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Cereal Growth Stages Guide



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Cereal Growth Stages

Why are they important to cereal growers?

A growth stage key provides farmers, advisors and researchers with a common reference for describing the crop's development. Management by growth stage is critical to optimise returns from inputs such as nitrogen, Plant Growth Regulators (PGRs), fungicides and water. Although referred to as a growth stage guide, it is actually more accurate to describe it as a development stage guide.

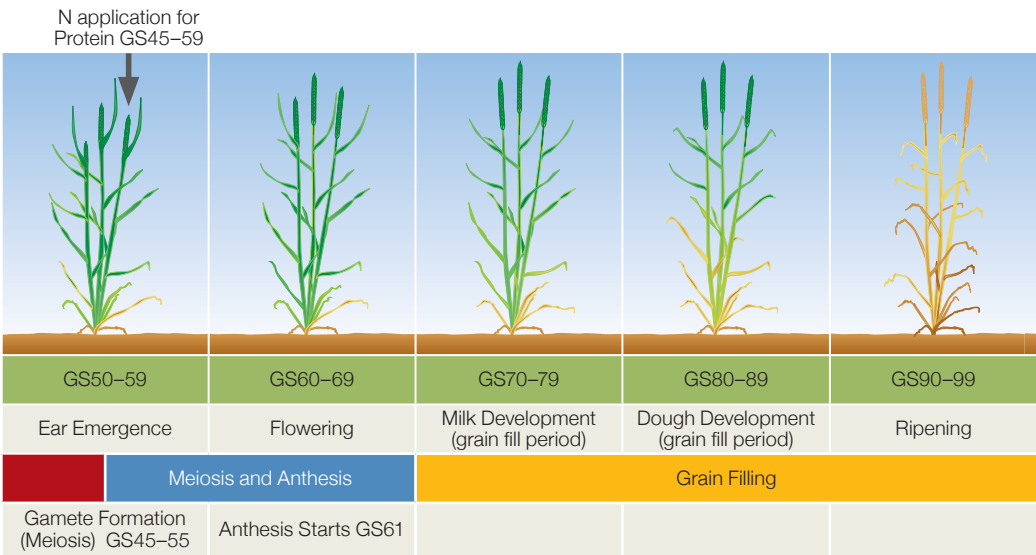
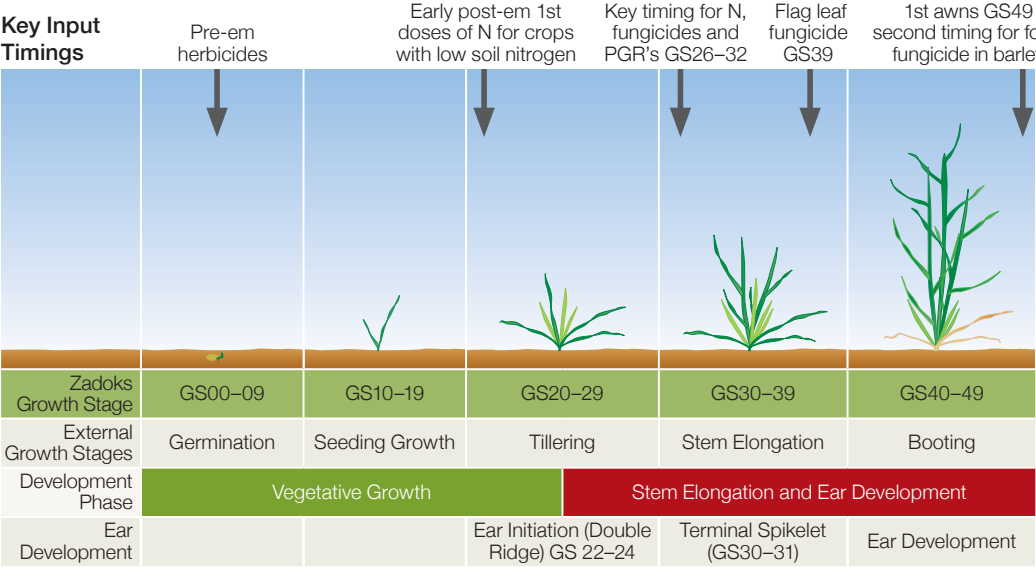
Zadoks Cereal Growth Stage Key

This is the most commonly used growth stage key for cereals in which the development of the cereal plant is divided into 10 distinct development phases covering 100 individual growth stages. Individual growth stages are denoted by the prefix GS (growth stage) or Z (Zadoks), for example GS39 or Z39.

Within each of the 10 development phases there are 10 individual growth stages, for example, in the seedling stage:

GS11	Describes the first fully unfolded leaf
GS12	Describes 2 fully unfolded leaves
GS13	Describes 3 fully unfolded leaves
GS19	Describes 9 or more fully unfolded leaves on the main stem

- The Zadoks Cereal Growth Stage key does not run chronologically from GS00 to GS99. For example when the crop reaches 3 fully unfolded leaves (GS13) it begins to tiller (GS20). This occurs before it has completed 4, 5, 6 fully unfolded leaves (GS14, GS15, GS16).
- As a consequence of growth stages overlapping it is possible to describe a plant with several growth stages at the same point in time. For example a cereal plant at GS32 (2nd node on the main stem) with 3 tillers and 7 leaves on the main stem would be at GS32, GS23, GS17, yet practically would be regarded as GS32, since this describes the most advanced stage of development.

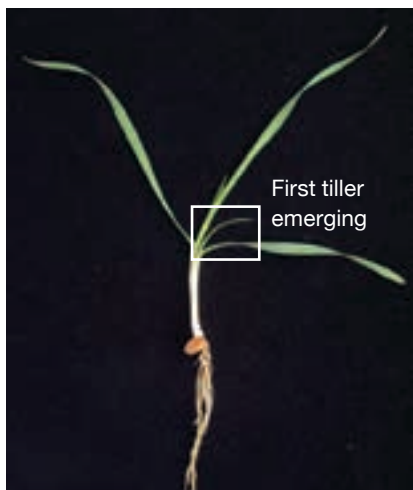




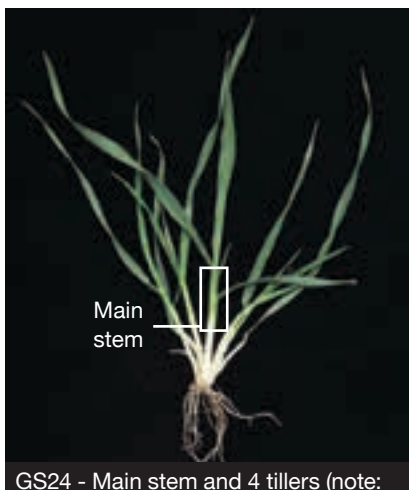
GS07 - Germinating seed with root (which forms first) and shoot



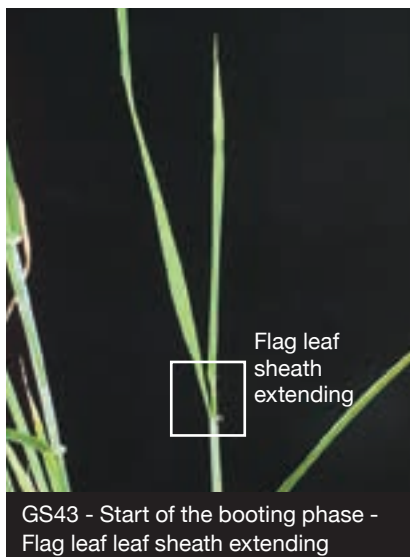
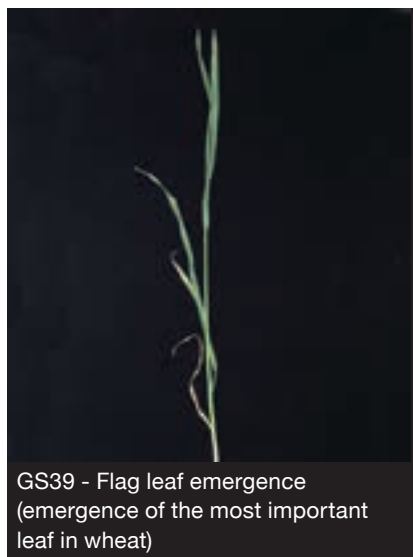
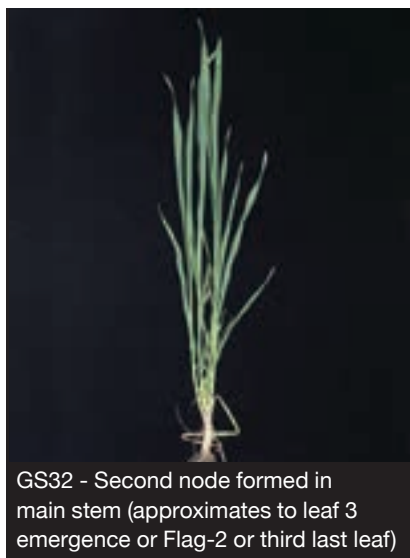
GS11 - 1st unfolded leaf (deep sown on left, correctly sown on right)



GS13 - Three unfolded leaves with first tiller emerging from first leaf axil



GS24 - Main stem and 4 tillers (note: appears to be 3 tillers, however very small tiller on right)





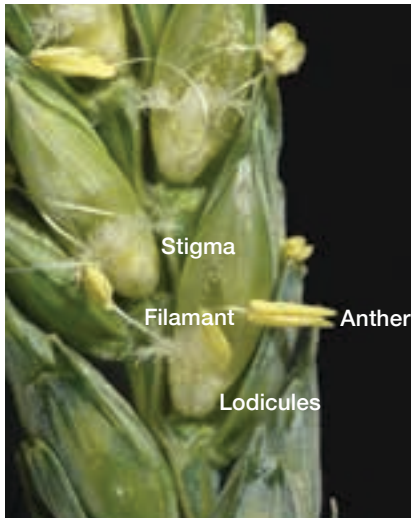
GS49 - End of booting - leaf sheath splitting open (for awned wheats and barley 1st awns emerging)



GS55 - Ear 50% emerged on the main stem



GS59+ Ear emergence complete



GS61 - Start of flowering



GS69 - End of flowering (anthers visible on outside of glumes along the length of the ear)



GS71 - Start of grain fill - forming grain watery ripe (awnless)



GS77 - Later grain fill - late milky ripe



GS87 - Hard dough stage towards end of grain fill (fungicide treated on right, untreated on left)

Key growth stages in relation to disease control and canopy management

The key growth stages for both disease control and canopy management in cereals are those covered by the period from GS30 (the start of stem elongation) to GS61 (start of flowering). These growth stages are particularly important for management decisions related to disease control.

Development Phase	Decimal Growth Stage	Description
Stem Elongation GS30-GS39	GS30	Pseudo stem erect (Embryo ear at 1 cm) - start of stem elongation.
	GS31	1st node on main stem.
	GS32	2nd node on main stem. Leaf 3 emerges on main stem, 2 leaves below the flag leaf (also known as Flag-2 or F-2).
	GS33	3rd node on main stem. Leaf 2 (also known as F-1) emerges on main stem.
	GS37	Flag leaf just visible on main stem.
	GS39	Flag leaf fully emerged on main stem with ligule showing.

Development Phase	Decimal Growth Stage	Description
Booting GS40-GS49	GS41	Flag leaf - leaf sheath extending
	GS45	Mid boot - ear swelling in top of main stem
	GS49	1st awns emerging (barley/awned wheat)
Ear emergence GS50-GS59	GS59	Ear fully emerged on main stem
Flowering GS60-GS69	GS61	Start of flowering on main stem (first anthers appear approximately 1/3 of the way up the ear)

Identifying early stem elongation GS30-GS33

The start of stem elongation is particularly important for decisions on fungicide and nitrogen inputs, since it marks the emergence of the first of the important yield contributing leaves and the point at which nitrogen uptake in the plant increases strongly. In order to correctly identify these growth stages more precisely, main stems of the cereal plants are cut longitudinally and the position of nodes (joints in the stem) and the length of internodes (cavity in the stem between nodes) are measured with a ruler.



Dissection

- Use a ruler to measure node movement in the main stem to define early stem elongation growth stages.
- Take care not to confuse the basal node at the stem base with the first true node. Basal nodes are usually signified by a constriction of the stem below the node with an incompletely formed internode space. They are the point where the lowest leaves attach to the stem. Basal nodes will often grow small root tips. This is not the first node.
- Nodal growth stage can give an approximate guide to which leaf is emerging from the main stem; this can save time with leaf dissection when it comes to making decisions on fungicide application pre flag leaf (before all leaves are emerged).



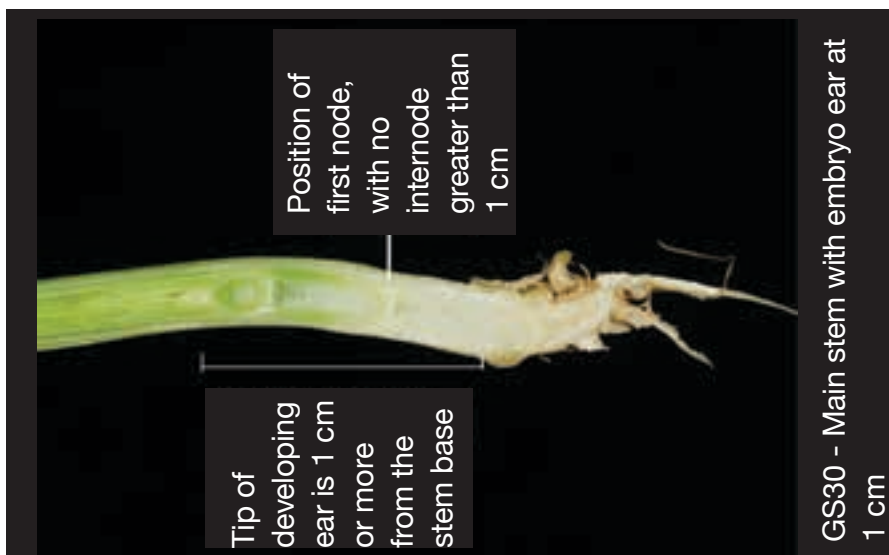
Dimensions defining early stem elongation.

GS30 - The tip of the developing ear is 1 cm or more from the base of the stem where the lowest leaves attach to the shoot apex.

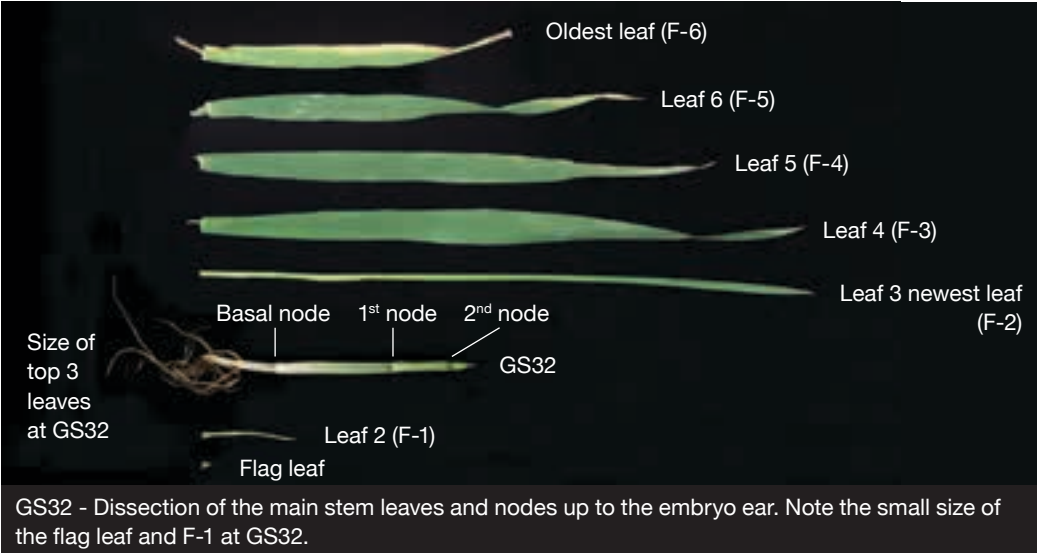
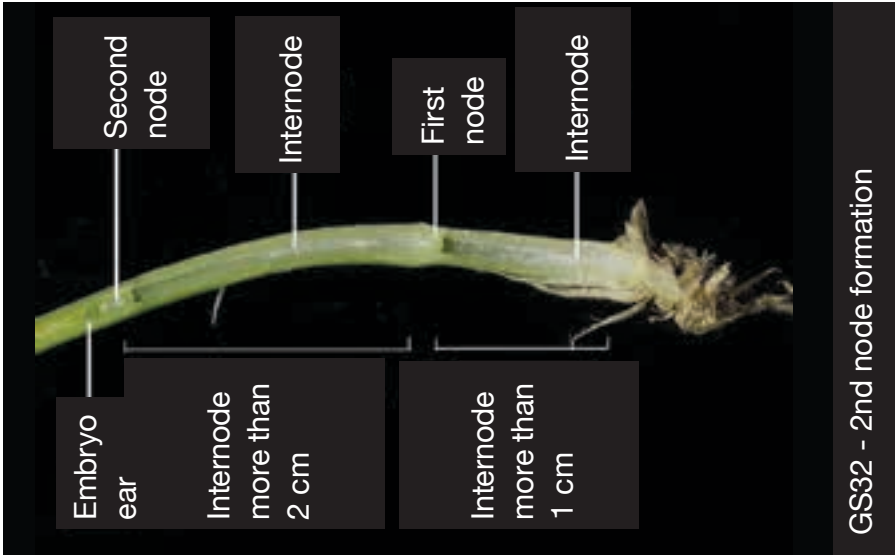
GS31 - The first node can be seen 1 cm or more above the base of the shoot (with clear internode space below it) and the internode above it is less than 2 cm.

GS32 - The second node can be defined when the internode below it exceeds 2 cm, however the internode space above the node has not yet reached 2 cm.

Third node (GS33) and all subsequent nodes e.g. GS34, GS35 and GS36 are defined in the same way as GS32; the node has to have a clear 2 cm space of internode space below it before it is distinguished as the next nodal growth stage.







How long does it take for the key leaves to emerge?

One of the most frequently asked questions in the field is “how long does it take for the key leaves such as flag leaf, leaf 2 and leaf 3 to emerge”?

The length of time taken for a leaf to emerge is called the phyllochron and is driven by temperature. It is measured in day degrees ($^{\circ}\text{C}$ days) meaning that the length of time for leaf emergence in calendar days depends on the temperature. Most wheat cultivars have phyllochrons of approximately 100-120 day $^{\circ}\text{C}$.

For all crop models such as the Sirius Wheat Calculator it is essential to have the correct phyllochron as well as the precise climate and soil data.

Example:

If the crop is at GS32 and leaf 3 is emerged, how long will it take before the flag leaf is emerged?

A simple calculation of average daily temperature is to take the maximum and minimum daily temperature and divide by two (maximum daily temp + minimum daily temp $\div$ 2).

Therefore suppose that from GS32 to GS39 the average maximum temperature was 20°C and the average minimum temperature was 10°C . It would take approximately 16 days for the flag leaf to emerge on a variety with a phyllochron of 120 day $^{\circ}\text{C}$.

- (Max daily temp 20°C + min daily temp 10°C $\div$ 2) = 15 day $^{\circ}\text{C}$
- Phyllochron 120 day $^{\circ}\text{C}$ divided by 15 day $^{\circ}\text{C}$ = 8 days per leaf
- Thus 8 days from leaf 3 at GS32 to the emergence of leaf 2, with another 8 days until flag leaf emergence = 16 days.

In reality since temperatures are warmer as spring progresses, it may be that there will be 9 days between leaf 3 and leaf 2 and only 7 days between leaf 2 and flag leaf emergence on the main stem.

Barley varieties tend to have shorter phyllochrons, so leaves tend to emerge more quickly.