can impact growth.

Bring the class back together and have students read off their lists. Write down their ideas on the board. If the same idea is mentioned, put a tick mark next to it. By the end, you will hopefully be able to narrow the list down to the top five impacts.

If students need help generating ideas, here are a few factors they may want to add to their list: location of the field, soil quality, pests in the field, the use of chemicals in the field, moisture, sunlight, soil temperature, and air temperature.

While all of those are important, farmers use a calculation called *growing degree days* (GDD). Now, hand out the Growing Degree Days Student Packet (pg. S1-S3, or available online at [kscorn.com](http://kscorn.com)).

Have students read the first page of the Growing Degree Days Student Packet, which give students a background in growing degree days. Encourage them to highlight portions they think are important.

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### Procedure for Lab

#### *Calculating Growing Degrees Days for Corn*

On the second page of the Growing Degree Days Student Packet, students are introduced to the Growing Degree Days (GDD) calculation.

This equation helps farmers calculate what stage of life their corn plant is in. It takes into account air temperature for any given day. The calculation is below:

$$\text{GDD } ^\circ\text{F} = \frac{\text{Daily Max Temp } ^\circ\text{F} + \text{Daily Min Temp } ^\circ\text{F}}{2} - \text{Lower Base Temperature } ^\circ\text{F}$$

The temperature will not always be between 50°F and 86°F. That is where a few rules come in when using the GDD equation. Make sure you explain these rules to students!

**Rule 1:** If your minimum or maximum temperature is below 50°F, set it to 50°F in the equation.

**Rule 2:** If your maximum temperature is above 86°F, set it to 86°F in the equation.

Remember, the growth process for corn halts with a temperature below 50°F; therefore, 50°F is our *Lower Base Temperature*. Also, remember that corn does not see a noticeable positive impact with temperatures above 86°F; therefore, 86°F is our *Upper Limit Temperature*.

So, if on a sunny May day, our high temperature was 70°F, and our low temperature was 54°F, our equation would look like this:

$$\text{GDD } ^\circ\text{F} = \frac{70^\circ\text{F} + 54^\circ\text{F}}{2} - 50^\circ\text{F}$$

That would give us a GDD number of “12” for that sunny, May day. The more growing degree days we “accumulate,” the farther along the corn plant is in its growth. Often, students hear the term *growing degree days*, and think they are adding the number of days together. In actuality, you can accumulate many growing degree days in one day. It is simply a number.

# Kansas Corn: Growing Degree Days

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After looking at the two examples in the Growing Degree Days Student Packet, show students the Growing Degree Days PowerPoint slide with information from the chart below (Slide 5). Have students work through the maximum and minimum temperatures to see if they can calculate the total number of growing degree days for that week. This concept is very unfamiliar to many students, so you may want to work through the data on Monday and Tuesday, then turn them loose to calculate the rest of the week.

	Monday	Tuesday	Wednesday	Thursday	Friday
Maximum Temperature	68°F	72°F	60°F	69°F	69°F
Minimum Temperature	52°F	54°F	50°F	54°F	55°F

Throughout this random week, our corn plant has “accumulated” 51.5 growing degree days.

	Monday	Tuesday	Wednesday	Thursday	Friday
Maximum Temperature	68°F	72°F	60°F	69°F	69°F
Minimum Temperature	52°F	54°F	50°F	54°F	55°F
GDDs	10	13	5	11.5	12

According to the chart below from Clemson Cooperative Extension (this table is also in the Growing Degree Days Student Worksheet and in the Growing Degree Days PowerPoint), our corn plant would not have even emerged from the ground. We need to accumulate another 73.5 (125-51.5) growing degree days before that will happen. It could be by the end of the next week!

**Table 1.** Approximate Growing Degree Days (GDD) required for a mid-season maturity corn hybrid to reach different growth stages from the time of planting<sup>1</sup>.

Stage	GDD
VE - Emergence	125
V6 - Tassel initiation	475
VT - Tassel emergence	1,150
Silking	1,400
R4 - Dough stage	1,925
R5 - Dent stage	2,450
R6 - Physiological maturity or black-layer	2,700

<sup>1</sup> Adapted from R.G. Hoefst, et al. 2000. *Modern Corn and Soybean Production*. Page 8.

# Kansas Corn: Growing Degree Days

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With the rules explained earlier in mind, now have students practice by calculating the growing degree days for this random week in May. The chart below is in the Growing Degree Days Student Packet.

	Monday	Tuesday	Wednesday	Thursday	Friday
Maximum Temperature	86°F	91°F	89°F	49°F	89°F
Minimum Temperature	52°F	45°F	50°F	42°F	51°F

	Monday	Tuesday	Wednesday	Thursday	Friday
Maximum Temperature	86°F	91°F	89°F	49°F	89°F
Minimum Temperature	52°F	45°F	50°F	42°F	51°F
GDDs	19	15.5	18	0	18.5

$19 + 15.5 + 18 + 0 + 18.5 = 71$  GDDs for the week

### *Real World Practice:*

Now, students will get real world experience. Have them go to the following website (the website is also shown in the Growing Degree Days PowerPoint): [tinyurl.com/KSCornGDD](http://tinyurl.com/KSCornGDD)

The student instructions are in the Growing Degree Days PowerPoint (Slide 11), but when students go to the website, the map will be zoomed in on Kansas. Have them choose a field in Kansas (any field!) by clicking on the field and then “Create GDD Graph”. A chart will pop up for that field. The county where the field is located will be listed at the top of the chart.

- Have students determine the earliest first freeze, as well as the latest last freeze. That is important, because you want to grow corn in areas with longer growing seasons.
- Now, have students unclick all of the lines except “2017 GDD”, which is found in the grid box in the graph (or the year listed).
- Have them hover over the remaining line. They will see GDDs accumulate as they move over the line.
- Using the chart on their Growing Degree Days Student Worksheet (pg. S4-S5, or available online at [kscorn.com](http://kscorn.com)), have them determine the dates when enough GDDs will have accumulated for each stage of growth.

# Kansas Corn: Growing Degree Days

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- When will the corn be ready for harvest? Usually, this will happen around R4.
- Have the students compare their results from fields around the state. Where in Kansas would you want to grow corn based on the results?

Now, have students click back to the map they saw when they first went to the website. Have them back up the map on the website so they can see other highlighted states.

- Have them use the Growing Degree Days Student Worksheet to guide them through picking two other fields. (This is good practice for students to remember where states are located!)
- Once finished, have students answer the questions on the back of the Growing Degree Days Student Worksheet.

### Reflection and Conclusion

The goal of this activity is for students to gain a better understanding of how weather and climate have a major influence on crop growth. Farmers can use knowledge gained from previous years to predict when a crop will reach maturity. This helps with knowing when to harvest and when to spray pesticides.

This is a great activity to revisit later in the growing season. Students can compare their data from earlier in the season to see how accurate it is with what actually happens.

### Assessments

To check for understanding, have students make their own “fake” growing degree days table. Have them make up a location, as well as come up with their own highs and lows. Emphasize that the table should be a mix of numbers between 50°F and 86°F, and some outside of that range. After creating the table, have them determine the number of GDDs for their week. Have them then exchange with another person in class to see if they get the same numbers.

### Science and Agriculture Careers

- Climatologist
- Agronomist
- Biologist
- Geneticist

To learn more about agriculture careers visit [agexplorer.com](http://agexplorer.com). You can also find career profiles at [www.kscorn.com](http://www.kscorn.com).



# Kansas Corn: Growing Degree Days

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### Sources

- Ohio Corn and Wheat curriculum – <http://ohiocorneducation.org/>
- Ground temperature and plant emergence – <http://www.agronomy.k-state.edu/extension/crop-production/corn/corn-growth-and-development.html>
- Temperatures and corn growth – <http://agron-www.agron.iastate.edu/courses/Agron541/classes/541/lesson02b/2b.1.html>
- Corn GDD Calculation – <https://ndawn.ndsu.nodak.edu/help-corn-growing-degree-days.html>
- Table showing approximate GDD required to reach different growth stages – Clemson Cooperative Extension <https://www.clemson.edu/extension/publications/files/agronomic-crops/ac09-introduction-to-growing-degree-days.pdf>

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at <http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf>, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

# Kansas Corn: Growing Degree Days

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### Answer Key – Growing Degree Days Student Worksheet

*Possible answers for reflection questions:*

1. Did any of the fields you chose never get to the R4 Date? If so, where? What do you think it means if the corn growth cannot make it to that level?
  - We probably wouldn't grow corn in that location since the growing season isn't long enough for corn. The climate is not conducive for corn growth.
2. Based on your data, where would be the ideal place to grow corn? What are three reasons why?
  - Any place where we can accumulate enough GDDs to get to at least R4 stage (R6 for dent corn).
  - Any place with late first freezes and early last freezes.
  - Any place without extreme high and low temperatures through the growing season.
3. What do you think would be the WORST place to grow corn in the United States? Why?
  - Possible answer: Arizona – it gets above 93° during the spring and summer, which would hinder corn growth.
  - Possible answer: Alaska – is has a late last freeze and early first freeze. Plus, the temperature takes longer to get into the 50°F to 86°F ideal growth zone.

## Growing Degree Days Student Packet

Name: \_\_\_\_\_

Period: \_\_\_\_\_

### What Do You Think?

Make a list of five factors that impact the growth of corn:

- 1.
- 2.
- 3.
- 4.
- 5.

### Growing Degree Days: An A“maize”ing Harvest Calculation

Driving through Kansas, it is difficult to miss fields of corn in the spring and summer. In an average year, more than 500 million bushels of corn are harvested in Kansas. That’s a lot! With numbers like that, it might lead one to believe it is easy to grow corn in Kansas. While Kansas is a large corn producer, to be successful, farmer need to know more than just when to plant and water their crop. There’s a science behind knowing when to plant corn, when to expect different stages of growth, and when to harvest. It’s called *growing degree days* (GDD).

In the spring, there are many important factors to consider when a farmer is thinking about planting corn. Are we done with freezes for the season? Is there moisture on the way? How much light is hitting my plants? While these are in the forefront of a farmer’s mind, another major factor is going to be temperature. We are not only talking air temperature, but also ground temperature.

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Iowa State University’s Department of Agronomy adds that corn will not grow below 50°F. Corn grows best in conditions between 50°F and 86°F. Between 86°F and 93°F, corn continues to grow, but the increase in temperature does not give additional benefit to the plant. Above 93°F, there can be a negative impact on the growth of corn. Above 110°F, true heat stress can occur on the plant. In general, warmer weather helps corn grow and cooler weather slows growth.

## Growing Degree Days Student Packet

### Growing Degree Days: An A“maize”ing Harvest Calculation

Temperature Impact on Corn	Temperature
Little to no growth	Below 50°F
Ideal growth conditions	Between 50°F and 86°F
Some negative impacts on growth	Above 93°F
Heat stress and harm to growth	Above 110°F

### Calculating Growing Degrees Days for Corn

Lower Base Temperature: 50°F

Upper Limit Temperature: 86°F

$$\text{GDD } ^\circ\text{F} = \frac{\text{Daily Max Temp } ^\circ\text{F} + \text{Daily Min Temp } ^\circ\text{F}}{2} - \text{Lower Base Temperature } ^\circ\text{F}$$

*A few rules:*

**Rule 1:** If the daily maximum and/or minimum temperature < 50°F, it's set equal to 50°F in the equation. (For example, if the temperature is 38°F, we bump it up to 50°F in the calculation.)

**Rule 2:** If the daily maximum temperature > 86°F, it's set equal to 86°F in the equation.

*Examples:*

**Example 1:** If on a beautiful May day, the high (maximum temperature) was 80°F and the low (minimum temperature) was 56°F, then:

The average temperature for the day is = (80°F + 56°F) / 2 = 68°F

And that day's Corn GDD (°F) = 68°F - 50°F = **18 GDD (°F)**

## Growing Degree Days Student Packet

### Examples (Continued):

**Example 2:** If on a mild April day, the high (maximum temperature) was 66°F and the low (minimum temperature) was 38°F, then:

Remember the rules!

In this case:

The daily minimum temperature of 38°F is replaced with 50°F, according to the rules.

The average temperature for the day is  $= (66^{\circ}\text{F} + 50^{\circ}\text{F}) / 2 = 58^{\circ}\text{F}$

And that day's Corn GDD ( $^{\circ}\text{F}$ )  $= 58^{\circ}\text{F} - 50^{\circ}\text{F} = \mathbf{8 \text{ GDD } (^{\circ}\text{F})}$

Now, it's your turn. Follow the process from the previous page to calculate the growing degree days for this example week. Work the problems out in the space below. Remember to add the GDDs you accumulate each day to see how many were accumulated for the week.

	Monday	Tuesday	Wednesday	Thursday	Friday
Maximum Temperature	86°F	91°F	89°F	49°F	89°F
Minimum Temperature	52°F	45°F	50°F	42°F	51°F

Total GDDs for the week:

### Sources

- Ground temperature and plant emergence – <http://www.agronomy.k-state.edu/extension/crop-production/corn/corn-growth-and-development.html>
- Temperatures and corn growth – <http://agron-www.agron.iastate.edu/courses/Agron541/classes/541/lesson02b/2b.1.html>

## Growing Degree Days Student Worksheet

Name: \_\_\_\_\_

### Growing Degree Days for Corn:

(Note: Data available online at [tinyurl.com/KSCornGDD](http://tinyurl.com/KSCornGDD))

**Table 1.** Approximate Growing Degree Days (GDD) required for a mid-season maturity corn hybrid to reach different growth stages from the time of planting<sup>1</sup>.

Stage	GDD
VE - Emergence	125
V6 - Tassel initiation	475
VT - Tassel emergence	1,150
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R4 - Dough stage	1,925
R5 - Dent stage	2,450
R6 - Physiological maturity or black-layer	2,700

<sup>1</sup> Adapted from R.G. Hoefst, et al. 2000. *Modern Corn and Soybean Production*. Page 8.

**Field #1 (must come from Kansas):** In which county is the field?

Earliest First Freeze (Since 1980):

Latest:

VE Date:

R4 Date:

V6 Date:

R5 Date:

VT Date:

R6 Date:

**Field #2 (must come from North Dakota, South Dakota, Missouri, Iowa, Nebraska, or Minnesota):** In which state, and in what portion of the state, is the field?

Earliest First Freeze (Since 1980):

Latest:

VE Date:

R4 Date:

V6 Date:

R5 Date:

VT Date:

R6 Date:



## Growing Degree Days Student Worksheet

**Field #3 (must come from Ohio, Indiana, Illinois, Wisconsin, or Michigan):** In which county is the field?

Earliest First Freeze (Since 1980):

Latest:

VE Date:

R4 Date:

V6 Date:

R5 Date:

VT Date:

R6 Date:

### Reflection

1. Did any of the fields you chose never get to the R4 Date? If so, where? What do you think it means if the corn growth cannot make it to that level?

2. Based on your data, where would be the ideal place to grow corn? What are three reasons why?

3. What do you think would be the worst place to grow corn in the United States? Why?

### Sources

- Table showing approximate GDD required to reach different growth stages – Clemson Cooperative Extension <https://www.clemson.edu/extension/publications/files/>