WHEAT DEVELOPMENT AND GROWTH

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Workshop objective: How would you like to be able to determine whether or not your crop is developing normally? This workshop will help you judge whether your crop is emerging and developing as it should. It will also let you know when weather or management may have affected your crop's development.

Workshop content: You will learn two things: 1. **To identify the different parts of the plant**, especially the main stem, leaves, and tillers and 2. **How plants count time,** not by days, but by the heat units collected each day**.** We want you to leave with the ability to track your crop as it emerges and produces leaves and tillers so that you can evaluate the development of your seedlings.

Major Points

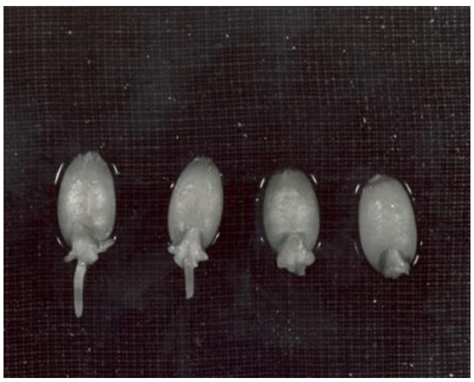
1. **Every part of a wheat plant is unique and can be uniquely named**.
2. **Each wheat plant assembles all of its parts with the exact same blueprint**.
3. **The timing of the formation and extension of the parts (DEVELOPMENT of the plant) is controlled not by the calendar, but by accumulated heat units.**
4. **The size of each plant part (GROWTH of the plant) is controlled by the resources available to the plant (water, nutrients, sunlight, carbohydrate reserves) when the particular part is developing.**

We are going to focus on learning to identify the parts of a wheat plant that are present during early DEVELOPMENT. We will then look at what can be learned by comparing expected development to actual development in a field. Observations of GROWTH of the parts will add to the story the plants can tell.

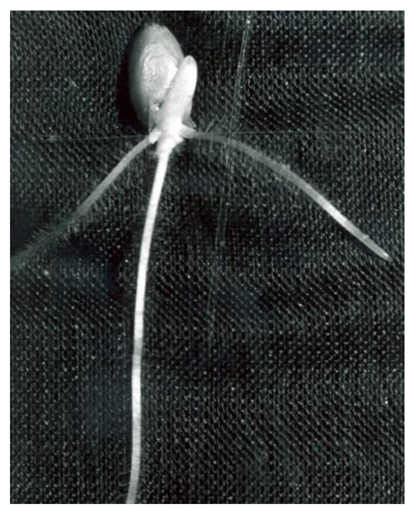
Planting, germination and emergence

Planting: Generally, you plant wheat seed at sufficient depth to reach enough water to get the seeds hydrated and get the embryo inside of the seed ready to develop. In a dry fall, you may have to dust the seed in. Seeds planted deep into moisture start developing at planting; dusted- in seeds begin development after the first good rain. Another difference between deep and shallow seeding is that the deep-seeded plants will show the seminal roots growing out of the seed and the crown roots developing up at the level of the crown.

Germination: When seeds are placed in warm, moist soil, food materials in the seed become soluble and move into the embryo to nourish it. The rate of this process is controlled by soil temperature. The embryo pushes out the first seminal (seed) root which grows downward. This root anchors the seedling, pushes into the soil and increases the surface area available to absorb water from the soil into the seedling. It takes a definite number of heat units for this root to appear in plants placed in good soil moisture. We have found that it takes 144 F-GDD (Fahrenheit Growing Degree Days) for this to happen if seeds are into good moisture. We'll learn how to calculate F-GDDs later.



Emergence: After seminal roots appear, the seedling begins to elongate the coleoptile and the first green leaf grows up inside of the coleoptile. When half of the coleoptiles have appeared above ground and half of the green leaves are on their way up the inside of this sheath, the crop is emerged for the purposes of these calculations. It takes 90 F-GDD for each inch of planting depth for the crop to get to the middle of its emergence pattern assuming that moisture is adequate. Therefore emergence from a two inch planting depth would be 144 F-GDD (for germination) + 90 + 90 F-GDD (for the two inches planting depth) = 144 +180 F-GDD =324 F-GDD.

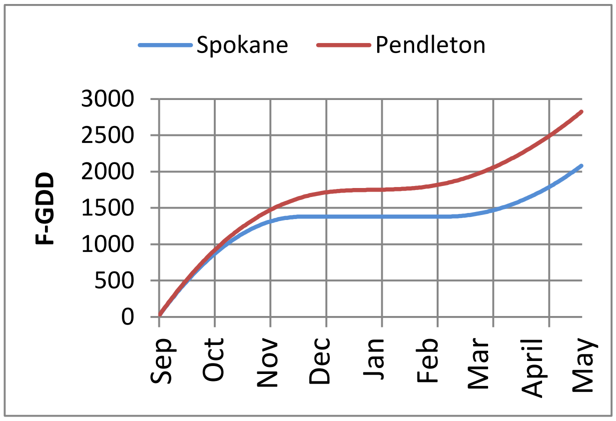


Heat Units

Heat units: We use cumulative Fahrenheit Growing Degree Days (F-GDD) to measure plant time. This is calculated by adding together the number of degrees that the average daily temperature exceeds 32 degrees. You can calculate the average daily temperature by adding the maximum and minimum temperatures and dividing by 2. The wheat seedling does not make any progress in its development when the average daily temperature falls below the freezing point of water. All values of 32 degrees or less are recorded as zero. To illustrate, if the average temperature is 46, 29, and 31 degrees Fahrenheit for a period of three days, there are 14 F-GDD collected over that time period. We get this by subtracting 32 degrees from each average temperature to get the F-GDD for that day and then adding the results together (14+0+0=14 F-GDD).

Day #	T max °F	T min °F	T Avg. °F	Cum. F-GDD
1	52	40	46	=14
2	38	20	29	+0=14
3	32	30	31	+0=14
4	42	36	39	+7=21
5	48	40	44	+12=33
6	52	38	45	+13=46
7	60	42	51	+19=65

Patterns of F-GDD look like this graph which shows the collection of heat units at Pendleton (the red line) and Pullman (the blue line) over a crop year starting on September 1. Each farm will have a slightly different pattern of cumulative F-GDD depending on such factors as elevation and latitude. Each season will also differ slightly. The box below gives you a way to get average F-GDD for different parts of the country.

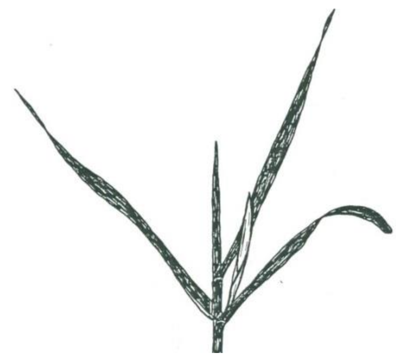


You can calculate Fahrenheit Growing Degree Days (F-GDD) from weather data on the internet. The site is **uspest.org/wea/.** Click on Map Index. This will bring you to an interactive map of the US. Click on your state. A pop-up box will appear showing interfaces available. In individual networks, select METAR, a NOAA site. Now you will see the Heading, “Degree-day and Phenology Model Calculator.” The first task is “Select Model”. Hit the down-arrow on this bar and go to the bottom of the drop-down list to “winter wheat Karow et al 1993” and select that. Next set the lower threshold to 32 and the upper threshold to 130. Ignore the box asking for Calc. method. Now enter your start (planting) date or, if you dusted the crop in, enter the date of the first significant rain after planting. Then enter end date, for example: Sept. 25, Nov. 11. Depending on your date choices select same year or following year. Ignore the boxes asking for Forecast zip code and Calc. selection. Now go down into the table and find a weather station near you, then in that line, select the correct year and, if needed, hit “CALC.” Cumulative F-GDD will be shown in tabular form with plant milestones.

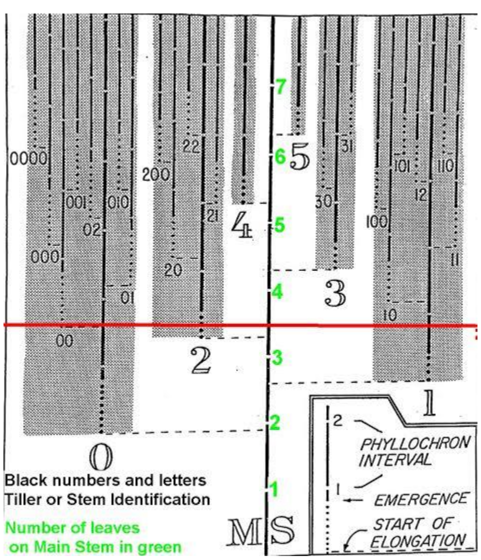
Seedling Development

Naming system. We name leaves in the order of their appearance. The first green leaf is called L1 for Leaf One, the second is L2, and the third is L3. These leaves are placed on the plant stem at points called “nodes”. You are familiar with nodes because you are used to feeling the joints of the stem in the spring as the stem elongates and pushes the head up into view. These “joints” are nodes and the elongated stems between the joints are internodes.

Wheat leaves develop in succession on opposite sides of the stem. If you hold a wheat plant in your hand with leaf one (LI) to your right, then leaf two (L2) and all of the other even numbered leaves will be on your left hand side. Leaf three (L3) and all of the other odd-numbered leaves will be on your right hand side. These are the first leaves on the main stem of the plant.



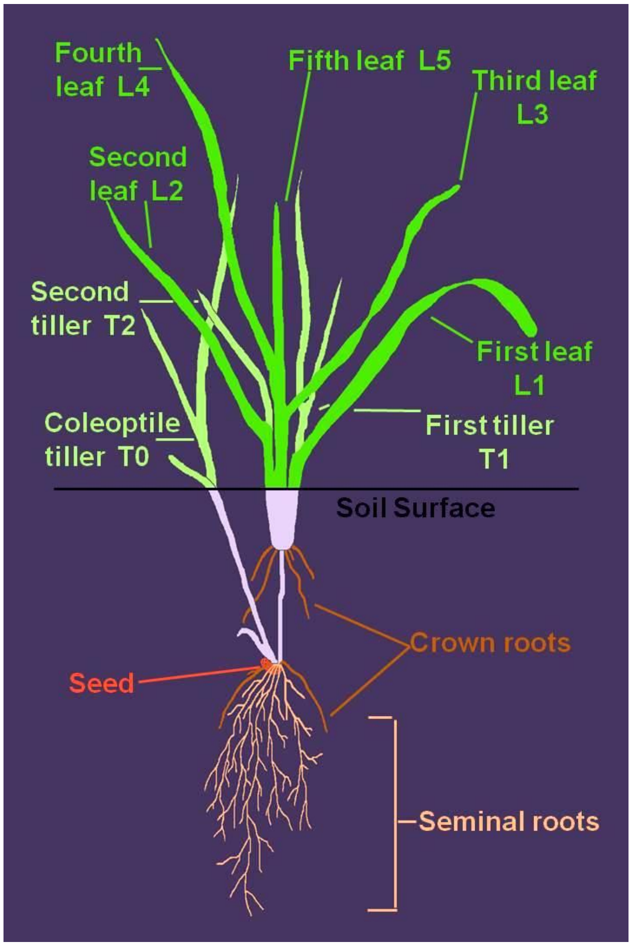
Most cereals develop tillers. For example, a tiller might develop from a bud on the node at the base of each of the first three or four main stem leaves, that is, from L1, L2, L3, and L4. These tillers are named after the leaf that they are associated with: T1, T2, T3, and T4. This drawing of a wheat seedling shows a plant with L1, L2, and L3 fully extended and L4 about half way out when you compare it to L 3. We would say that this plant has 3.5 leaves on the main stem. It also has a tiller (little branch) coming out of the first leaf. This would be called T1; it is associated with L1. This is the pattern in wheat. The newest tiller develops on the node three below the newest leaf. The coleoptile is a modified leaf, called L0, and can develop a tiller called T0 in very good seedbeds. Incidentally, there are definite roots associated with each node on the plant too and they have a special time to appear in normal development.



This graph shows you the normal leaf and tiller developmental pattern in a wheat plant. Each leaf and tiller has a time when it develops. The central vertical line shows you the timing of development of the first seven leaves on the main stem. The side branches give you the time to expect to begin to see the tillers on the main stem. For example, when Leaf 4 is half way out (seen on the red line as 3.5), the tiller from the first node, T1, is on its way out too.

Heat Driven Plant Development.

You can predict leaf appearance using F-GDD. We know that it takes about 144 F-GDD for a seed to germinate and that it takes about 180 F-GDD for a plant to emerge from a planting depth of 2 inches (90 F-GDD per inch). Therefore, it takes a total of 324 F-GDD just to get the first leaf of the plant out of the ground. If you have planted a wheat crop in moist soil and find that more than 324 growing degree days have-accumulated since planting, yet no plants have emerged, you should examine the field and the planted seed. There may be problems that will require reseeding.



We know that it takes about 180 F-GDD for each leaf to extend. We call this value of 180 F-GDD one phyllochron. It is the amount of "plant time" that it takes to produce one leaf. If you pick up a plant with 4.5 leaves on the main stem, you know it has been about 180 x 4.5=810 F-GDDs since that plant emerged. It has been 4.5 phyllochrons since the crop emerged. The 180 F-GDDs per leaf is an average number. Values can range from about 150 to 200 depending on planting date and variety; however, for most development predictions, 180 F-GDDs per leaf works well.

Tiller development is also heat driven, but tillers do not appear until well after their parent leaf has extended. In fact, a tiller is not produced at a node until the third leaf above it appears. For example, the tiller forming from node one (Tl), associated with leaf one (LI), appears as the fourth leaf elongates. Tiller 2 develops with the appearance of leaf five.
This drawing of a plant shows well-developed seminal roots, early crown roots, and a clear internode between the seed and the crown. It has a T0 which means it was planted into excellent moisture in a good seedbed. It has 4.5 main stem leaves and two tillers. Tiller 1 has 1.5 leaves on it and T2 is about half way through production of its first leaf.

Practical Use of this Information

Why this topic for a Wheat Academy workshop? The wheat plant produces your annual income. You make management decisions to improve the growing conditions faced by your crops. When those decisions are based on a knowledge of what weather and your management practices do to the wheat plant, they will more likely benefit plant development, growth, production and ultimately your income. Your ability to provide a repeatable set of numbers to measure crop development will enrich your ability to judge how well a crop was planted, how well it is developing, and whether it is developing at its maximum expected rate.

Seed beds may or may not be uniform. A repeatable set of numbers based on observations of plants from the field provides an accurate measure for comparing seed beds. Year to year differences may occur in crop development because of tillage changes. Within field effects of different drills or drill modifications can be compared using numbers from the crops themselves.

Weed sprays, fungicides, fertilizers, and irrigation all have impacts on the wheat plant. How much impact? Again, repeatable numbers from observations of development taken from plants that have experienced the treatment in question provide a method to measure any impacts. Numbers of leaves present on the plant, numbers of plants bearing specific tillers, and numbers of those tillers that produce heads, each measures the impact of weather or management events. These numeric measures allow reliable comparison between seasons, between fields, or between management practices.

These plant observations allow the plants themselves to tell what they have been able to do with the soil, weather, and management system they find themselves in. Based on the messages they provide your practices are evaluated. Satisfactory production or unsatisfactory production will have a history of observations that can be used to help plan, plant, and grow future crops.