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EARLY GROWTH AND DEVELOPMENT OF CEREALS

A companion to the videotape, Early Growth and Development of Cereals, *produced by Oregon State University.*

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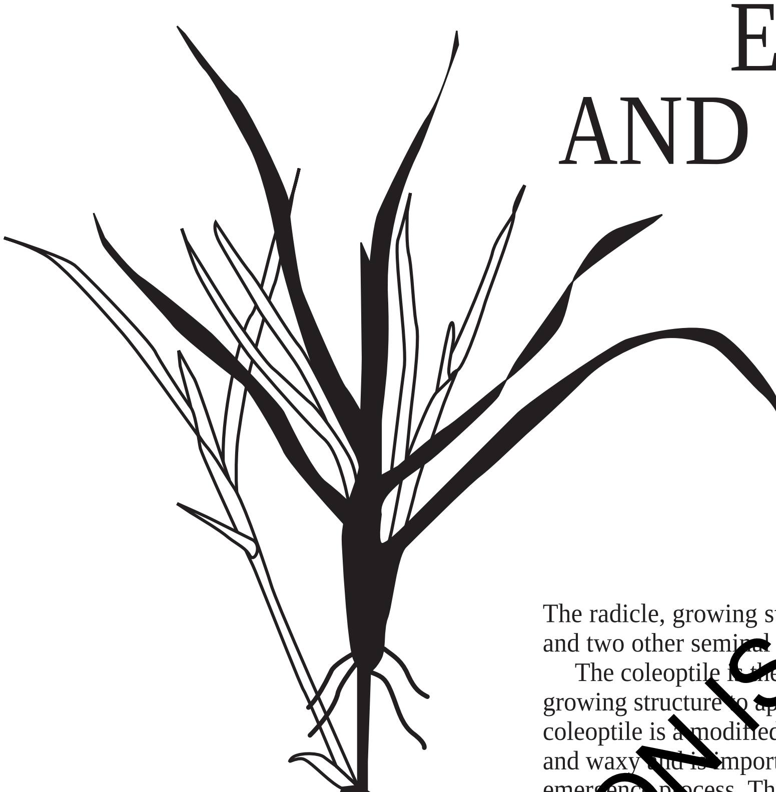

Early development in cereal plants follows a regular pattern. Heat, measured as growing degree days (GDD), is the driving force behind development. If you know how many GDDs have accumulated since you planted your crop and have knowledge of the development pattern, then you can predict development and compare your predictions against field observations. Differences between predicted and observed development are due to stress and can be used as a tool to evaluate the quality of growing conditions in a field.

Initial Growth

Cereals grow from seed. As long as the seed is kept dry, nothing happens. But once exposed to both moisture and heat, the small plant inside the seed begins to grow. The first evidence of growth is a swelling of the seed as moisture is taken up, followed by emergence of a root called the radicle. Other seminal roots then develop. Figure 1 is a picture of a developing wheat seed. The radicle, growing straight downward, and two other seminal roots are evident.

The coleoptile is the first upward growing structure to appear. The coleoptile is a modified leaf. It is tough and waxy and is important in the emergence process. The coleoptile protects the first true leaves as the shoot pushes upward through the soil; however, the coleoptile can grow to a length of only 3 to 4 inches. If you plant deeper, the first true leaf will emerge below the soil surface and be torn to shreds as it continues to grow.

Once the coleoptile has emerged from the soil, the first true leaf will emerge from it, and other leaves then will emerge in a definite pattern.

Naming System

We have developed a naming system for the leaves of cereal plants. This system is shown in Figure 2. Leaves are named according to their order of appearance. For example, the first true leaf is called leaf one or L1, the second true leaf L2, the third L3, and so on. Leaves grow from and are attached to the stem at structures called nodes.

Leaves develop in succession on opposite sides of the stem. If you hold a wheat plant in your hand with leaf one (L1) to your right, 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 first leaves are on the main stem of the plant. Most cereals also develop secondary stems or branches. These secondary stems are called tillers. In a healthy plant, one tiller will develop from a growing point or bud at the base of each of the first three or four main stem leaves. Secondary tillers can develop on these primary tillers. Tillers increase the number of heads per acre in a mature crop and thereby increase yield potential.

Tillers are named after the leaf from which they develop (Figure 2). A tiller developing from the bud associated with leaf one (L1) is called tiller one or T1. T3 would develop from the base of main stem leaf three.

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As you'll recall, the coleoptile is a modified leaf. It too can have a tiller associated with it. This tiller is called the T0 tiller. The presence or absence of the T0 tiller indicates how favorable seedbed conditions were at planting. In a good seedbed (where moisture and nutrients are not limiting), a high percentage of plants will have a T0 tiller.

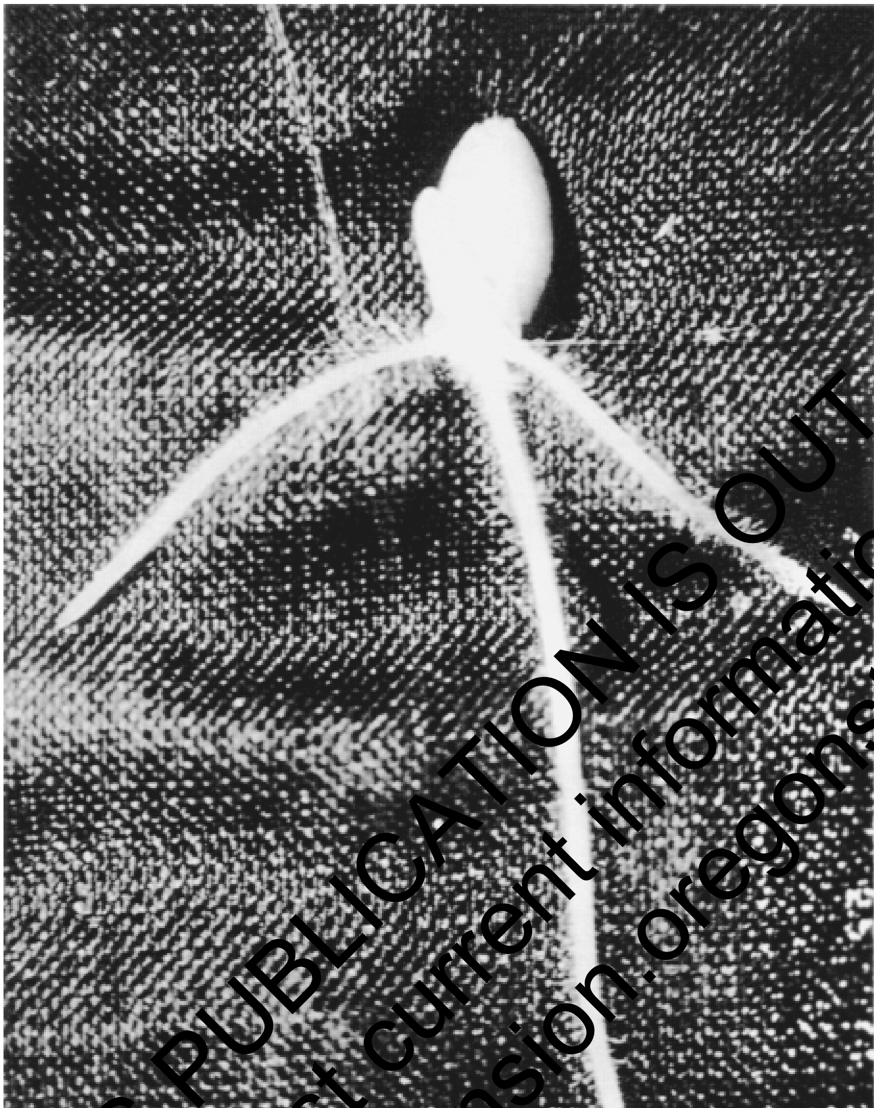

Figure 1.—*A wheat seedling early in the emergence process. The radicle and a pair of seminal roots have elongated and the coleoptile is beginning to emerge.*

Table 1.—*Sample growing degree day (GDD) calculation.*

Day	Max F Temp	Min F Temp	Avg Temp (ºF)	Avg Temp. (ºC) = Daily GDD	Cumulative GDD
1	72	48	60	16	16
2	78	45	62	17	33
3	69	43	56	13	46
4	73	45	59	15	61
5	75	46	60	16	77
6	74	49	62	17	94

GDD = (Max T + Min T)/2. Centigrade degree days are used for prediction purposes. As wheat will grow at 0 ºC, any average temperature above freezing counts toward the degree day accumulation.

Root Systems

Cereal root systems also develop in a predictable and coordinated pattern along with leaves and tillers. Two distinct systems are present. Figure 2 shows the two root systems, seminal and nodal roots.

Seminal (seed-borne) roots develop directly from root growing points present in the seed. As noted earlier, they are among the first plant structures to develop. The nodal root system develops as the plant matures. It grows from buds at nodes in a part of the plant called the crown. You will see these roots also referred to as crown or adventitious roots. The crown is the area of the plant above the coleoptile where the main stem and tillers appear to originate.

Effects of Stress

- Every leaf on a cereal plant (even those on tillers) has a tiller bud at its base. These buds can be observed with a hand lens or microscope. When a plant grows with adequate moisture, nutrients, and heat, tiller buds develop into tillers. If, on the other hand, a plant is grown under stress, tiller buds may remain dormant, or tillers may abort once they start to develop. The presence or absence of tillers is an indication of whether or not a plant developed under stressed conditions.

Leaves also are affected by stress. Leaves become smaller with mild stress. Stems will abort, and leaves will cease to appear with extreme stress.

Heat Driven Development

One of the most interesting things we've discovered about early cereal growth is that you can predict development if you know to what temperatures a plant has been exposed. Time and heat drive a predictable pattern of development.

Growing degree days (GDD) are the unit used to measure heat accumulation over time. Table 1 shows a sample calculation of growing degree days. In a field situation, the high and low air temperature for a day are averaged. This average value, if in Fahrenheit, is converted to centigrade. Any average temperature below freezing is given a growing degree day value of 0. This centigrade daily mean temperature is the number of growing degree days accumulated for that day. To find the number of degree days that have passed since planting, the average temperatures for each day after a crop was seeded are added together. Figure 3 shows a typical accumulation of degree days for the first part of a winter wheat growing season in Pendleton, OR.

We know that it takes about 80 degree days for a seed to germinate and that it takes about 100 degree days for a plant to emerge from a planting depth of 2 inches (50 GDD per inch). Therefore, it takes a total of 180 degree days 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 250 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 100 degree days for each leaf to extend. If you pick up a plant with 5½ leaves on the main stem, you know it has been about 550 degree days since that plant emerged. 100 GDDs per leaf is an average number. Values can range from about 75 to 120 depending on planting date; however, for most development predictions, 100 GDDs per leaf works well.

Table 2.—*The relation between growing degree days and wheat plant development.*

Growing Degree Days (centigrade; 0 base) From Planting	From Emergence	Plant Growth Stage	No. of Main Stem Leaves Present	Tillers Present
0	—			
80	—	Germination Complete		
180	0	Emergence Complete		
280	100	First leaf fully developed	1	
380	200		2	
480	300		3	T0
580	400		4	T0, T1
680	500		5	T0, T1, T2
780	600	Sixth leaf fully developed	6	T0, T1, T2, T3

The table assumes that the seeds were placed 2 inches deep and that it takes 100 GDD for each leaf to grow out.

Tiller development is also leaf 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 (T1), the origin of leaf one (L1), appears as the fourth leaf elongates. Tiller 2 develops with the appearance of leaf five. Figure 4 shows in schematic form the development pattern for a typical wheat plant. The middle vertical line shows the number of leaves on the main stem (MS). The other vertical lines represent tillers. For example, 0 represents T0, the coleoptile tiller; 1 represents T1, the tiller developing from the first leaf node. By placing a straight edge horizontally across the figure, it is possible to determine how many tillers a plant should have when the main stem has a given number of leaves.

Table 2 can be used for the same purpose. If you know how many degree days have passed since planting or emergence, you can use the table to determine approximate plant growth stage, leaf number, and tiller number.

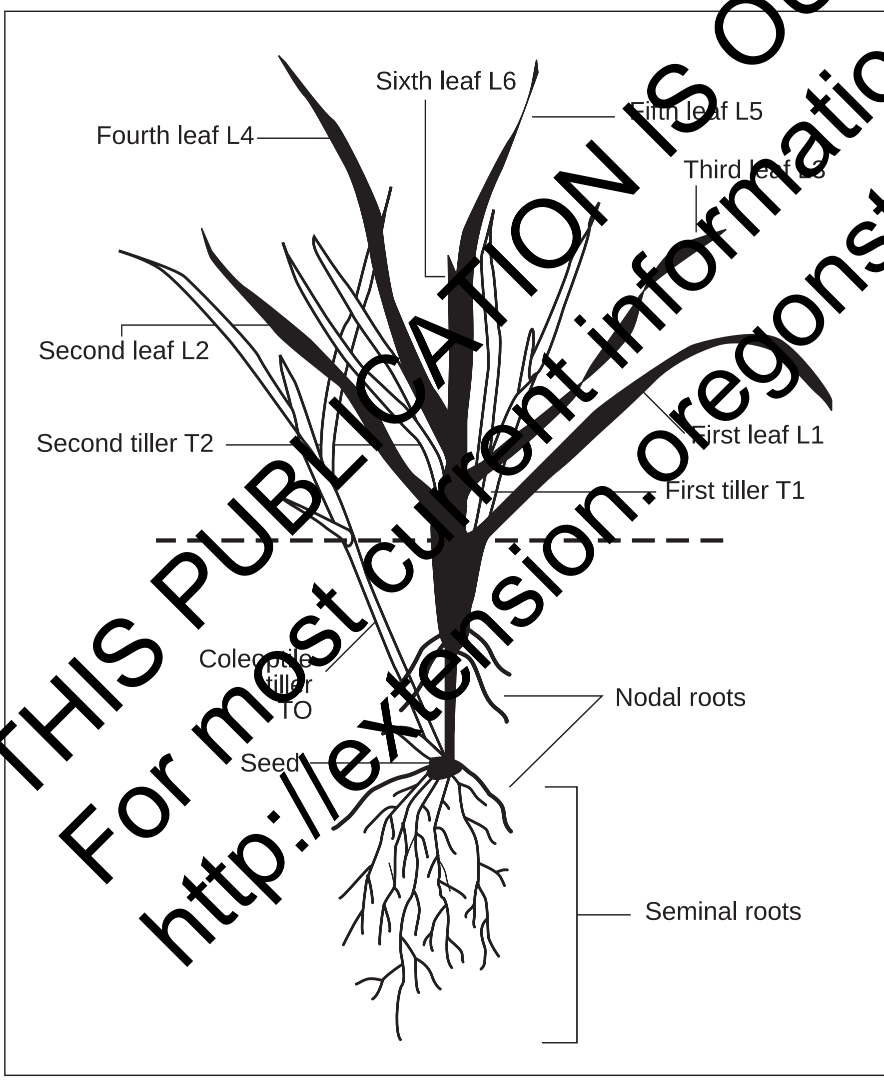

Figure 2.—*Drawing of a young wheat plant showing identified leaves, tillers, and roots. The coleoptilar node produces a tiller and nodal roots under good seedbed conditions.*

Field Use

Armed with information about accumulated degree days and knowledge of plant development patterns, you should be able to walk into any early growth cereal field and "read" the plants. Your reading will tell a great deal about what has happened and what is happening to the plants in that field. This information can be a powerful management tool. For example, if you know that 700 GDD have accumulated since you planted a wheat crop, assuming that 80 GDD are needed for germination and 100 for emergence (50 GDD per inch of depth), then the crop has had 520 GDD available for leaf development. If conditions in the field have not limited growth, five leaves should be present on the main stem (100 GDD per leaf) and the T0, T1, and T2 tillers should be present (using Figure 4). If one or several of these structures are missing, you know that some stress has occurred, and you can try to determine the cause. If possible, eliminating this stress in future years may lead to higher plant productivity.

Other Resources

If you would like more information on this naming system and on the temperature driven model of cereal growth, purchase the computer program, PLANTEMP. This program, written for IBM and IBM-compatible personal computers, helps you estimate plant growth stages and ground cover percentages by entering weather data and production information such as the planting date, seeding rate, and seeding depth. The program allows input of "real-time" weather data and the use of historical records for predictions.

To order PLANTEMP (EM 8308), send $25.00 per copy to:

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For more information

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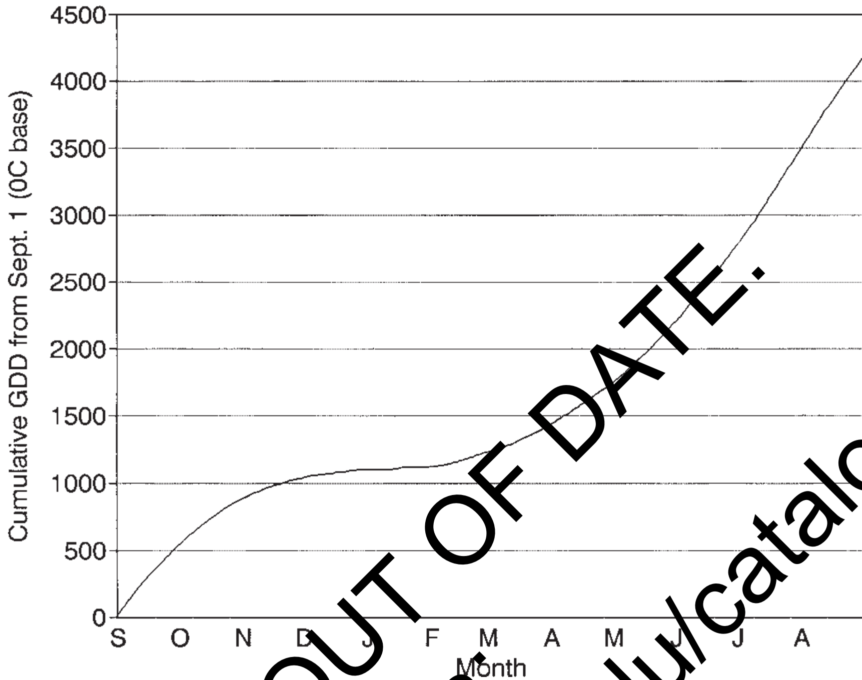

Figure 3. —*Cumulative growing degree days (base 0° centigrade) for Pendleton, OR.*

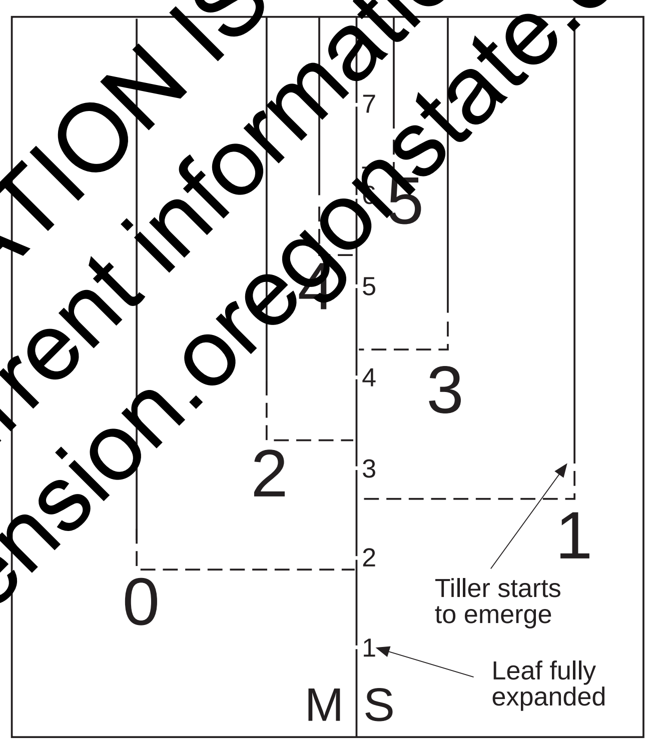

Figure 4. —*Relationships of leaf and tiller production in winter wheat based on data for 'Stephens' wheat.*

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