GROWING-DEGREE DAYS AND DEVELOPMENT OF THE WHEAT PLANT

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Plant growth is a complex process. It involves an irreversible increase in plant weight or size, usually brought about by expansion of plant parts and by the use of products of photosynthesis to make the new parts or to increase the size of old parts. To explain plant growth, we must be prepared to talk about temperature, light, water, nutrients and other factors that are involved. However, we can talk about a slightly different idea--that of plant development--in somewhat simpler terms.

Development of a plant is merely a description of what parts are present and how many of them there are and says nothing about how big or heavy any one part may be. When we talk about a plant that is at the four-leaf stage, we are talking about a developmental stage. A four-leaved plant may have huge leaves and weigh a lot or it may be weak with short, narrow leaves, but it will still be at the four-leaved stage. In the case of wheat plants, we consider development to include: leaf number, tiller number, and root number as well as any information that we may have on the reproductive stage of the apical meristem of the plant.

One of the important ideas developed over the past several years is the idea that plant development can be described and followed quantitatively by following the development of leaves and tillers and roots. This development under field conditions can be described using a unit called "cumulative growing-degree-days". This talk will tell you how to measure growing degree days and how to use the concept to monitor your wheat plants as they grow in the field.

Calculation of Growing Degree Days

Cumulative growing degree days (GDD) are calculated from the average centigrade temperature of each day over a time period--usually from planting to the present. Here are the steps to follow in this calculation:

1. Obtain daily Fahrenheit maximum and minimum temperatures from planting to the present.

2. Convert these temperatures to centigrade (C) degrees from Fahrenheit (F) degrees with this formula

$$C = 5/9 (F-32).$$

3. Calculate the average centigrade temperature for each day with the formula

$$\text{Average} = (\text{max} + \text{min})/2.$$

4. Add together all of the Positive values from planting to the present to obtain the cumulative GDD's.

Table 1 shows an example of this calculation.

Table 1. Cumulative Growing Degree Days calculation example.

Day	Max (F)	Mm (F)	Max (C)	Mm (C)	Ave (C)	Cumulative Growing Degree Days
Mon	52	40	11.1	4.4	7.8	7.8
Tues	49	37	9.4	2.8	6.1	13.9
Wed	47	30	8.3	-1.1	3.6	17.5
Thurs	33	27	0.6	-2.8	-1.1⇒0	17.5
Fri	48	30	8.9	-1.1	3.9	21.4
Sat	57	37	13.9	2.8	8.4	29.8
Sun	53	42	11.7	5.6	8.7	38.5

Cumulative growing degree days are a measure of the amount of warmth that plants have experienced over the past time. In the case of winter cereals like wheat, temperature in the early spring is usually the limiting factor for plants to develop and growing degree days give a direct measure of the "driving" factor. Wheat ceases growth at the freezing point, 0 degrees centigrade. You can picture the relationship between how fast a plant develops and average temperature as a straight line, at least until you get to the very high temperatures. The warmer it is, the faster the plant will develop. That relationship is the reason that GDD works to predict development: the warmer it is, the faster the plant collects heat units for development.

Corn and other warm season crops cease growth at about 10 degrees centigrade. This means that, for corn, all time below 10° C doesn't "count" in development. Thus when using the cumulative heat unit idea with the warm season crops we have to use a base temperature to cut off growth below that base temperature. However, for the winter annuals like wheat, barley, cheatgrass, wild oat, forage grasses, and other grasses--including your lawn--we can use a base temperature of 0 degrees centigrade and make the calculation a lot easier. In fact, for winter annuals, the cumulative growing degree days are nothing but the sum of the average centigrade temperatures.

How Plant Development Can Be Measured

To describe a wheat plant, we use a naming system that involves numbering all of the nodes on the plant. A node is merely the point of attachment of a leaf, but that point also has roots and tillers associated with it. For example, the first foliar node is the point on the stem or crown where the first leaf is attached, but it may also have a tiller at that node as well as up to four roots. We name these nodes in the crown and all of their associated parts with a number. Node 1 can bear Leaf 1, Tiller 1 and its subtillers, and some root axes called lA, lB, lX, and lY.

To measure plant development, we can merely state how many nodes have developed leaves big enough to be visible without dissection. The 4-leaved plant stage is a statement of how developed that plant is. However, a plant at that stage might have tillers and crown roots and we might want to know about those too.

The method used to measure leaf development was used by a man named Haun, who described leaf development by measuring the number of fully-developed leaves and expressing, as a decimal fraction, the comparison of the length of the newest leaf with the length of its predecessor. For example, a plant with four fully extended leaves and with the fifth leaf half as long as the fourth would have a development stage of 4.5.

Relationships Between GDD and Leaf Development

Generally it takes about 100 GDD for each leaf on a cereal plant to grow out. We say that the phyllochron for wheat is 100 GDD. Thus, if you know when the plant emerged, you can calculate about how many leaves it should have on it after a certain period of time if you know what the temperature has been. Say that you know that your crop began to emerge on November 1 and you also know that there have been 275 GDD from November 1 to the present. You would then expect that your crop would be getting its third leaf since it should be at about the 2.75 leaf stage.

The actual number of GDD per leaf required by a crop is not exactly 100, but ranges from about 80 to 120. The most important factor in setting the phyllochron is the environment at or near planting time and no one yet knows exactly what the triggering factor is. Generally wheat planted early in the fall will have a longer GDD requirement than that planted later in the fall. There is very little varietal difference in the phyllochron for different cultivars of wheat planted at the same time, but there is a tendency for spring wheats to have shorter phyllochrons than winter wheats.