A Visual Guide to

Winter wheat staging

Grain Farmers of Ontario

Ontario

with contributions from:

COOL BEAN
University of Wisconsin-Madison | UW Extension
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Zadoks scale
for cereal growth stages

			Fungicide application timing
Germination	00	Dry seed	
	01	Start of imbibition	
	03	Imbibition complete	
	05	Radicle emerged from seed	
	07	Coleoptile emerged from seed	
	09	Leaf just at coleoptile tip	
Seedling Growth	10	First leaf through coleoptile	
	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	Pseudostem erection	T1
	31	1st node detectable	T1
	32	2nd node detectable	T1
	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	T2

A leaf is unfolded when its ligule or collar is visible.

Stage	Code	Description	Fungicide application timing
Booting	40	---	T2
	41	Flag leaf sheath extending	T2
	45	Boot just visibly swollen	
	47	Flag leaf sheath opening	
	49	First awns visible	
Heading	50	---	
	51	First spikelet of head visible	
	53	1/4 of head emerged	
	55	1/2 of head emerged	
	57	3/4 of head emerged	
	59	Head emergence completed	Day 0
Flowering	60	---	
	61	Beginning of flowering	T3
	63	Flowering 1/4 complete	T3
	65	Flowering 1/2 complete	T3
	67	Flowering 3/4 complete	
	69	Flowering complete	
Milk Stage	70	---	
	71	Kernel watery ripe	
	73	Early milk	
	75	Medium milk	
	77	Late milk	
Dough Stage	80	---	
	83	Early dough	
	85	Soft dough	
	87	Hard dough (physiological maturity)	
Ripening	90	---	
	91	Kernel hard (difficult to divide with thumbnail)	
	92	Kernel hard (no longer dented with thumbnail)	
	93	Kernel loosening in daytime	
	94	Overripe, straw dead and collapsing	
	95	Seed dormant	
	96	Viable seed giving 50% germination	
	97	Seed not dormant	
	98	Secondary dormancy induced	
	99	Secondary dormancy lost	

Introduction

Understanding the growth stages of winter wheat is critical to make informed and profitable management decisions. Applications of nutrient inputs, plant growth regulators (PGRs) and crop protection products such as herbicides, fungicides, and insecticides have labelled application windows tied to specific cereal growth stages.

This guide is an adaptation of the University of Wisconsin-Madison's Cool Bean guide "Visual Guide: Winter Wheat Development and Growth Staging". In this version, we focus on the Zadoks scale (most commonly used in Ontario) and winter wheat production. The described methods of staging can generally apply to other cereal crops including winter barley and spring cereals such as oats, rye, triticale, and spring wheat.

When determining the growth stage of the crop, here are some helpful tips:

- **Do not stick to one area!** Instead, randomly select one plant from 10 - 12 different locations in the field for a better idea of the growth stage that represents the entire crop.
- **Dig up the entire plant.** This is especially important for identifying early growth stages.
- **Carry a knife** when staging to cut open the stem and determine the location of nodes and the forming wheat head. Cut the stem at the base of the plant, level with the soil surface.
- **Be sure to use the main shoot when identifying** different growth stages (see basic wheat anatomy illustration on the next page).
- **Peel back the leaves on the main stem to expose the nodes before heading.** Use fingers to feel for nodes if not visible right away or cut open the stem.

References:

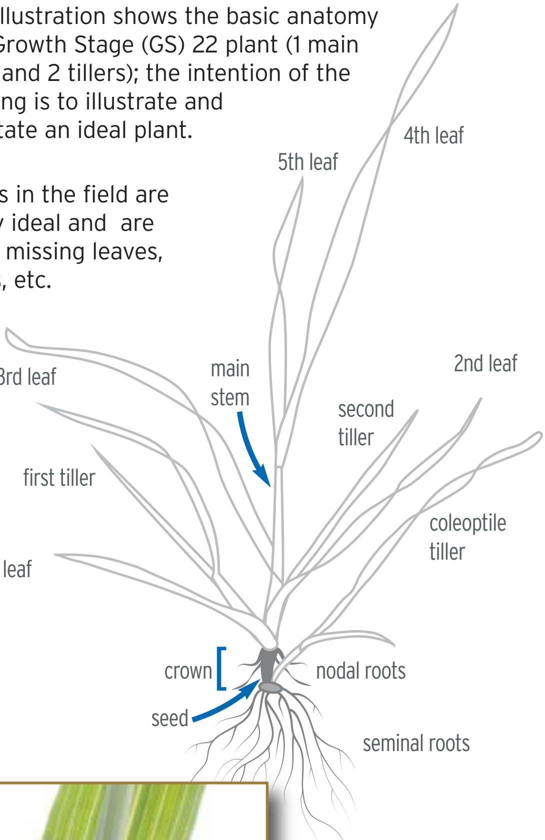
University of Wisconsin-Madison's Cool Bean guide "Visual Guide: Winter Wheat Development and Growth Staging"

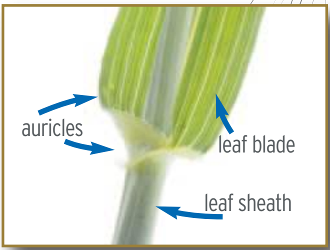
J.C. Zadoks, T.T. Chang, C.F. Konzak. A Decimal Code for the Growth Stages of Cereals. Weed Research 1974 14:415-421.

Basic wheat anatomy

This illustration shows the basic anatomy of a Growth Stage (GS) 22 plant (1 main stem and 2 tillers); the intention of the drawing is to illustrate and annotate an ideal plant.

Plants in the field are rarely ideal and are often missing leaves, tillers, etc.





During the vegetative stages, the auricles are often a good way to distinguish between different cereal crops.

WHEAT

Auricles blunt and hairy; leaf sheath and blade always hairy; ligule medium length; leaf blades twist clockwise.

Germination begins when the **dry seed** imbibes water and begins to expand.

GS00
Dry seed

GS01
Start of imbibition

radicle
The first root

GS05
Radicle emerged from seed

coleoptile
The round sheath that protects the first leaf

GS07
Coleoptile emerged from seed

Planting depth and soil temperature influence the duration of the germination stages.

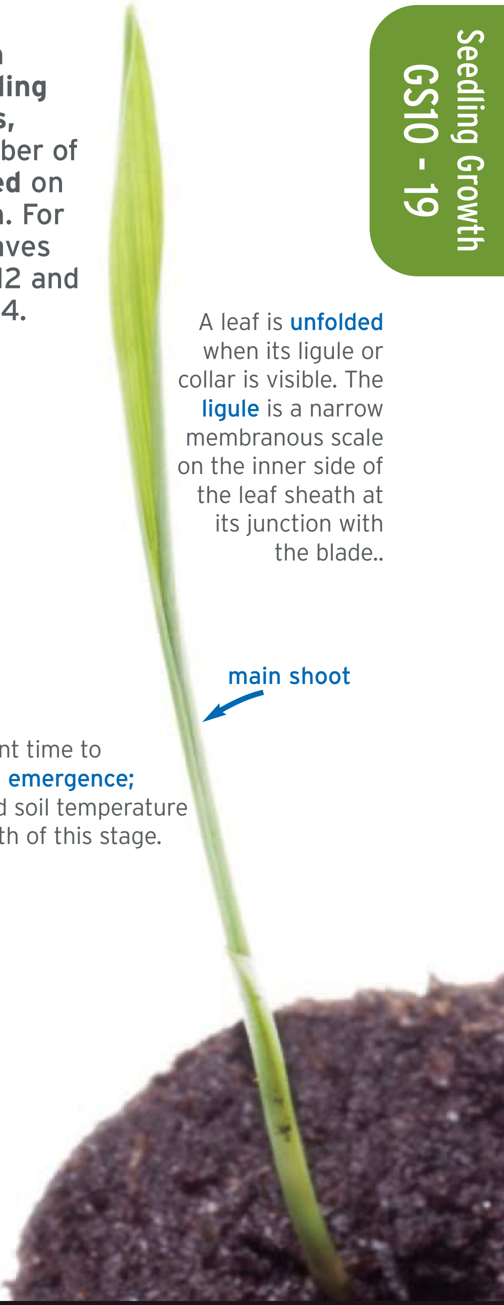
Wheat needs 80 growing degree days (GDD) to germinate and 50 more GDD per 2.5 cm of seeding depth to emerge.


The **first true leaf** emerges through the coleoptile's tip.
GS10
First leaf through coleoptile
GS09
Leaf just at coleoptile tip
The **coleoptile** stops growth when it encounters light above the soil surface.
seed
The **seminal roots** provide a path of water absorption during early stages of development.

SEEDLING GROWTH
Emergence; one stem formed; first leaf through coleoptile

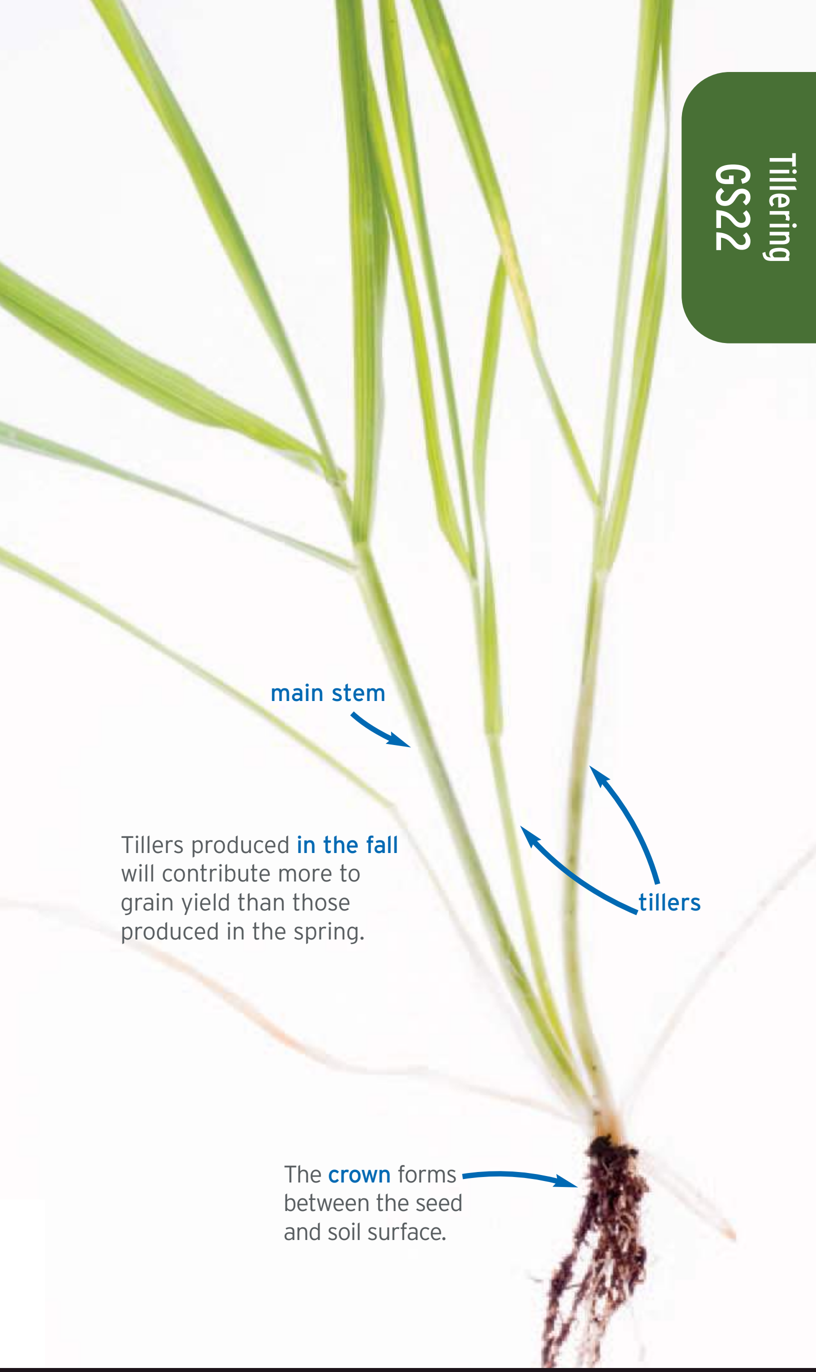
To distinguish between seedling growth stages, count the number of leaves **unfolded** on the main stem. For example, 2 leaves unfolded = GS12 and 4 leaves = GS14.

A leaf is **unfolded** when its ligule or collar is visible. The **ligule** is a narrow membranous scale on the inner side of the leaf sheath at its junction with the blade..



This is an important time to **check for uniform emergence;** planting depth and soil temperature influence the length of this stage.

TILLERING
Tiller development begins


main stem
tillers
Tillers produced **in the fall** will contribute more to grain yield than those produced in the spring.
The **crown** forms between the seed and soil surface.


main stem
tiller
tillers
prophyll
The independent sheath at the base of each tiller.
tiller

Are tillers important?

Tillers are absolutely necessary for high yields.

1 **planted seed** can produce **4-5** **tillers**

tillers are also called auxillary or side shoots; not all tillers will complete development and produce grain.

In Ontario, the **recommended seeding date** for optimal tiller development is dependent on your location. Scan the QR code below or see the Contributors and Acknowledgments section to access a map of recommended seeding dates.

A **tiller** is capable of forming a single head (spike).
The **head** is made up of spikelets.
Each **spikelet** contains individual florets.
Individual **florets** can produce a single **kernel.**

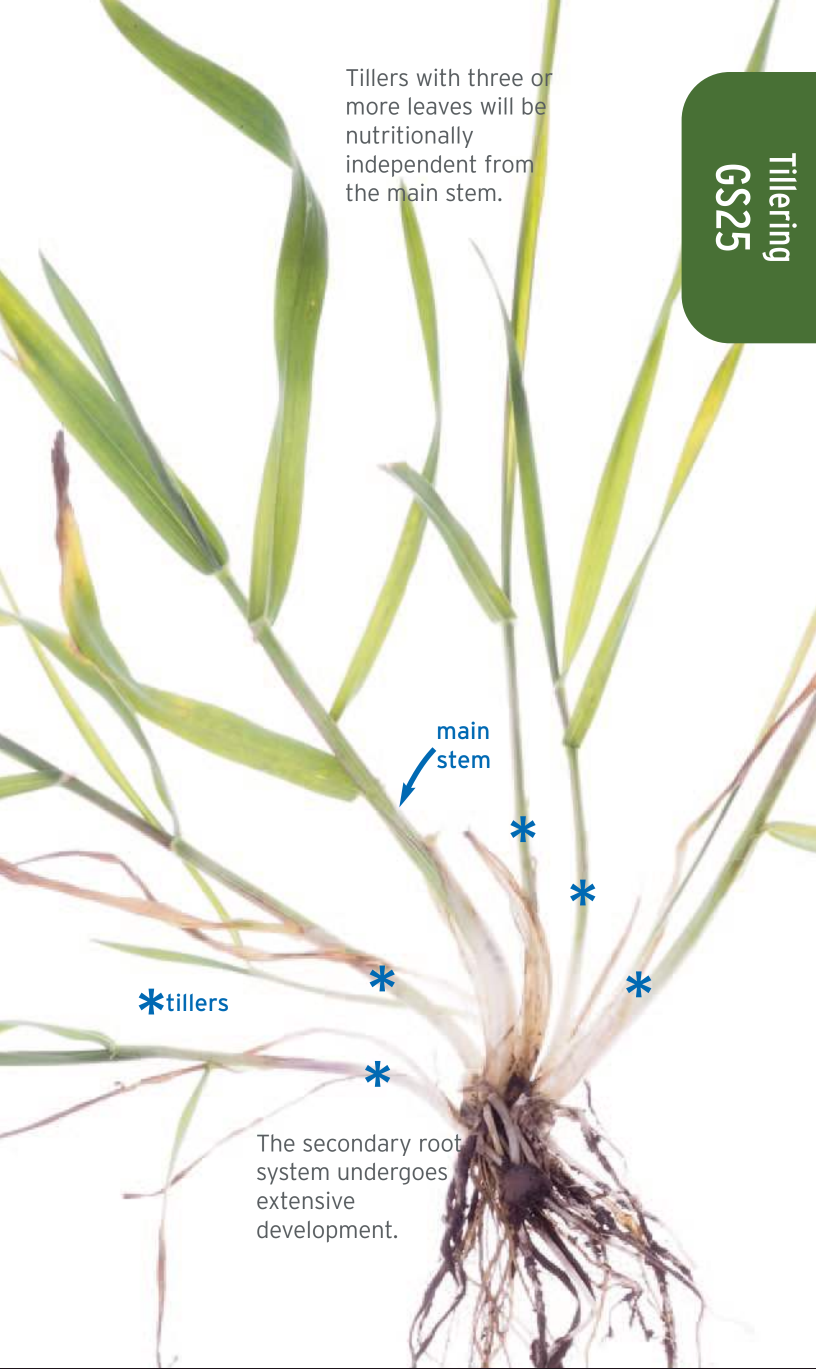
The **total number of tillers** that are produced in the fall is dependent on **the number of GDD accumulated since planting**.

KEY YIELD COMPONENT

Final tiller number is complete in the spring when stems become pseudo-erect. Many of these tillers will die before flowering.

TILLERING
Tillering completed

Tillers with three or more leaves will be nutritionally independent from the main stem.



The secondary root system undergoes extensive development.

Tillering can occur in the fall and spring as winter wheat development is dependent on both temperature and planting date.

What happens during winter dormancy?

Vernalization!

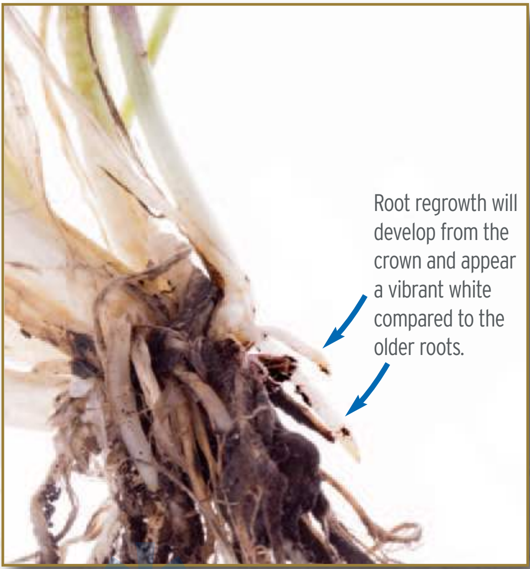
Winter wheat requires exposure to a period of low temperatures (<10° C) to initiate reproductive development.

Spikelets are produced and the number of florets initiated during this stage will determine the potential number of kernels per head.

Seeding within or prior to your optimum planting date will increase the chances of winter survival.

KEY YIELD COMPONENT

Regrowth will occur after a week or two of warm weather, typically late April to early May, depending on the location and year.



Factors affecting winter survival

- (+) Good snow cover acts as an insulator keeping soil temperature from going below critical levels.
- (-) Cyclic freezing and thawing increases injury from ice crystal growth in the tissue.
- (-) Mid-winter thaw and rain can cause flooding at the plant base; crowns can die at warmer temperatures.
- (-) Ice encasement traps carbon dioxide and suffocates plant by inhibiting respiration.
- (-) Frost heaving can push the root system out of the ground, leaving plants vulnerable and weak.

4 steps when assessing plant stands in the spring:

1. **Venture out across the field after a week or two of warm weather** to determine field variability and locate any missing plants or patches in the stand. Before green up, plants can be assessed for survival by looking for new growth on roots or bring some plants indoors and look for new white roots after a few days (see image on previous page).

2. **Take stand counts across multiple areas of the field.** Locate any poor areas, as these are the most concerning. Consider that 5 healthy plants per foot of row is the minimum to maintain 80 per cent yield potential (see next page). Do not count plants that are frost heaved. Before making any termination decisions, determine the percent area of the field that is in poor condition.

3. **Determine the causes of poor plant stands for future management.** Are plants frost heaved? Was planting depth too shallow? Was soybean residue spread not uniform? Are there field drainage and soil structure or compaction issues?

4. **Consider a nitrogen application.** If wheat was planted late or if the stand is thin, an application of nitrogen at green up can encourage tillering and canopy development.

How to perform a plant count

Measure a 1-foot section in a row and count the number of plants on either side of the 1-foot section.

Repeat this count at 10 different spots in the field to get a better overview of the entire field.

This will provide 20 stand counts (2 counts at 10 different spots).

Take the average to determine the yield potential of the stand count.

Determining yield potential for various plant stand counts

Plant spacing (plants/foot of row)	Yield potential (per cent)	Yield (bu/acre)	
		October 5 planting date	October 15 planting date
20[1]	100	80	72
10	95	76	68
7[2]	90	72	65
6	85	68	61
5	80	64	58

Source: Smid, Ridgetown College, University of Guelph, 1986-90

1 *Full Stand*

2 *Seven plants/foot of row, healthy and evenly distributed, will still achieve 90 per cent of yield potential and does not require replanting. A field with this average that does not have uniform distribution, or with plants severely damaged by heaving and other injury factors, will not yield well. Consider replanting in this case.*

T1 fungicide timing

An important time for **weed control, nitrogen applications**, and the start of the optimum window for most **PGR applications.**

STEM ELONGATION
Leaf sheaths lengthen, pseudostem erection begins

Wheat plants have a pseudostem, which is a false stem composed of concentric rolled leaf sheaths that surround the growing point (the developing head).

During stem elongation, leaf sheaths lengthen, making the plants stand more upright.

Stem Elongation GS30

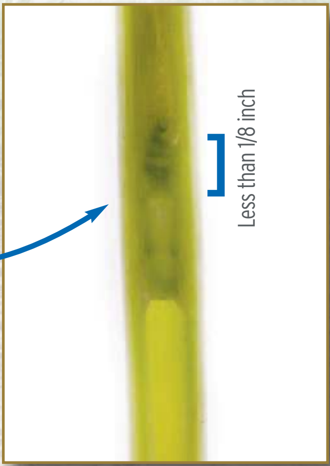
For herbicide applications, avoid temperatures below 5° C the day before and after spraying.

T1 fungicide timing

This is the last stage that some herbicides can be used without risk of injury!
Always read and follow herbicide labels.

STEM ELONGATION
Leaf sheaths fully elongated, pseudostem strongly erect

The growing point is at the **terminal spikelet stage** and about 1/4 inch above the crown.

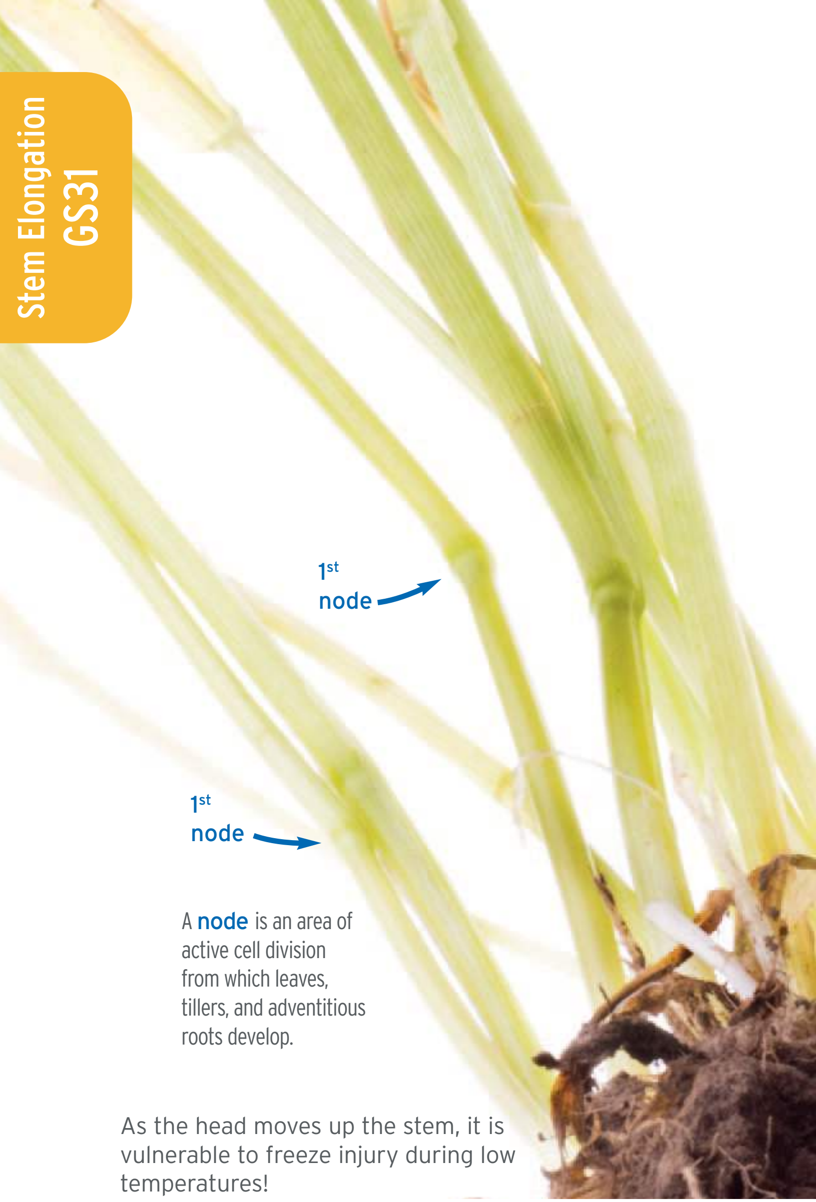


As the **developing head** is pushed up into the pseudostem, it becomes more vulnerable to damage.

The **number of spikelets per head** has been determined by this stage.

KEY YIELD COMPONENT

Stem Elongation GS31

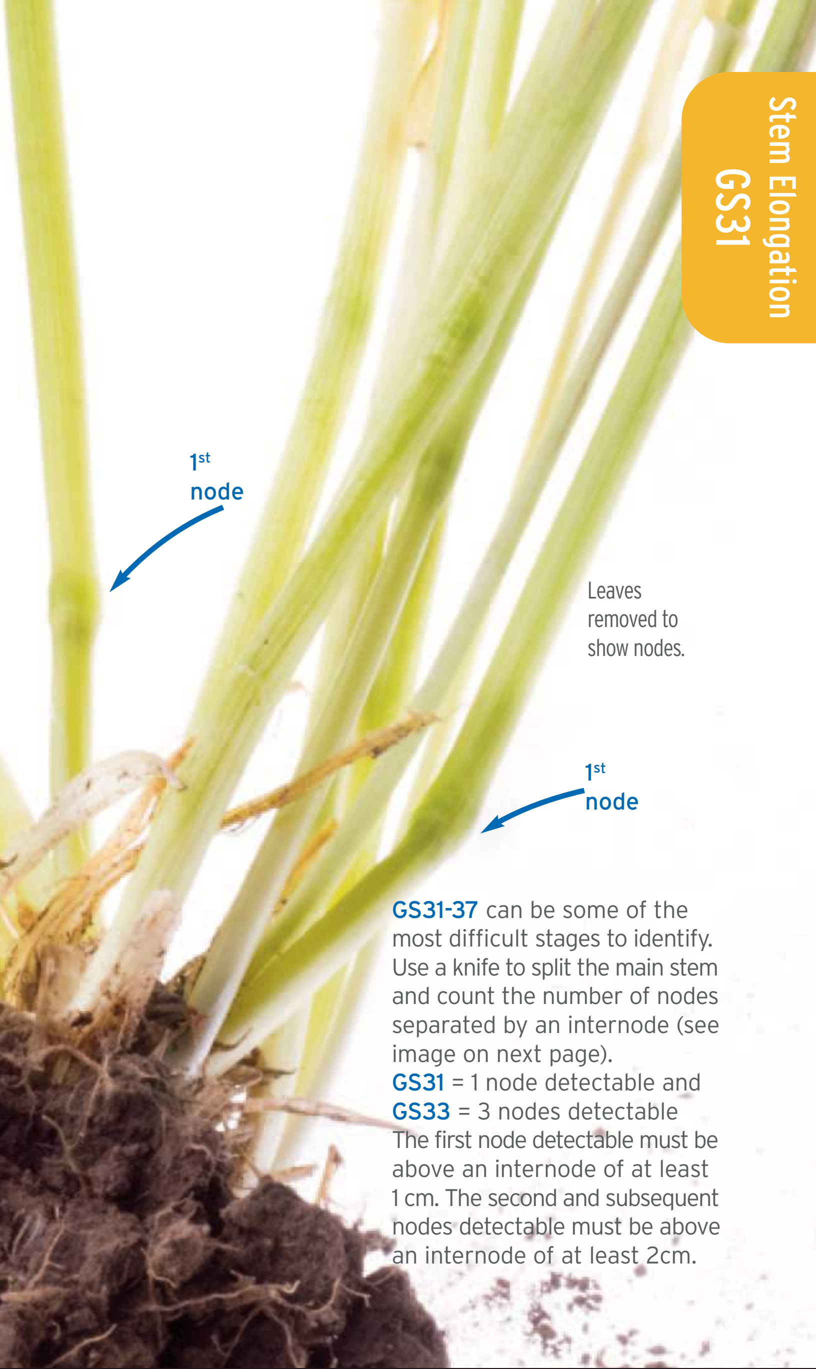


A **node** is an area of active cell division from which leaves, tillers, and adventitious roots develop.

As the head moves up the stem, it is vulnerable to freeze injury during low temperatures!

T1 fungicide timing

STEM ELONGATION
First node of stem visible at the base of the shoot; jointing

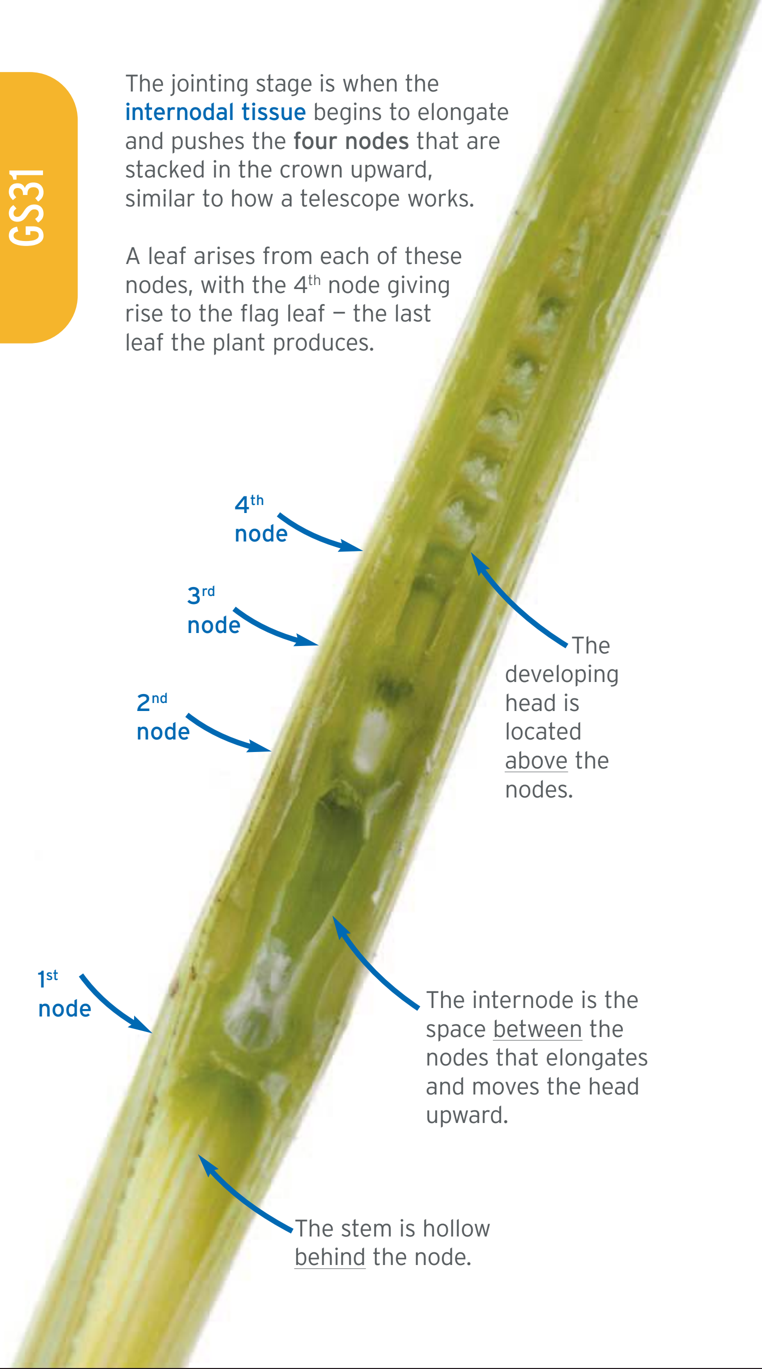


GS31-37 can be some of the most difficult stages to identify. Use a knife to split the main stem and count the number of nodes separated by an internode (see image on next page).
GS31 = 1 node detectable and
GS33 = 3 nodes detectable
The first node detectable must be above an internode of at least 1 cm. The second and subsequent nodes detectable must be above an internode of at least 2cm.

Stem Elongation GS31

The jointing stage is when the **internodal tissue** begins to elongate and pushes the **four nodes** that are stacked in the crown upward, similar to how a telescope works.

A leaf arises from each of these nodes, with the 4th node giving rise to the flag leaf – the last leaf the plant produces.



Stem Elongation GS31

A **GS31** plant with all leaves intact.

WATER USE INCREASES

From this growth stage forward, **broken stems due to wheel traffic will result in yield loss!**

The developing head is moving up the stem and needs to be protected.

The final number of tillers that form heads has been established by this stage.

KEY YIELD COMPONENT

Stem Elongation GS32

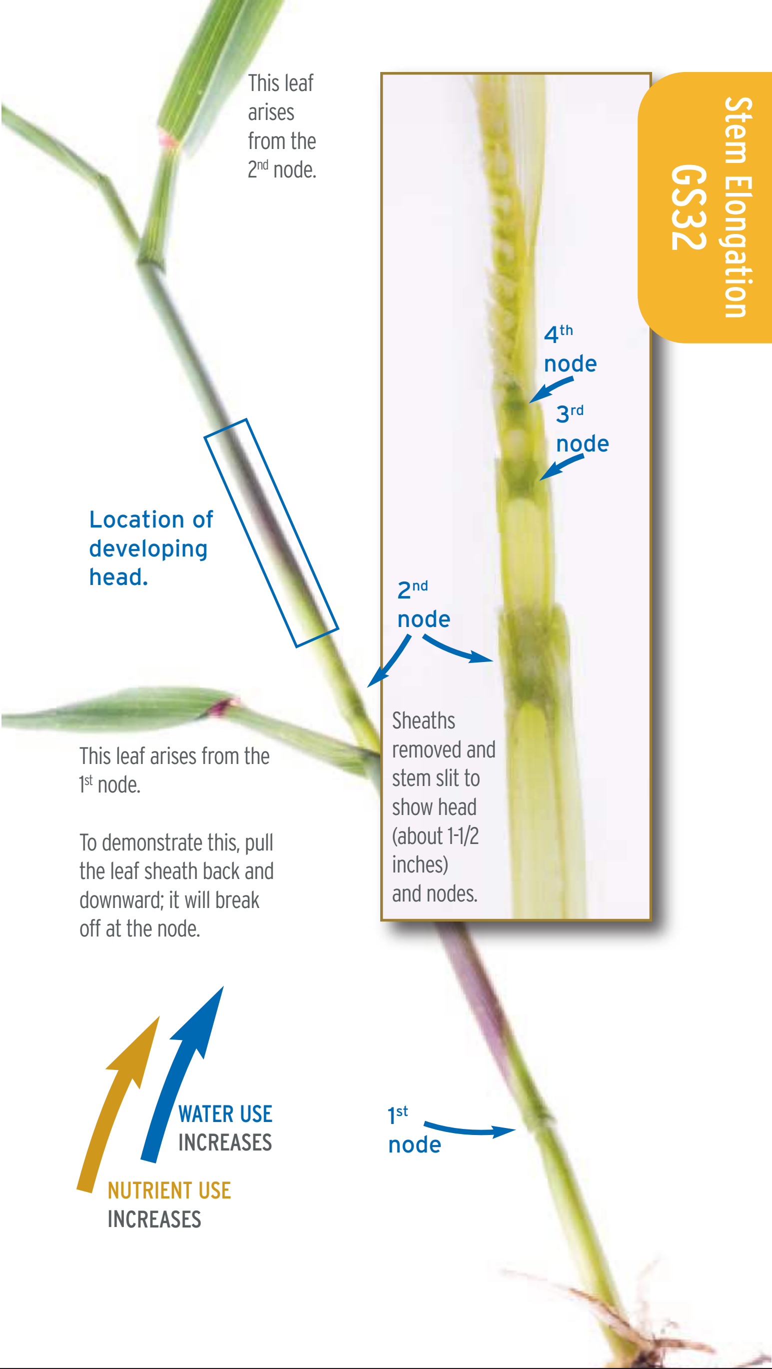
If split applying N, **GS32-39** is the recommended 2nd application window."

Scout now! To make well informed management decisions about protecting the flag leaf. Although effective at later stages, GS32 marks the end of the optimum PGR application window for most products.

T1 fungicide timing

STEM ELONGATION
Two nodes visible above the soil line

Stem Elongation GS32



Stem Elongation
GS37

Flag leaf facts

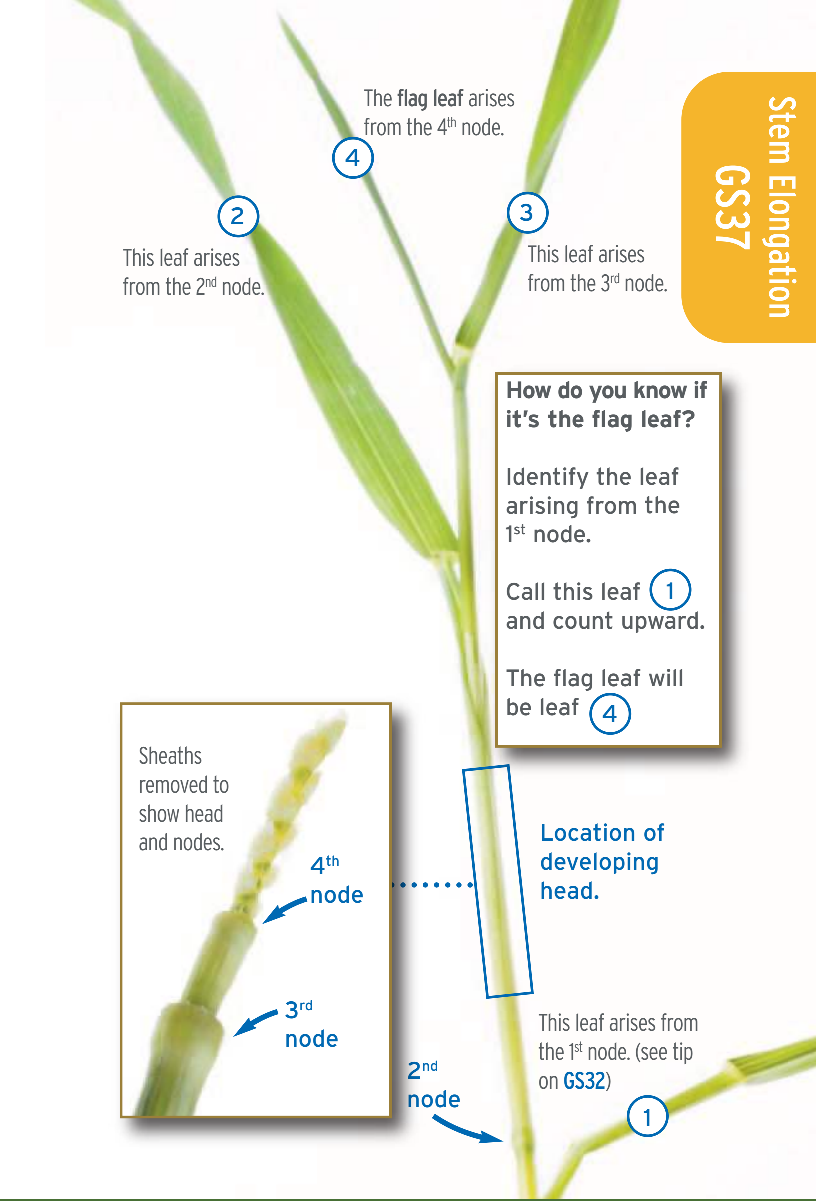
The flag leaf accounts for over 50 per cent of the photosynthates used for grain development, a.k.a **YIELD.**

It must be protected from disease or insect damage to ensure the plant's full yield potential.

Fungicide application decisions to protect the flag leaf should be made based on **presence** and **severity** of disease on the two leaves immediately below it.

In HRW, a final fertilizer application between GS37-39 can contribute to increased protein in the grain.

STEM ELONGATION
Flag leaf just visible, still rolled up



How do you know if it's the flag leaf?

Identify the leaf arising from the 1st node.

Call this leaf (1) and count upward.

The flag leaf will be leaf (4)

Kernel weight is determined by crop health and water/nutrient availability beginning now and continuing through grain fill.

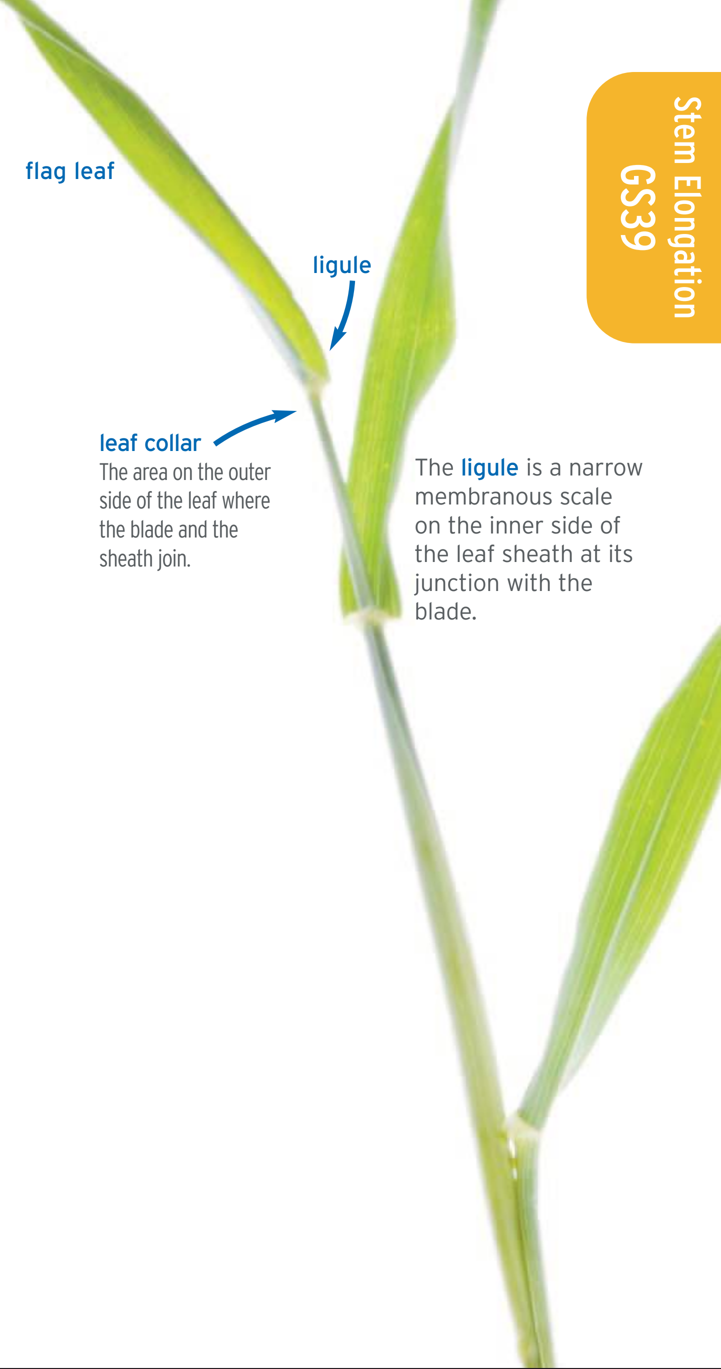
KEY YIELD COMPONENT

Stem Elongation GS39

T2 fungicide timing

Continue to scout for insect pests and diseases! Depending on disease pressure, a **T2 fungicide application may be necessary** to protect the emerging flag leaf.

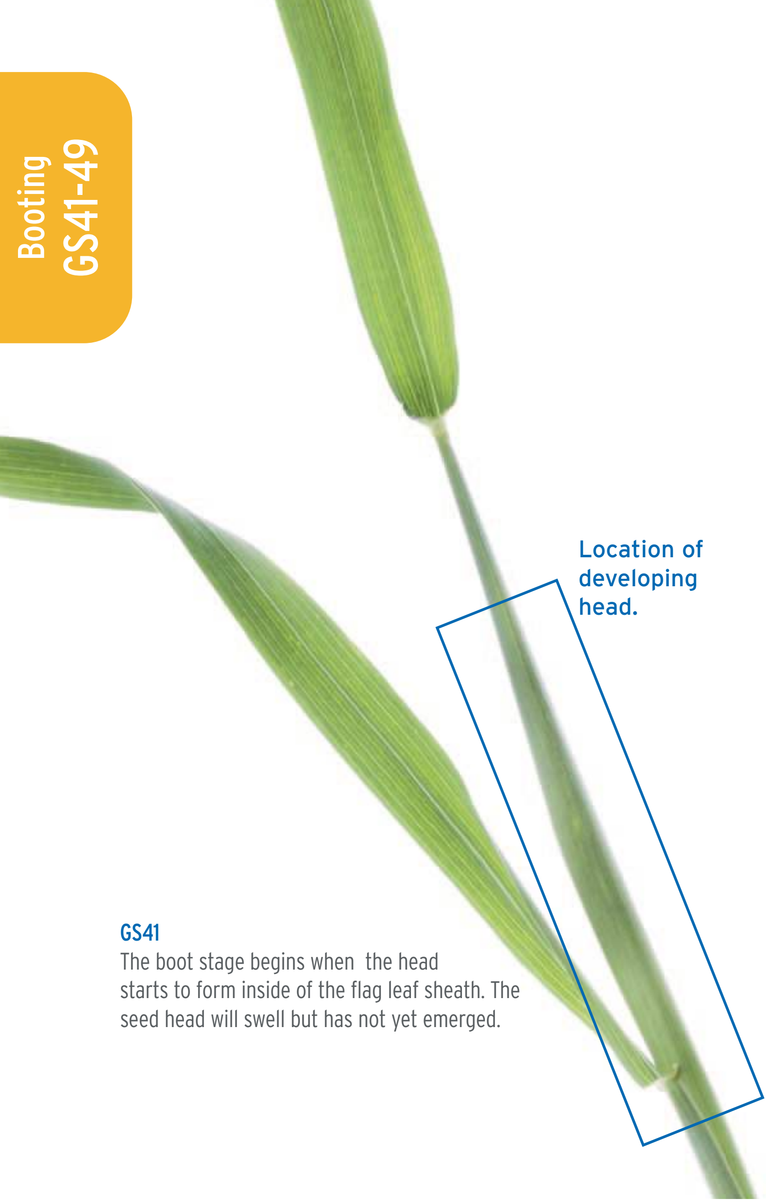
STEM ELONGATION
Flag leaf fully emerged from the whorl; ligule just visible



leaf collar
The area on the outer side of the leaf where the blade and the sheath join.

The **ligule** is a narrow membranous scale on the inner side of the leaf sheath at its junction with the blade.

Booting GS41-49



GS41

The boot stage begins when the head starts to form inside of the flag leaf sheath. The seed head will swell but has not yet emerged.

Continue to scout for insect pests and diseases!
Strobiluron fungicides should NOT be applied from GS41 through flowering.

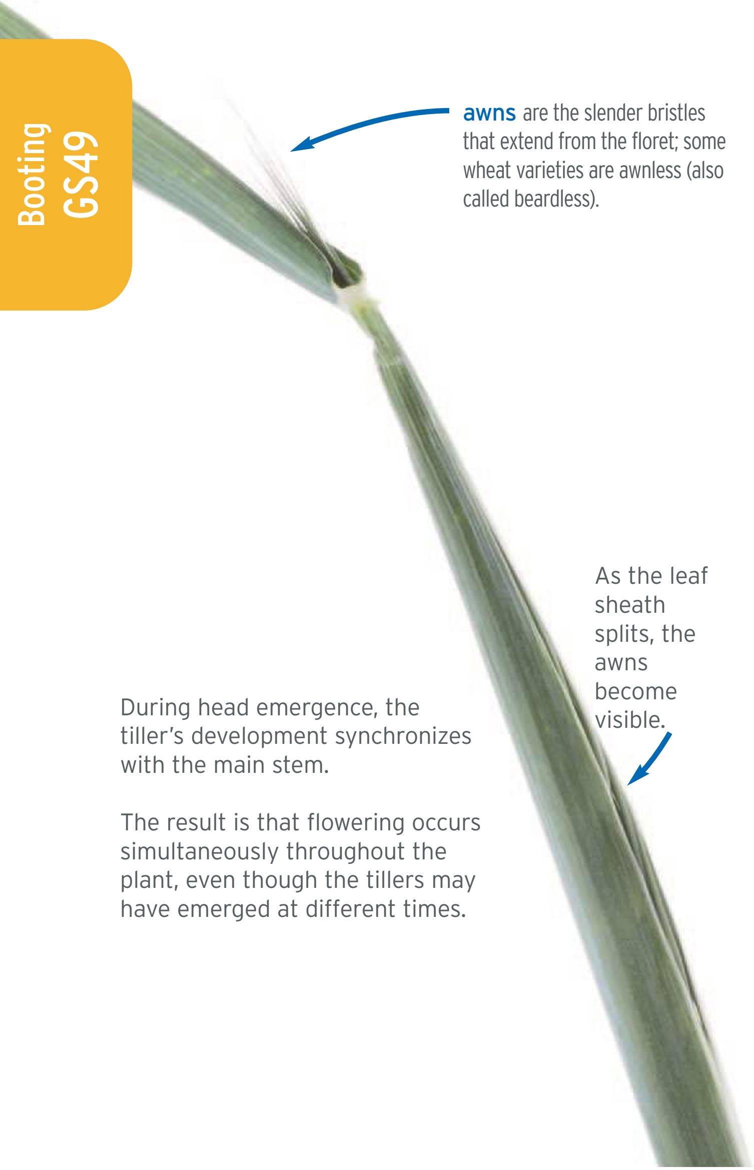
T2 fungicide timing

BOOTING
Flag leaf sheath completely grown out; head visible in the leaf sheath

Booting GS45

The developing head is pushed through the flag leaf sheath as the peduncle and sheath elongate.

Booting GS49



awns are the slender bristles that extend from the floret; some wheat varieties are awnless (also called beardless).

As the leaf sheath splits, the awns become visible.

During head emergence, the tiller's development synchronizes with the main stem.

The result is that flowering occurs simultaneously throughout the plant, even though the tillers may have emerged at different times.

T2 fungicide timing

BOOTING
First awns of the head just visible

When determining the growth stage of a field, **50% of the plants** must be at that stage or above.

Heading
GS51-59

HEADING

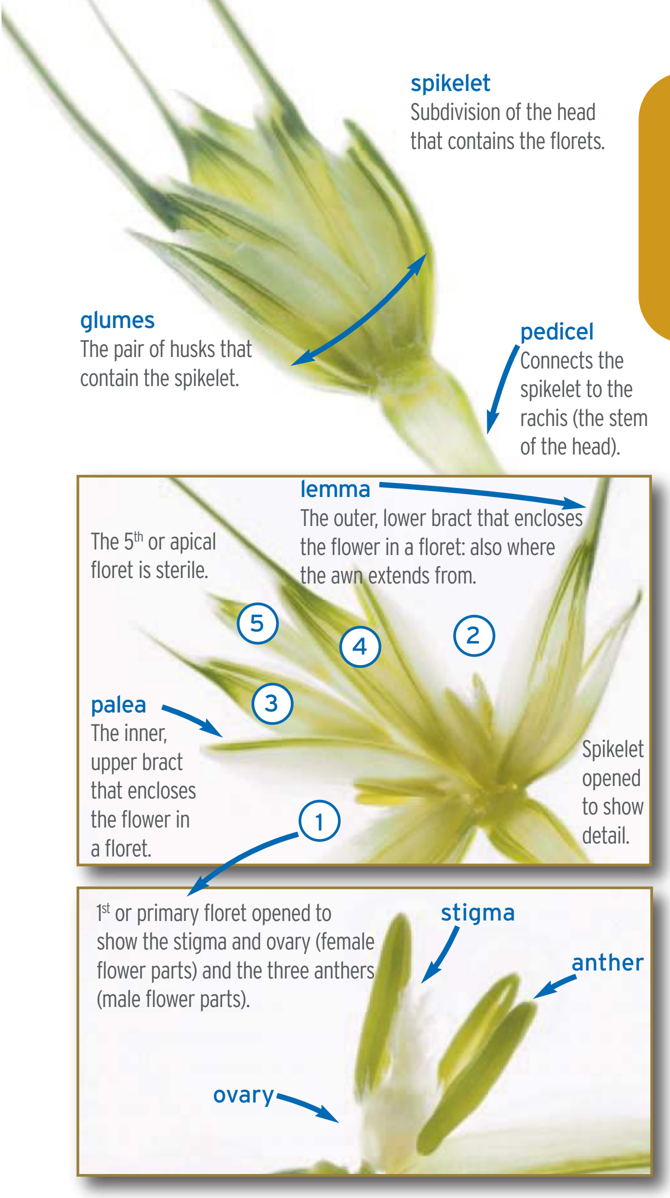
As the stem continues to elongate, the head is pushed out of the flag leaf sheath

Sheaths removed to show developing heads.

Heading GS51

HEADING

At GS51, one quarter of the head has emerged above the flag leaf ligule



HEADING

At GS55, half of the head has emerged above the flag leaf ligule

HEADING
At GS57, three quarters of the head has emerged above the flag leaf ligule

Head lifted out of sheath to show elongating peduncle.

Heading
GS59

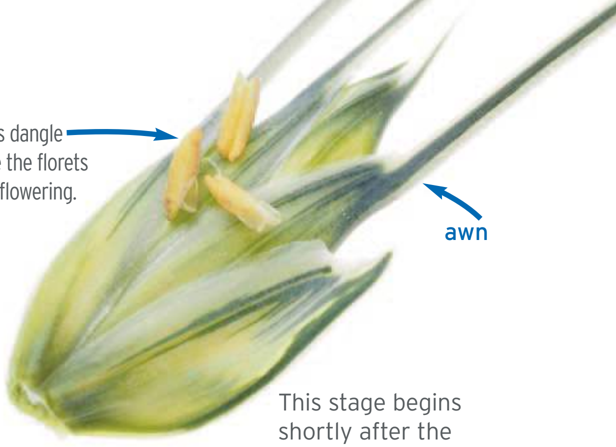
When 75 per cent of a field has heads fully emerged, it is considered to be **Day 0** for T3 fungicide timing.

HEADING
Head completely emerged from the leaf sheath and fully above the flag leaf ligule

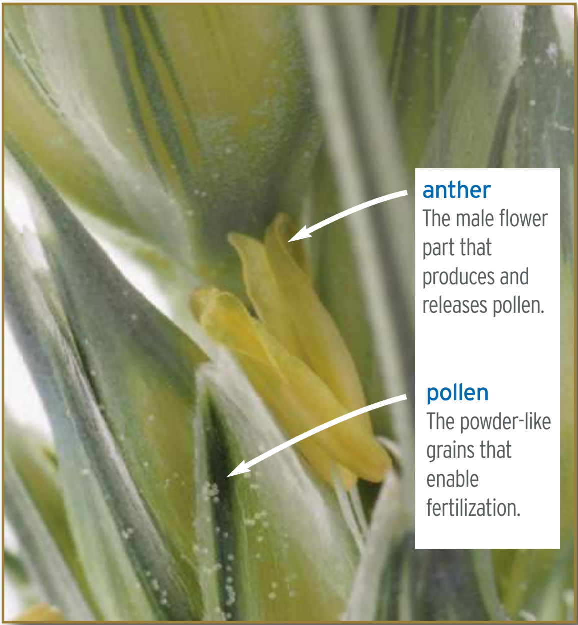
This stage completes the inflorescence emergence process.

Flowering GS61

Anthers dangle outside the florets during flowering.



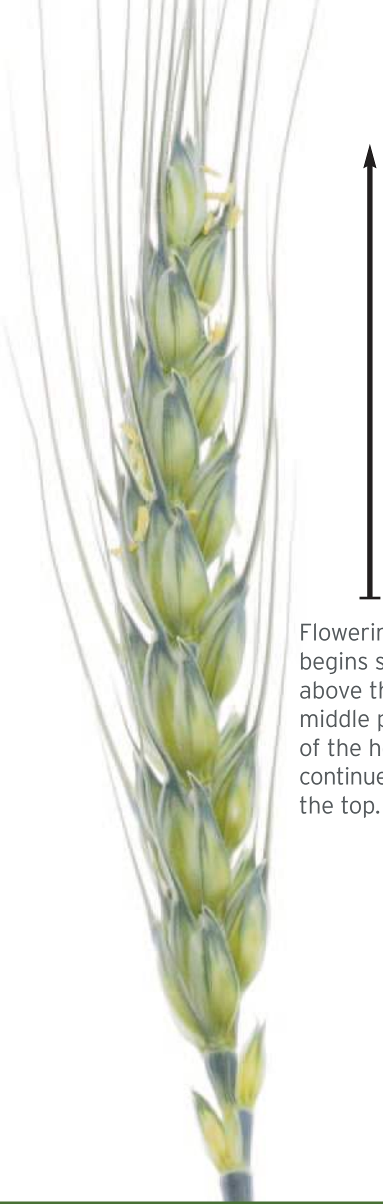
This stage begins shortly after the head has completely emerged from the leaf sheath.



Cereal crops are most susceptible to **Fusarium head blight (FHB)** during the flowering period. If using a protective T3 fungicide, **starting now**, and continuing **5 - 7 days after this stage**, is the optimum time for application.

T3 fungicide timing

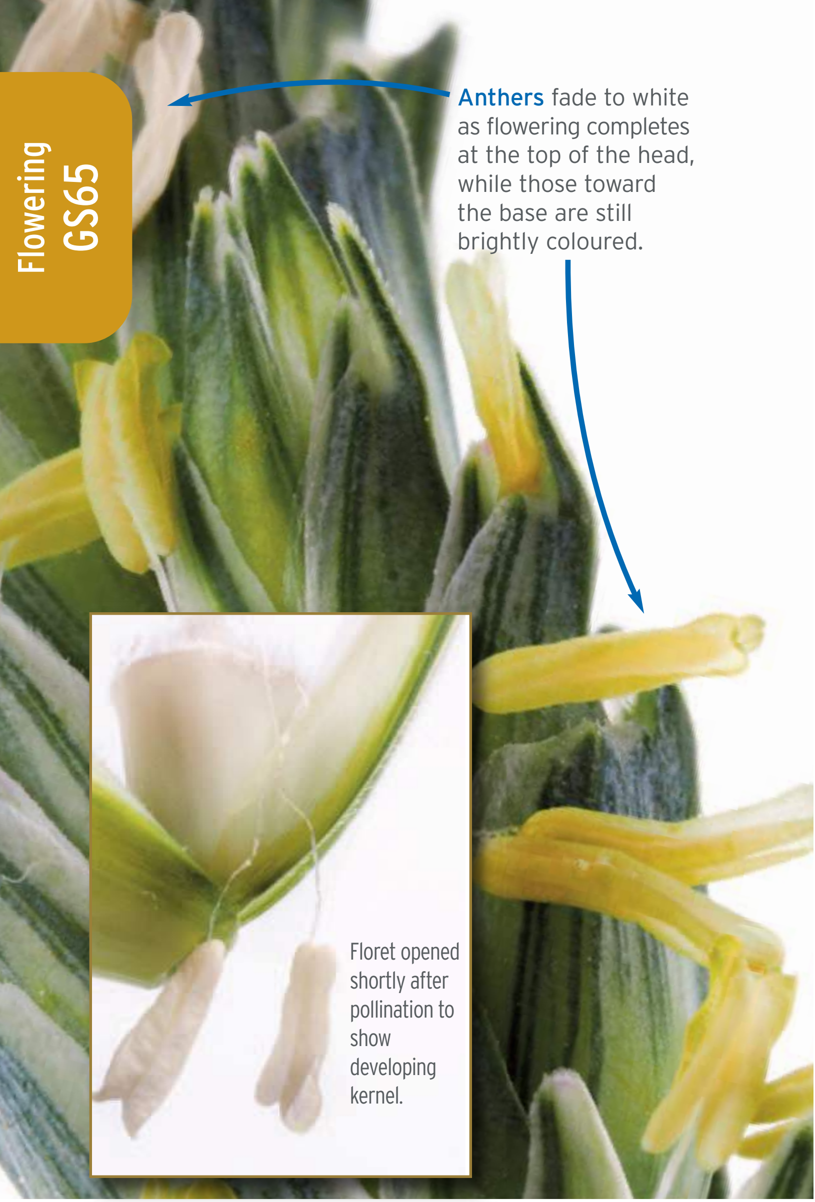
FLOWERING
Beginning of flowering



Flowering begins slightly above the middle portion of the head and continues towards the top.

The number of **flowers pollinated** determines the potential number of kernels that will develop.

KEY YIELD COMPONENT

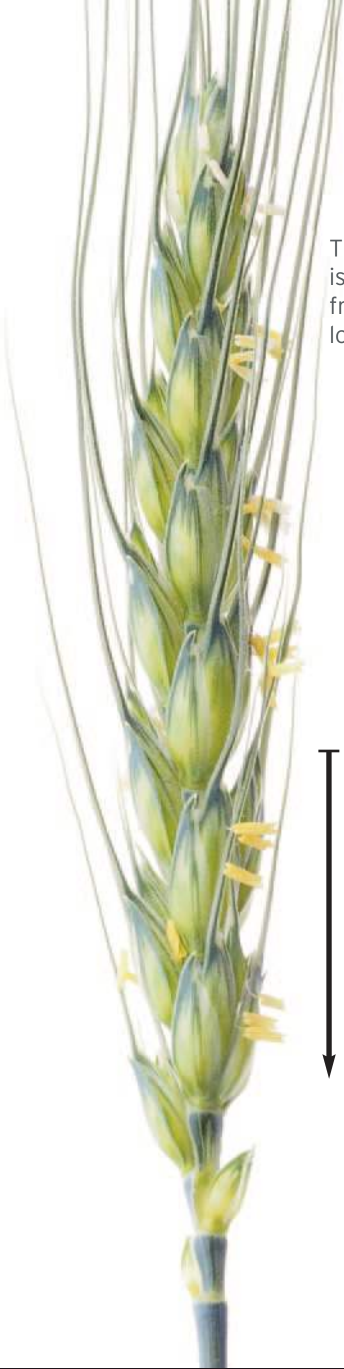


Wheat heads are **very sensitive to tank contamination.** It is essential to clean out sprayers completely (including boom end caps) before applying any products.

T3 fungicide timing

FLOWERING

Flowering complete to the top of the head



The **developing head** is still vulnerable to freeze injury during low temperatures.

Flowering continues towards the base.

FLOWERING
Flowering complete at the base of the head

Flowering
GS69

This stage signals the end of pollination.

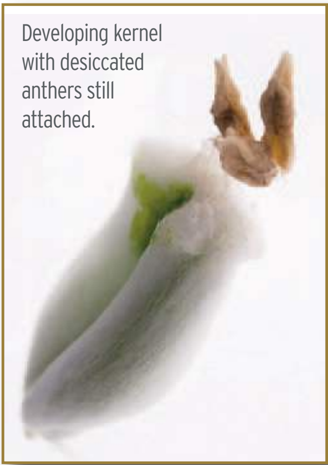
Floret outer structure removed to show developing kernel.

Milk Stage
GS71-77

The milk stage marks the beginning of **grain fill**. Kernel length is also established during this stage.

MILK STAGE
Flowering complete; kernels begin to accumulate starch and protein

At the watery ripe (**GS71**), when the kernel is squeezed, a **clear fluid** is released."



Developing kernel with desiccated anthers still attached.

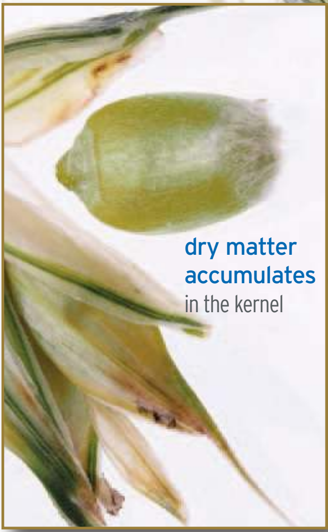
Kernel size increases but not dry matter accumulation.

Milk Stage
GS75

Adverse environmental conditions during any of the milk development stages can effect dry matter accumulation and potentially decrease yield. The longer these conditions last and the earlier they occur during grain fill, the greater the effect on yield.

MEDIUM MILK

Kernel milky ripe; milk development stage



When squeezed, **milk-like fluid** is released from the kernel.

Dough Stage
GS85

DOUGH STAGE
Kernel mealy ripe; soft but dry consistency; soft dough stage

Dough Stage GS85

Green colour of the kernel, glume and peduncle begins to fade.

Starch, nutrients and dry matter accumulate rapidly in the kernel.

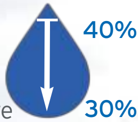
The kernel's content is a soft-doughy material.

Dough Stage
GS87

DOUGH STAGE
Kernel hard; difficult to divide with a thumbnail; hard dough stage

Dough Stage GS87

Kernels reach their **maximum dry weight** and are **physiologically mature**. Peduncle has turned yellow.



Ripening
GS92

The majority of final crop nitrogen is in the grain at this stage. The remainder is in the chaff, straw, and stubble.

RIPENING
Kernel harvest ready; straw dead

Contributors and Acknowledgements

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Optimum Planting Date: Winter Wheat