Crop Growth and Development

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CROP 200 Crop Ecology and Morphology
Growth and Development

- **Growth** – the quantitative, irreversible increases in weight or size of plant cells, organs, or the entire plant.

- **Development** – the qualitative changes in function or number of cells, tissues, organs, or the entire plant. Also known as differentiation or morphogenesis.

- **Phenology** is the study of crop development in relation to the environment.

Canola (TG Chastain photo)
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- Leaf development and the passage of time are related in crop plants. Leaves are the principle photosynthetic organs of crop plants and function as a biological solar energy collector.

- **Plastochron** is the time interval between two repetitive events in plant development. Most often is used to denote the interval between initiation of successive leaf primordia on the stem apex.

- **Phyllochron** is the interval between appearance of successive leaves on a stem.
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- **Growing degree days (GDD)** – a tool for tracking crop growth and development.

\[
GDD = \sum \left( \frac{(T_{\text{max}} + T_{\text{min}})}{2} - T_{\text{base}} \right)
\]

Where:
- \( T_{\text{max}} \) = Maximum Daily Temperature
- \( T_{\text{min}} \) = Minimum Daily Temperature
- \( T_{\text{base}} \) = Base Temperature for Developmental Process

Temperature effects on leaf appearance rate; an important factor in plastochron and phyllochron
## Growth and Development

Base temperature and phyllochron for selected crops

<table>
<thead>
<tr>
<th>Species</th>
<th>$T_{\text{base}} , ^\circ \text{C}$</th>
<th>Phyllochron (GDD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>Sorghum</td>
<td>8</td>
<td>48</td>
</tr>
<tr>
<td>Wheat</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>Barley</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>Cotton</td>
<td>12</td>
<td>41</td>
</tr>
<tr>
<td>Soybean</td>
<td>7</td>
<td>54</td>
</tr>
<tr>
<td>Peas</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Pigweed</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Sorghum crop (TG Chastain photo)
A new leaf is produced on each tiller in a perennial ryegrass seed field every 118 growing degree days (base temperature = 0°C).

For a month with average (°F): 54 high, 37 low; 2.2 new leaves are produced; 80 high, 55 low; 6.1 new leaves are produced.

The rate of leaf appearance varies with temperature and with species (ranges from Chewings fescue at 97 GDD to tall fescue at 135 GDD). Data source TG Chastain.
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Developmental stages of grass seed crops in relation to GDD from September 1st in Oregon.

- Fall Leaf Tiller Growth
- Winter Quiescence
- Stem Elongation
- Flowering
- Harvest

TG Chastain, Oregon State University
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- The number of GDDs that accumulate over a growing season vary with regional climates and elevation.
- These differences affect the rate of crop development and the maturation of the crop.
• Cell division and cell wall expansion are factors in leaf development. Expansins are proteins that regulate the loosening of the cell wall, allowing growth of cells within the leaf.

• The cell division component of leaf elongation takes place in a zone at the base of the leaf. In grasses, this zone is enclosed within the leaf sheath. The leaf elongation zone is a sink for carbohydrates and nutrients.
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Physiological processes during development of a grass leaf

- Cell division
- Cell expansion
- CHO deposition
- CHO utilization
- Secondary cell wall
- Photosynthetic enzyme deposition
- N deposition
- Chloroplast replication
- Collar appearance
- Elongating leaf lamina and sheath

Distance (mm)
Root and leaf development are coordinated. In wheat, for every two leaves produced, four roots are produced.

Betty Klepper, USDA Crop Physiologist
• Exploration of the soil by pea roots is coordinated with above-ground development.

Pea field (TG Chastain photo)

Pea root elongation rate = 0.12 cm per degree day.

(Klepper, 1985)
Morphological responses of crops to shading:

- Reduced branching
- Etiolation of stems
- Reduction in root density
- Reduced number of stomata

Grass plant (TG Chastain photo)

Red fescue tiller etiolation in response to shading (Chastain and Grabe, 1988)
• Leaves absorb blue (≈ 400 nm), red (R) light and transmit more FR (730 nm) and less R light (660 nm). In a canopy, the R to FR light ratio is reduced while in the open, the ratio of R:FR is 1:1.

• Exposure to FR light results in elongation of internodes, permitting a plant to grow out of the shade under a canopy and into the light.
Flowering is the most important event in the production of a grain or seed crop, after establishment of the stand.

Five phases of reproductive development in plants:

1. Juvenility
2. Induction
3. Initiation
4. Flower and Inflorescence Development
5. Seed Development

Vegetative sunflower plant (top), reproductive sunflower plant (right) TG Chastain photos.
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• A **juvenile** plant is unable to flower because it is immature, small, not enough leaves or other organs, or unknown reasons. Species with a juvenile phase are not receptive to stimuli that promote flowering until they have further developed.

• Some plants such as winter wheat, winter barley, and perennial ryegrass are never juvenile – simply exposing seeds of these species to low temperatures will promote flowering.

Young canola plant (TG Chastain photo)
The crop’s biological requirements for flowering must be completely satisfied for the full expression of flowering. This process is known as floral induction.

- **Photoperiodic induction** - promotion of flowering by exposure to a critical photoperiod. Photoperiodic time measurement is set by a circadian rhythm.
- **Thermal induction** - promotion or acceleration of flowering by exposure to a critical temperature.
Types of photoperiodic induction:

- **Long-day plant (LDP)** – require short night length for flowering. Pea, winter barley, winter wheat, canola, perennial ryegrass, sugar beet, alfalfa, and red clover.

- **Short-day plant (SDP)** – require long night period for flowering. Winter rice, and some cultivars of corn.

- **Day-neutral plant (DNP)** – flowering not influenced by photoperiod. Soybean, cabbage, and some cultivars of corn.
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- **Vernalization** is the induction of flowering by exposure to low temperature.
- Exposure to long days is required for further development of the flower for many species.
- In Kentucky bluegrass, tillers must be exposed (6-12 weeks) to low temperatures (37˚F to 53˚F) accompanied by short days for flowering to be induced.

No flowering without vernalization

Flowering after vernalized at 6˚C for 12 weeks in 8 hour days

Vernalization effects on flowering in vernalization-requiring clone of perennial ryegrass: plant will not flower without vernalization (TG Chastain photos)
Initiation of the inflorescence is indicated by a visible change in the shoot apical meristem (SAM) from the vegetative to the reproductive condition.

The double ridge stage marks the beginning of visible floral development in grasses.

Before this stage the stem apex produces only leaves, but afterwards flower parts are produced which are modified leaves.

Vegetative SAM in left photo (A = apical meristem and L = leaf primordium). Right photo depicts reproductive SAM (DR = Double ridge). The upper ridge is the spikelet ridge and the lower is the leaf ridge.