



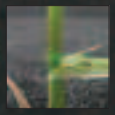

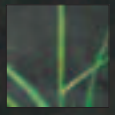

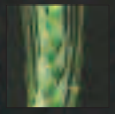

Bayer CropScience

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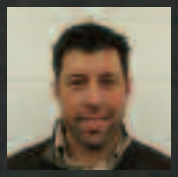
6250-0108

A FIELD GUIDE TO

CEREAL STAGING

Presented by the
Ontario Ministry of
Agriculture, Food and Rural Affairs
University of Guelph
and Bayer CropScience

Contributors



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The Importance of Cereal Staging

Profitable small grain production requires a thorough knowledge of crop development. When required, proper application timing of inputs such as fertilizer, plant growth regulators, herbicides and fungicides is critical to maximizing product performance, yield and profitability. Being able to properly identify the various stages of crop development can help growers know when inputs should be applied.

That's why Bayer CropScience, the Ontario Ministry of Agriculture, Food and Rural Affairs and the University of Guelph cooperated to produce this easy-to-use staging guide with high quality photographic images.

While several development scales are available, this guide will use the Zadoks[1] scale. This scale follows plant development through 10 primary developmental stages (first digit), sub-divided into secondary growth stages (second digit) to produce a two-digit scale number. The primary stages are defined in the following table.

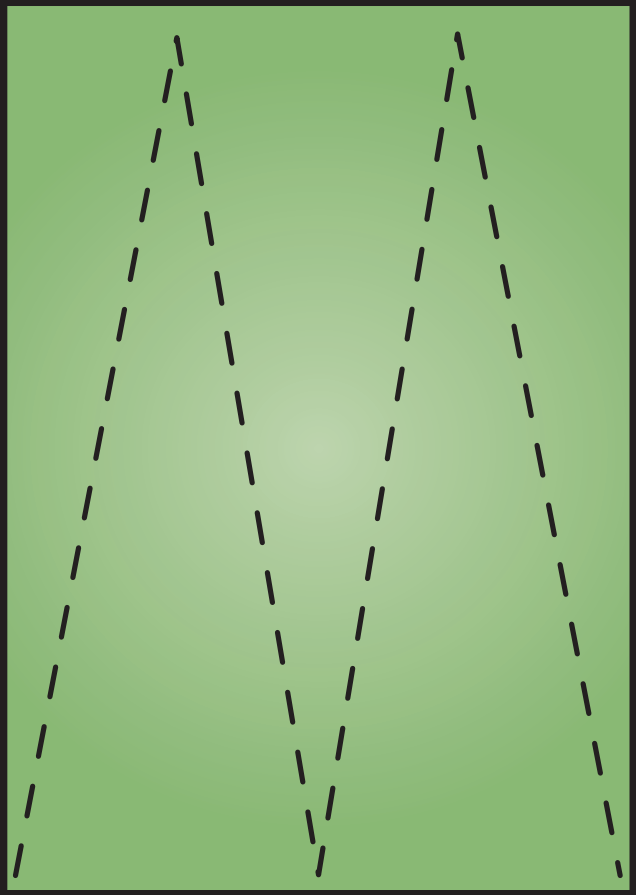
Code	Description
0	Germination
1	Seedling growth
2	Tillering
3	Stem Elongation
4	Booting
5	Inflorescence emergence
6	Anthesis
7	Milk development
8	Dough development
9	Ripening

1. Zadoks, J.C., Chang, T.T. & Konzak, C.F. (1974) A decimal code for the growth stages of cereals. Weed Research 14, 415-21.

Identifying Growth Stages

How to select plants in a field

To get a good sample of plants in a field, select a single plant from 10 locations in each field. Select the locations using an "M" or zig-zag pattern.



To randomly select plants, drop to one knee and place your index finger on the ground. Dig up the entire plant nearest your finger.

Field Staging Form

Identify the development stage of at least 10 plants per field and record them on a staging form similar to the one below. The development stage is the average of these plants. If you care to download and print forms like this one, go to www.cerealcentral.ca.

Crop			**Field #**					**Date**		
Plant number	1	2	3	4	5	6	7	8	9	10	Ave
# of main stem leaves											
# of tillers											
# of main stem nodes											
Flag leaf (Yes/No)											
Boot stage (Yes/No)											
Headed (Yes/No)											
Flowered (Yes/No)											
Grain development stage (water, milk, doughy, hard, ripe)											

How to Handle Plants

Whole plant

1. Roots
2. Crown
3. Secondary tiller
4. 2nd primary tiller
5. 1st primary tiller
6. 3rd primary tiller
7. Main stem

1. Locate the first leaf

The first leaf:

- Is the lowest leaf and generally has a blunt, or rounded tip.
- In older plants, the first leaf may be dead or missing. Look for leaf and sheath remnants at the crown.
- Sheath encloses all later leaves.
- Arises on the opposite side of the plant as the coleoptilar tiller (if present) and the remnants of the coleoptile.

2. Position the plant

- Hold plant so that the first leaf points to your left and carefully fan-out the leaves and tillers.

3. Locate the main shoot or stem.

- The main shoot or stem is usually the tallest and has the most leaves.

How to Stage Plants

1. Count the leaves on the main shoot or stem

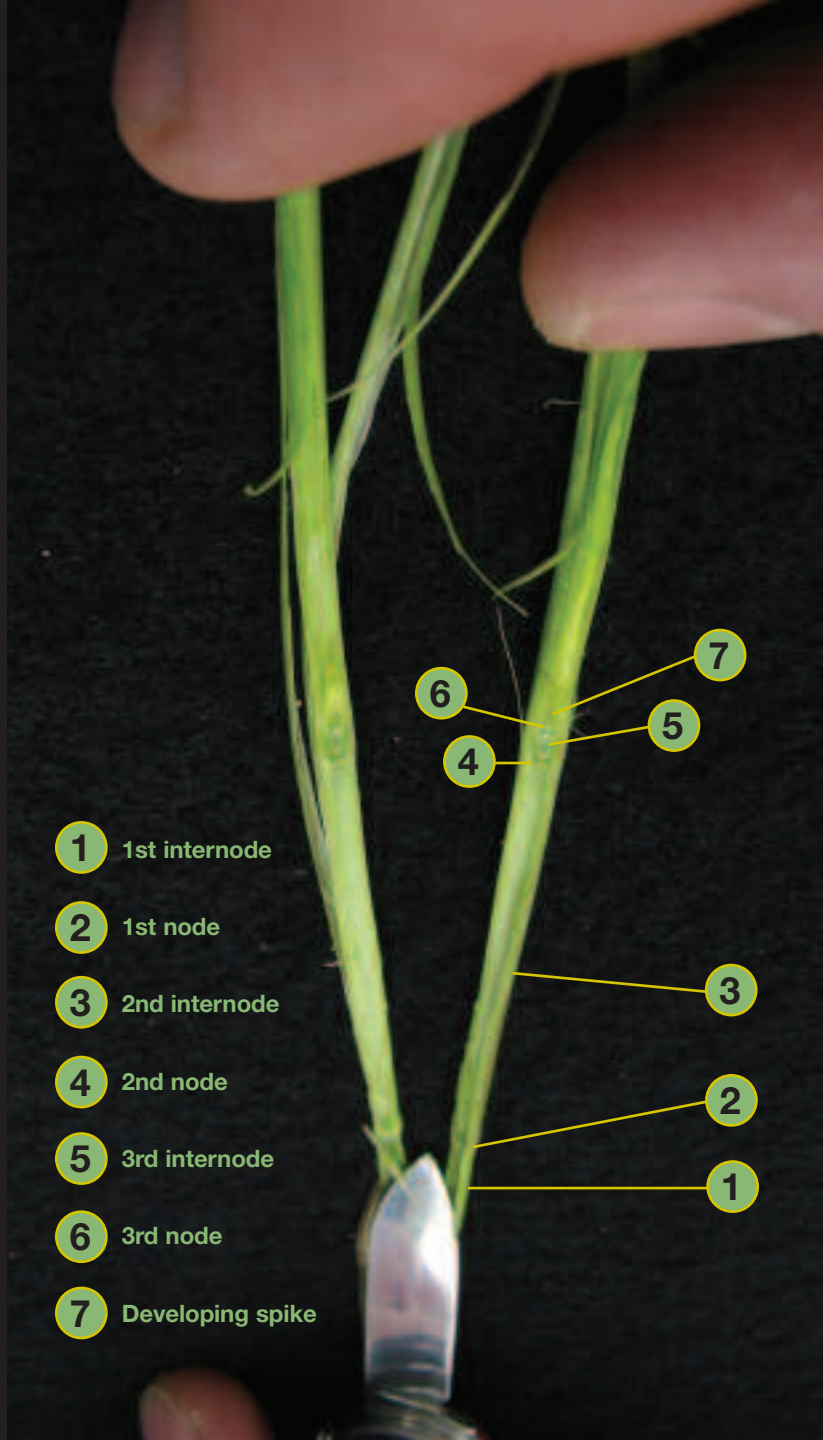
- Leaves arise on opposite sides of the main shoot or stem.
- Count the youngest leaf when it is at least one-half the length of the leaf below it.
- When positioned correctly, all leaves on the left side of the main stem are designated with an odd number and on the right side with an even number. The coleoptilar tiller (if present) and the remnants of the coleoptile are also located on the right side of the plant.
- Dead or missing leaves must be counted. Look for leaf and sheath remnants at the crown.

2. Count the tillers

- Each tiller has its own sheath called a prophyll. Each tiller belongs to the main shoot or to other tillers.
- For Zadoks stage determination, only count primary tillers.
- Secondary and tertiary tillers also may be formed, so more than one tiller may emerge from each leaf axil of the main shoot.
- Tillers that emerge after the fifth leaf has emerged are not likely to produce heads and need not be counted.

3. Count the nodes

- Nodes can easily be seen or felt on the stem above ground level.
- If no nodes are detected above ground, split the main shoot lengthwise to determine if stem elongation has begun.
- The elongating internode is hollow between the crown and the elevated growing point. In solid stem varieties, the internode is not hollow but nodes are still easily identified.



4. Has the flag leaf emerged?

- The flag leaf emerges after at least three nodes are present above the soil surface.
- To confirm flag leaf emergence, split the leaf sheath above the highest node. If the developing head is present and no additional leaves are contained inside, then the last leaf emerged was the flag leaf.
- An alternative method is to crush the stem between your fingers above the second node. If the stem crushes easily above the second node and a third node is felt, then the flag leaf is emerging or has emerged.

5. Has boot stage begun?

- Boot stage begins following emergence of the flag leaf collar and continues until heading. The head will be clearly visible inside the sheath of the flag leaf if it is opened up.

6. Has head emergence and flowering occurred?

- Heading begins when the first awns or the tip of the head become visible above the flag leaf collar.
- Examine florets to determine if flowering has occurred. Most barley varieties flower prior to head emergence while most wheat varieties flower following head emergence.

7. Determine grain development stage.

- Grain development begins as soon as the flower has pollinated. Stages include watery ripe, milk, soft dough, hard dough, kernel hard and harvest ripe.

Zadoks scale in detail

Zadoks scale in detail

Germination

00 Dry seed
01 Water uptake (imbibition) started
03 Imbibition complete
05 Radicle emerged from seed
07 Coleoptile emerged from seed
09 Leaf just at coleoptile tip

Seedling growth

10 First leaf emerged
11 First leaf unfolded
12 2 leaves unfolded
13 3 leaves unfolded
14 4 leaves unfolded
15 5 leaves unfolded
16 6 leaves unfolded
17 7 leaves unfolded
18 8 leaves unfolded
19 9 or more leaves unfolded

Tillering

20 Main shoot only
21 Main shoot and 1 tiller
22 Main shoot and 2 tillers
23 Main shoot and 3 tillers
24 Main shoot and 4 tillers
25 Main shoot and 5 tillers
26 Main shoot and 6 tillers
27 Main shoot and 7 tillers
28 Main shoot and 8 tillers
29 Main shoot and 9 or more tillers

Stem elongation

30 Pseudo stem erection
31 1st node detectable
32 2nd node detectable
33 3rd node detectable
34 4th node detectable
35 5th node detectable
36 6th node detectable
37 Flag leaf just visible
39 Flag leaf ligule/collar just visible

Booting

40 - - - - - - -
41 Flag leaf sheath extending
45 Boot just swollen
47 Flag leaf sheath opening
49 First awns visible

Heading (Inflorescence emergence)

50 First spikelet of head visible
53 1/4 of head emerged
55 1/2 of head emerged
57 3/4 of head emerged
59 Emergence of head complete

Pollination (Anthesis)

60 Beginning of pollination
65 Pollination half complete
69 Pollination complete

Milk Development

70 - - - - - - -
71 Kernel watery
73 Early milk
75 Medium milk
77 Late milk

Dough Development

80 - - - - - - -
83 Early dough
85 Soft dough
87 Hard dough

Ripening

90 - - - - - - -
91 Kernel hard (difficult to separate by fingernail)
92 Kernel hard
93 Kernel loosening in daytime
94 Overripe, straw dead and collapsing
95 Seed dormant
96 50% of viable seed germinates
97 Seed not dormant
98 Secondary dormancy
99 Secondary dormancy lost

Zadoks Staging Key

Stage 0: Germination

- Secondary stages (i.e. imbibition, radical emergence) are susceptible to herbicide residues, soil borne diseases and insect feeding.

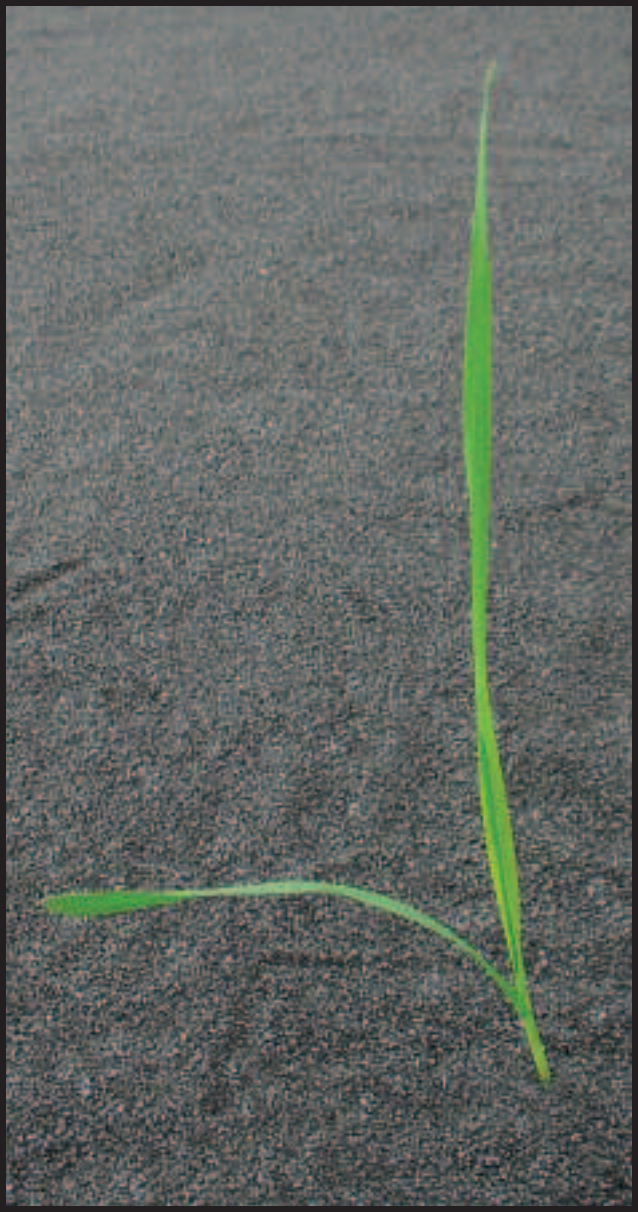
Z 09 Leaf just at coleoptile tip

Stage 1: Main stem leaf production

- A new leaf is counted as fully emerged when 50% of the leaf blade has unfolded.
- Leaves are counted on the main stem of the plant.
- Earliest stage by which many herbicides can be applied.
- Early disease scouting should be done at this stage.
- Stage at which you may see effects from underground feeding of grubs.
- Monitor for cereal aphids during this stage.
- For spring cereals, fertilizer should be applied by stage 14.

Z 10 First leaf through coleoptile

Z 11 First leaf unfolded



Z 12 2 leaves unfolded

Z 13 3 leaves unfolded

Z 14 4 leaves unfolded (also Z20)

Stage 2: Tillering

- Important classification stage for fertilizer, herbicide and insecticide applications.
- An important time to evaluate disease pressures and estimate the necessity for fungicides either alone or in combination with a herbicide application.
- Stage at which you may see effects from underground feeding of grubs.
- Monitor for cereal aphids during this stage.

Z 21 Main shoot and one tiller

Z 21 Main shoot and one tiller (close up)

Z 22 Main shoot and two tillers

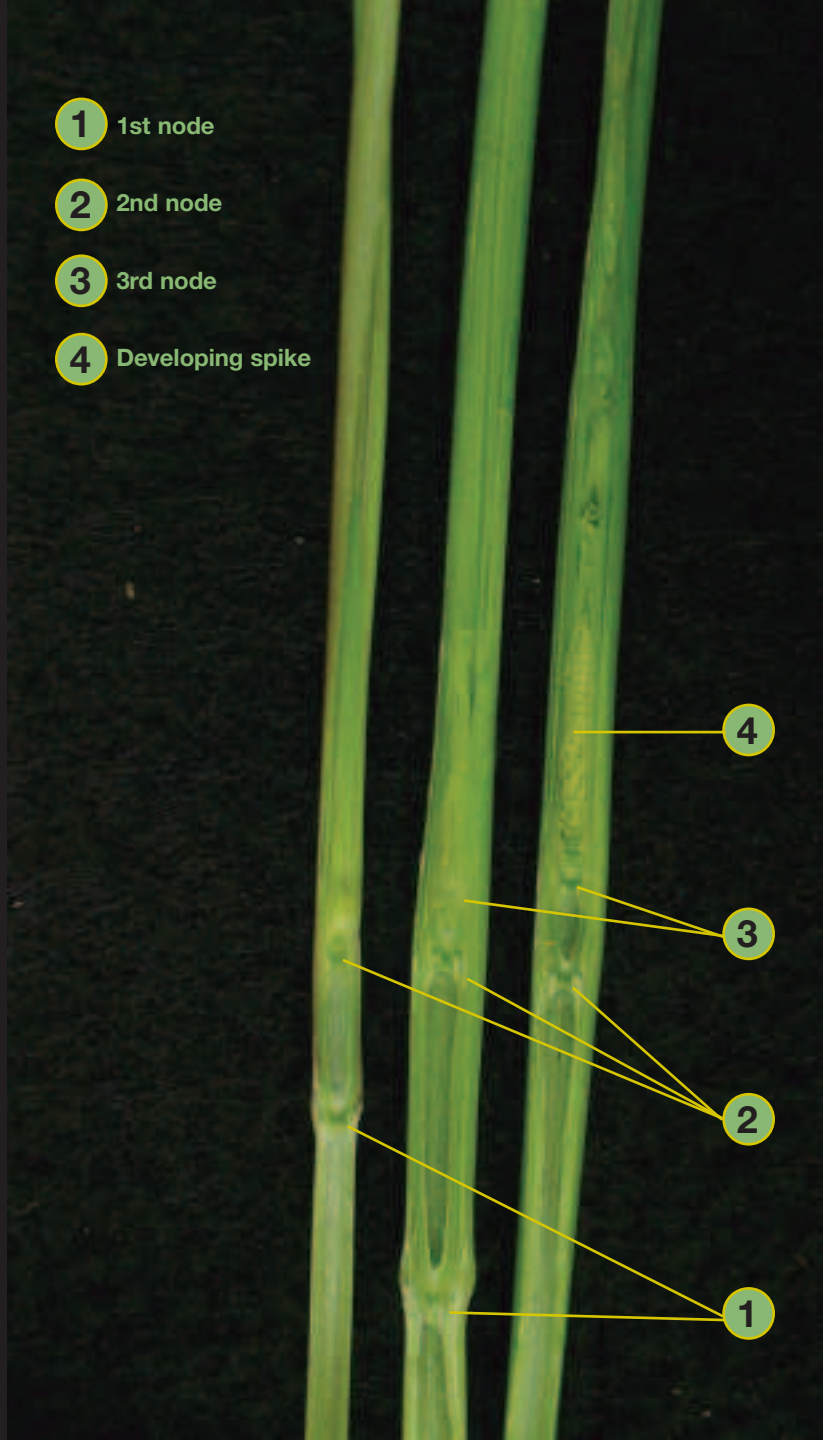
Z 22 Main shoot and two tillers (close up)

Z 24 Main shoot and four tillers (also Z30)

Z 24 Main shoot and four tillers (close up) (also Z30)

Stage 3: Stem Elongation

- For winter cereals, stage 30 represents the shift of the plant from vegetative (prostrate growth habit) to reproductive growth (erect growth habit).
- By stage 30, all meaningful tillering has usually been completed. Later tillers are not likely to produce fertile heads.
- Stages 31 and 32 are called the jointing stage, which is the point where the head has been initiated at the crown and the stem begins to elongate.
- Stage 30 is preferable for nitrogen application over stage 31 since nitrogen fertilizer applications at stage 30 influence the number and size of seeds on the head (yield). However, fertilizer applied at this stage has no effect on the number of heads per plant.
- The main stem and tillers synchronize at Stages 30 and 31 so that the difference in their appearance is reduced to only a few days in terms of heading date.
- Nodes can be determined by feeling along the main stem or the main stem can be sliced open with a knife or razor blade to determine the number of nodes and the position of the head.
- Mechanical damage can seriously harm the plant at this stage as the head is now fully differentiated and the stem is elongating.
- Nitrogen applied at Stage 37 can boost protein levels of kernels.
- Foliar fungicides applied to protect the flag leaf are best applied between Stages 37 and 39.



Dissection of a barley plant's stem to determine and compare Z32 and Z33. Left stem - Z32

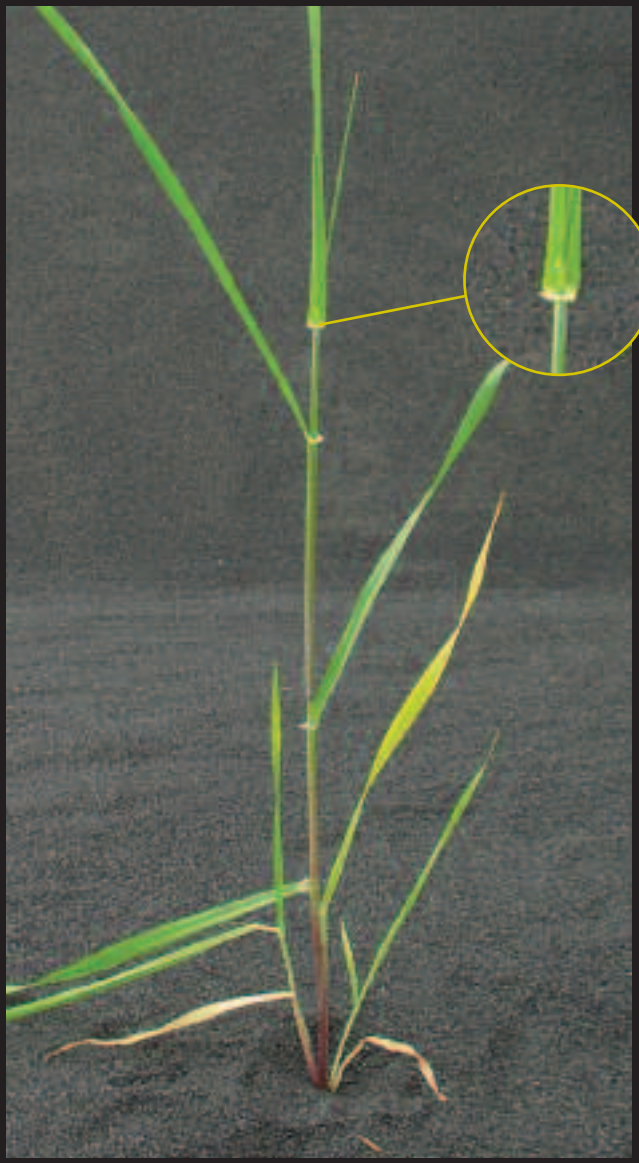
Middle stem - just starting Z33

Right stem - Z33 - 1st node not shown

See previous picture for details

Z 32 2nd node detectable (Z16/Z20/Z32)

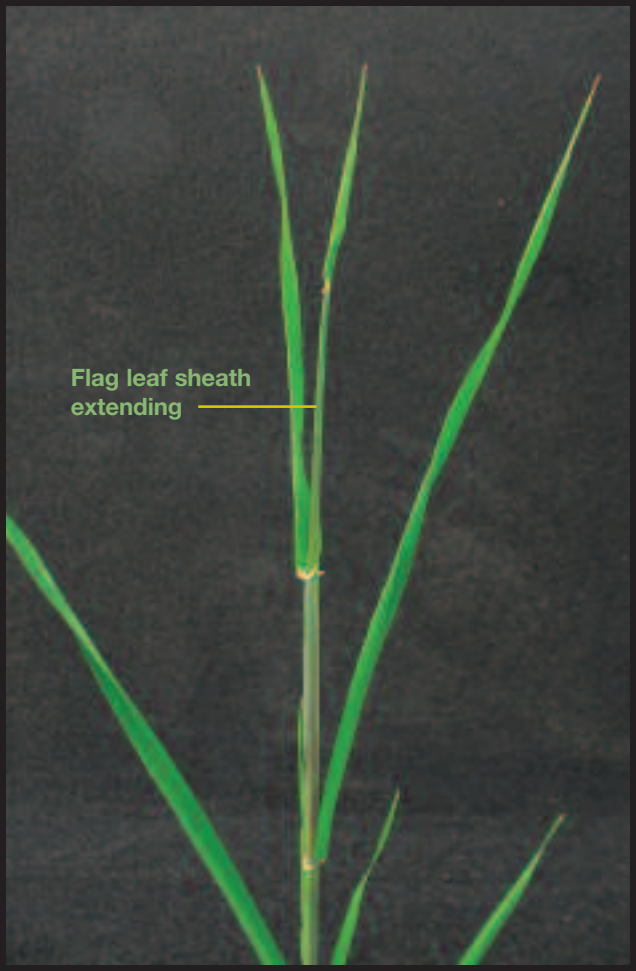
Z 32 2nd node detectable (Z16/Z20/Z32) close up



Z 39 Flag leaf ligule/collar just visible
Approximate time that pollen development begins. The occurrence of frost at this stage of barley will result in sterile florets in the head, dramatically reducing yield.

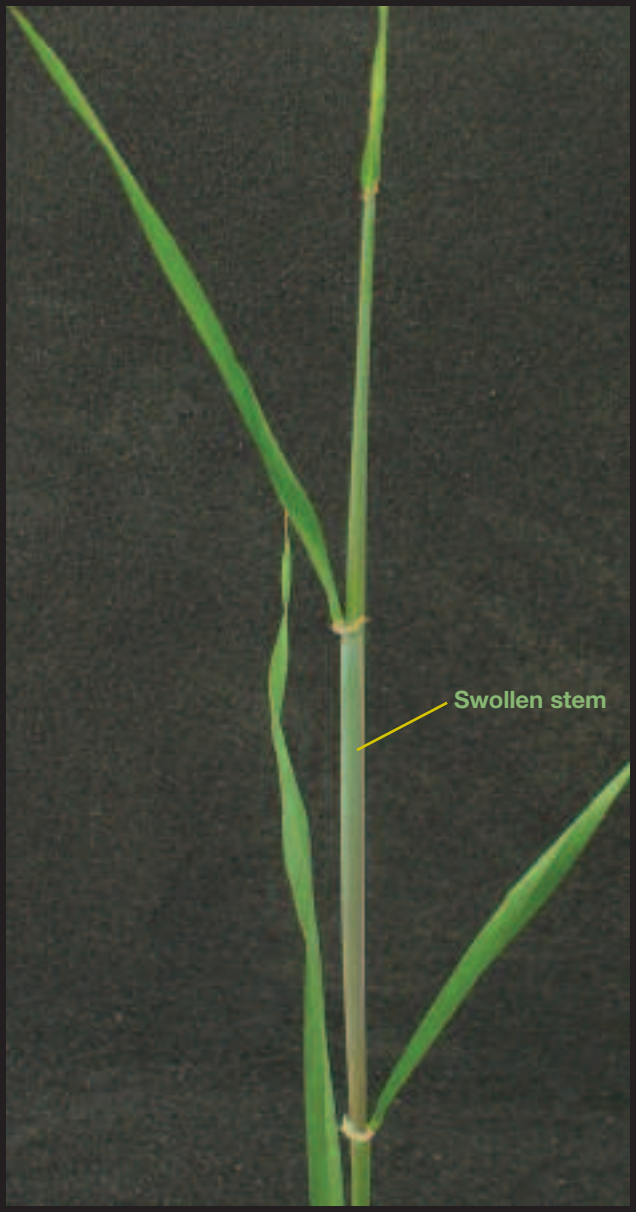
Stage 4: Booting

- Critical stage for application of some growth regulators. Application timing is very important.
- Armyworm infestations are most likely to occur after Stage 39, but can occur earlier on late planted cereal crops.

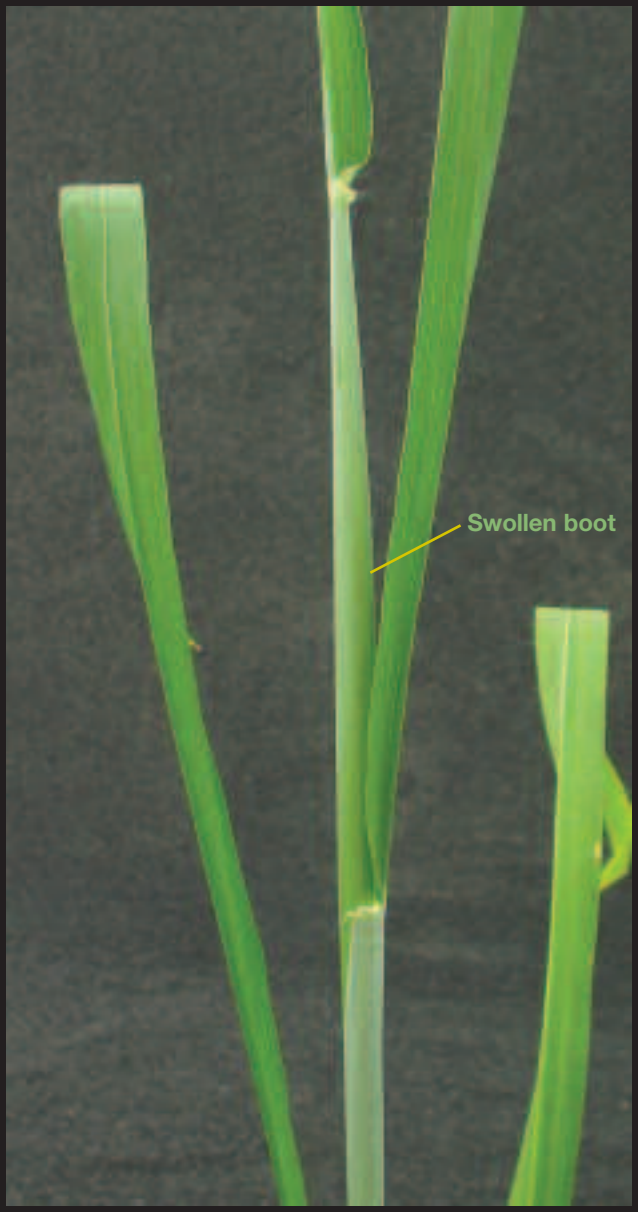


Z 41 Flag leaf sheath extending

Z 41 Close-up of flag leaf sheath extending
Approximate time that pollen development begins in wheat, making it highly susceptible to frost damage and sterile florets in the spike.



Z 43 Boot just visibly swollen



Z 45 Boot swollen

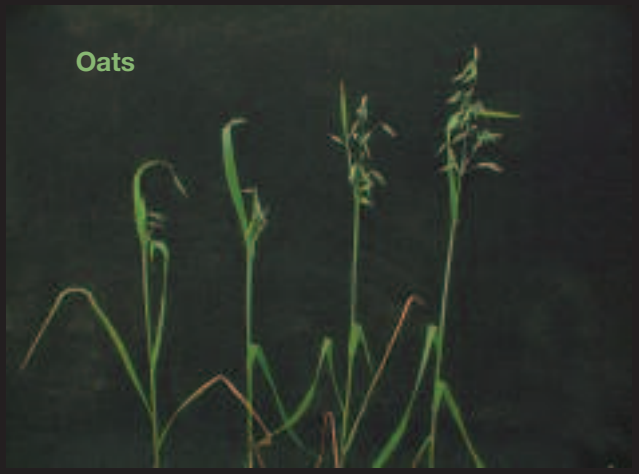
Z 47 Flag leaf sheath opening

Z 49 First awns visible

Stage 5: Heading (Inflorescence emergence)

- Grain fill occurs from Stages 55 through 85. The longer this period lasts, the higher the yield.
- Environmental stresses can negatively affect yield during this period.
- In barley, apply *Fusarium* head blight (FHB) fungicides (Proline) between Z56 and up to three days after the crop has reached full head emergence (Z58) for optimum suppression of FHB.
- In wheat, apply FHB fungicides (Proline or Folicur) between Z56 and up to three days after full head emergence (Z58) or 50% flower for optimum suppression of FHB.

Z 50 First spikelet of inflorescence just visible
Z 52 1/4 of head emerged
Z 54 1/2 of head emerged
Z 56 3/4 of head emerged
Z 58 Emergence of head completed



Z 50 First spikelet of head just visible
Z 52 1/4 of head emerged
Z 54 1/2 of head emerged
Z 56 3/4 of head emerged
Z 58 Emergence of head completed

Stage 6: Pollination (Anthesis)

- Some cereals, particularly two-rowed barley and oats, do not always extrude the anthers from the floret and therefore this stage may be difficult to accurately identify. If the flower is opened by hand, yellow anthers may be visible inside.
- For optimum protection against *Fusarium* head blight in wheat, FHB fungicides (Folicur or Proline) should be applied between Z56 and Z64 or 50% flower. In warm weather, these stages can be covered in the span of only a day or two.

Z 60 Beginning of pollination

Z 64 Pollination half way

Z 68 Pollination complete


Spike/head
Floret
(Basic flower structure)
Spikelet
(Group of florets)
Wheat spike or head
Spikelet
Floret
Wheat spike or head (close up)

Wheat at pollination (anthesis) with anthers extruding from the floret. Note: pollen grains on the lemma and palea of the floret.

Stage 7: Milk development

Stage 8: Dough development

Stage 9: Ripening

Glossary of Terms

Anther: The male portion of a flower which produces and releases the pollen.

Anthesis: The time of flowering or pollination.

Auricles: A pair of claw-like projections at the junction of the sheath and blade.

Axillary tillers: The tillers that emerge from the leaf axils.

Blade: The flat expanded portion of a leaf.

Coleoptile: The round sheath which surrounds and protects the first leaf as it emerges from the seed to the soil surface.

Coleoptilar tiller: The tiller that emerges from the coleoptilar node at the seed.

Collar: The junction of the leaf blade and leaf sheath.

Crown: The first node established above the seed shortly after germination. This is the origin of the secondary (main) root system. The growing point is located here until stem elongation begins.

Endosperm: The area of starch and protein storage in the kernel.

Floret: The flower contained within the spikelet. Each flower has three anthers and a single ovary resulting in one seed upon fertilization.

Glumes: The pair of husks that contain the spikelet.

Growing point: The plant part where differentiation of leaves, tillers and the head occurs.

Internode: The region of the stem between two successive nodes.

Leaf axil: The junction of the leaf with the main stem.

Lemma: The outer, lower bract enclosing the flower in a floret.

Ligule: A short membrane or row of hairs on the inside of the leaf at the junction of the blade and sheath.

Nodes: The area of active cell division from which leaves, tillers and adventitious roots arise. They are the ‘bumps’ on the elongating stem that are at the base of each leaf sheath.

Ovary: The female reproductive structure that develops into the seed.

Palea: The inner, upper bract enclosing the flower in a floret.

Panicle: An open and branched inflorescence with pediceled flowers, a common character of oats and some grasses.

Peduncle: The last elongated internode which supports the head (top internode).

Plant Growth Regulator: A chemical used to inhibit peduncle elongation and increase lodging resistance.

Pollen: The powder-like grains produced by the anthers which function as the male element in pollination.

Pollination: Fertilization of the egg cell by pollen to give rise to the embyro and the endosperm (seed).

Primary tiller: A tiller produced by a node on the main stem.

Prophyll: The sheath which encloses the base of a tiller.

Radicle: The first root to emerge from the seed.

Secondary tiller: A tiller produced on a primary tiller.

Seminal roots: The roots originating directly from the seed.

Sheath: The tubular portion of a grass leaf that encloses the stem.

Spike: Technical name for the head in a grassy plant.

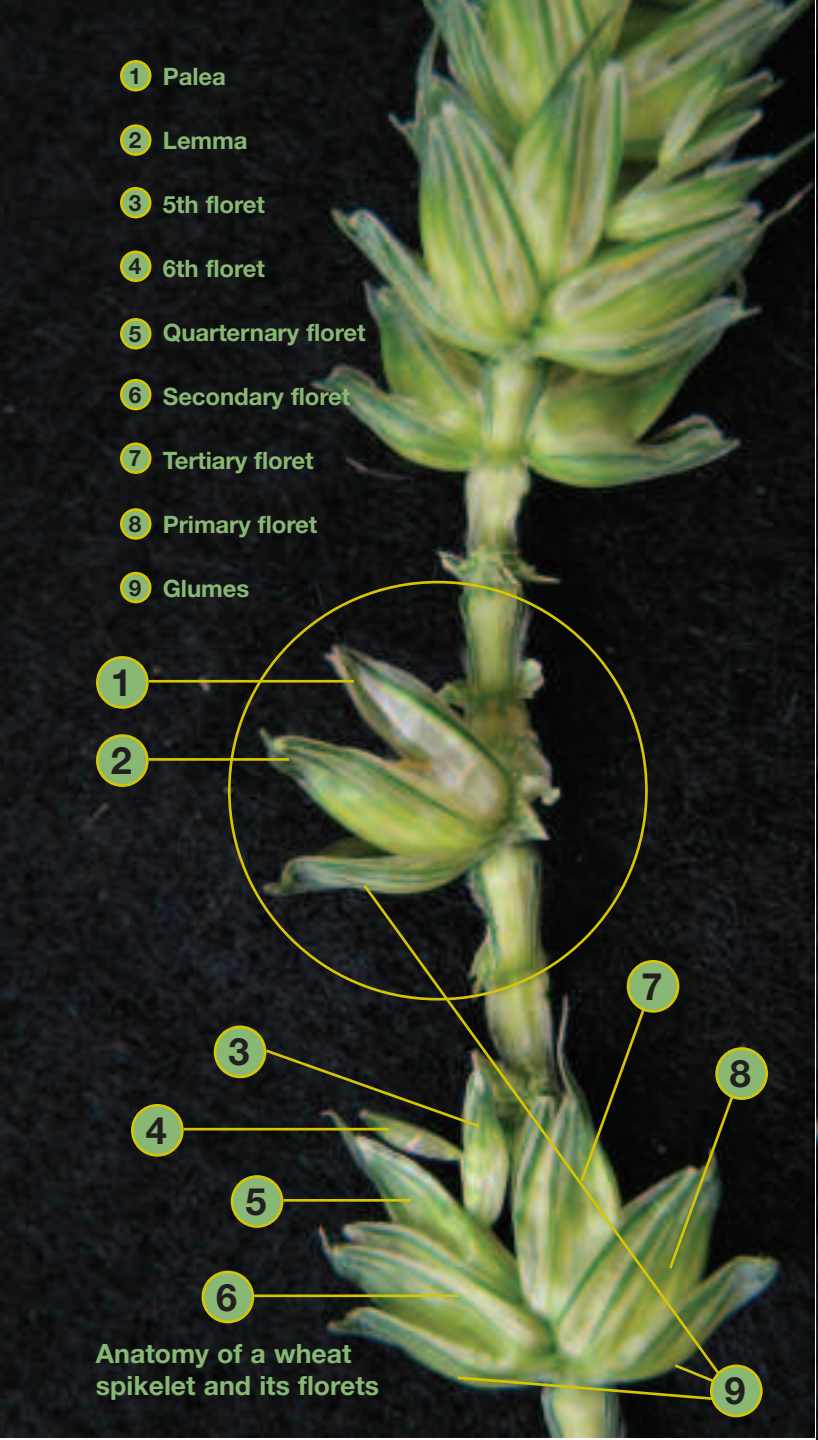
Spikelet: Subdivision of the spike that contains the individual florets.

Stigma: These are the feathery structures designed to catch pollen for fertilization. Stigmas are connected to the ovary where the seed will form.

Subcrown Internode: The internode between the seed and crown. This internode elongates upon germination to place the crown approximately one inch below the soil surface in wheat and barley.

Tertiary tiller: A tiller produced on a secondary tiller.

Tiller: A shoot that arises from buds at the nodes of a plant.



Anatomy of a wheat spikelet and its florets

Wheat floret