

VISUAL GUIDE

Winter Wheat

DEVELOPMENT AND GROWTH STAGING



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Other cereals



.....	Barley
.....	Oats
.....	Rye
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Introduction

Understanding the growth stages of cereals crops and how to identify them is key to successful cropping and pest management decisions.

Although there are several growth staging methods, this guide is based on the Feekes scale, which is a popular tool used in the field. It has eleven development stages with some stages having more detailed subdivisions.

The Zadoks scale is the standard scale used in research and has ten development stages, each stage having ten subdivisions. Both scales are useful to know, so this guide cross-references the Zadoks equivalents to the Feekes.

This guide uses winter wheat as an example.

However, the methods generally apply to other cereals as well and at the back of the guide are sections that showcase barley, oats, rye and triticale.

A few notes on growth staging plants:

- Select plants that represent at least 50% of the field
- Dig plants (if possible), so you can assess the entire plant
- Start at the base of plant and work your way upward
- Use a knife to split the stems and sheaths
- Look and feel for nodes

References:

Large, E. C. (1954). *Growth Stages in Cereals Illustration of the Feekes Scale*. Plant Pathology, 3: 128–129. doi:10.1111/j.1365-3059.1954.tb00716.x

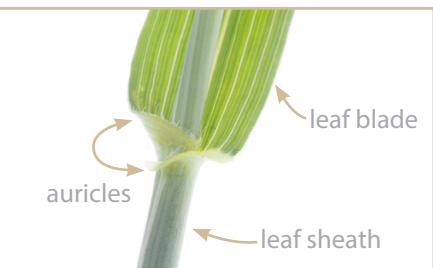
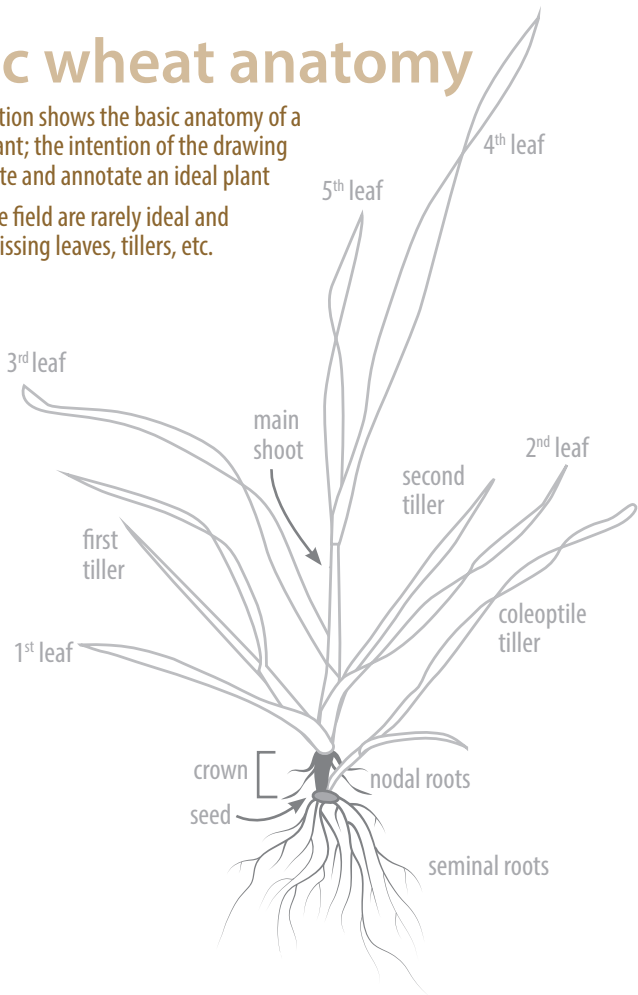
Feekes, Willem (1941). *De Tarwe en Haar Milieu [Wheat and Its Environment]*. Verslagen van de Technische Tarwe Commissie. (in Dutch (English summary)). 17: 523–888.

J.C. Zadoks, T.T. Chang, C.F. Konzal. *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 Feekes 2 plant; 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

Feekes scale for cereal growth stages

SEEDLING GROWTH	1 One shoot, first leaf through coleoptile
TILLERING	2 Tillering begins; main shoot and one tiller
	3 Tillers formed; leaves often twisted In some varieties, plant may be prostrate in appearance
	4 Leaf sheaths lengthen; beginning pseudostem erection
	5 Leaf sheaths fully elongated to form strongly erect pseudostem
STEM EXTENSION	6 First node of stem visible at base of shoot; jointing
	7 Second node of stem formed; next-to-last leaf just visible
	8 Flag leaf visible but still rolled up
	9 Ligule of flag leaf just visible
	10 Flag leaf sheath completely grown out; booting
HEADING	10.1 First awns of head just visible
	10.2 1/4 of heading process complete
	10.3 1/2 of heading process complete
	10.4 3/4 of heading process complete
	10.5 All heads out of sheath
FLOWERING	10.5.1 Beginning of flowering
	10.5.2 Flowering complete to top of head
	10.5.3 Flowering complete at base of head
	10.5.4 Flowering complete; kernel watery ripe
RIPENING	11.1 Kernel milky ripe; milk stage
	11.2 Kernel mealy ripe; soft but dry consistency; soft dough stage
	11.3 Kernel hard; difficult to divide with thumbnail; hard dough stage
	11.4 Kernel harvest ready; straw dead

Zadoks scale for cereal growth stages

Germination	00	Dry seed	Feekes scale equivalent	
	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		1
	11	First leaf unfolded		TILLERING
	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	TILLERING	
	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		3
	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	4-5	
	31	1 st node detectable	6	
	32	2 nd node detectable	7	
	33	3 rd node detectable	STEM EXTENSION	
	34	4 th node detectable		
	35	5 th node detectable		
	36	6 th node detectable		
	37	Flag leaf just visible		8
	39	Flag leaf ligule/collar just visible		9

A leaf is unfolded when its ligule is visible, or the tip of the next leaf is visible

Booting	40	-----	STEM EXTENSION	10
	41	Flag leaf sheath extending		
	45	Boot just visibly swollen		
	47	Flag leaf sheath opening		
	49	First awns visible		
Inflorescence emergence	50	First spikelet of inflorescence visible	HEADING	10.1
	53	1/4 of inflorescence emerged		10.2
	55	1/2 of inflorescence emerged		10.3
	57	3/4 of inflorescence emerged		10.4
	59	Emergence of inflorescence completed		10.5
Anthesis	60	Beginning of anthesis	FLOWERING	10.5.1
	65	Anthesis half-way		10.5.2
	69	Anthesis completed		10.5.3
Milk development	70	-----	FLOWERING	10.5.4
	71	Kernel watery ripe		
	73	Early milk		
	75	Medium milk		
	77	Late milk		
Dough development	80	-----	RIPENING	11.2
	83	Early dough		
	85	Soft dough		
	87	Hard dough		
	90	-----		
Ripening	91	Kernel hard (difficult to divide with thumbnail)	RIPENING	11.3
	92	Kernel hard (no longer dented with thumbnail)		11.4
	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		

Germination

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



Zadoks 00
Dry seed



Zadoks 01
Start of imbibition



radicle
The first root

Zadoks 05
Radicle emerged from seed

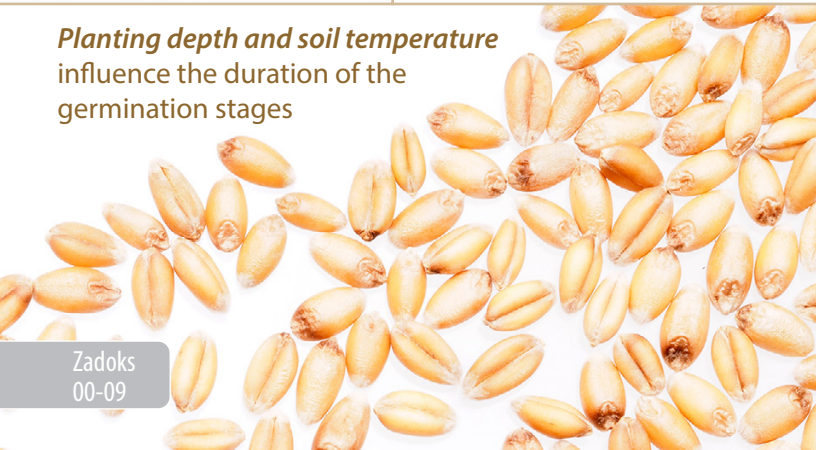


coleoptile
The round sheath that protects the first leaf

Zadoks 07
Coleoptile emerged from seed

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

Zadoks
00-09



The **first true leaf** emerges through the coleoptile's tip

Zadoks 09
Leaf just at coleoptile tip

The **coleoptile** stops growth when it encounters light above the soil surface

seed

The **seminal roots** begin developing

Seminal roots are fibrous and are produced by the seed



A close-up photograph of several young corn plants. The plants are bright green and have a single, long, narrow leaf that has just emerged from the coleoptile. The background is a clear blue sky with some light clouds. The ground is dark brown soil with some dry leaves and twigs.

Feekes

1

Zadoks 10

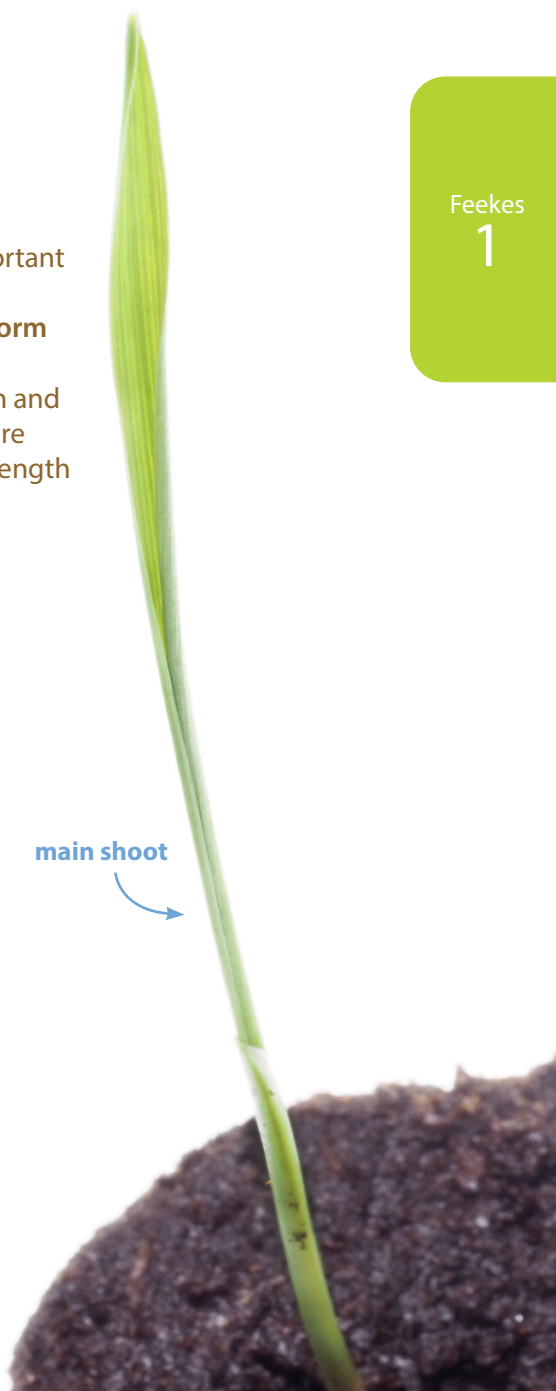
EMERGENCE | **Feekes 1** | One shoot formed;
first leaf through coleoptile

Feekes

1

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

main shoot





Feekes
2

Zadoks 21

TILLERING | **Feekes 2** | Tiller development begins

Tillers produced **in the fall** will contribute more to grain yield than those produced in the spring

Feekes
2

main shoot

tillers

The **crown** forms between the seed and soil surface



Feekes

2

main shoot

tiller

tillers

prophyll

The independent sheath at the base of each tiller

tiller

The secondary root system starts developing



Are tillers important?

Tillers are absolutely necessary for high yields

Feekes
2

1 can produce
planted seed

4-5

tillers

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

The **total numbers of tillers** a plant produces is determined by both **environmental conditions** and **genetic potential**

KEY YIELD COMPONENT

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**



In Wisconsin, the recommended planting date range for optimal tiller development in winter wheat is **September 20 to October 10**

Feekes
3

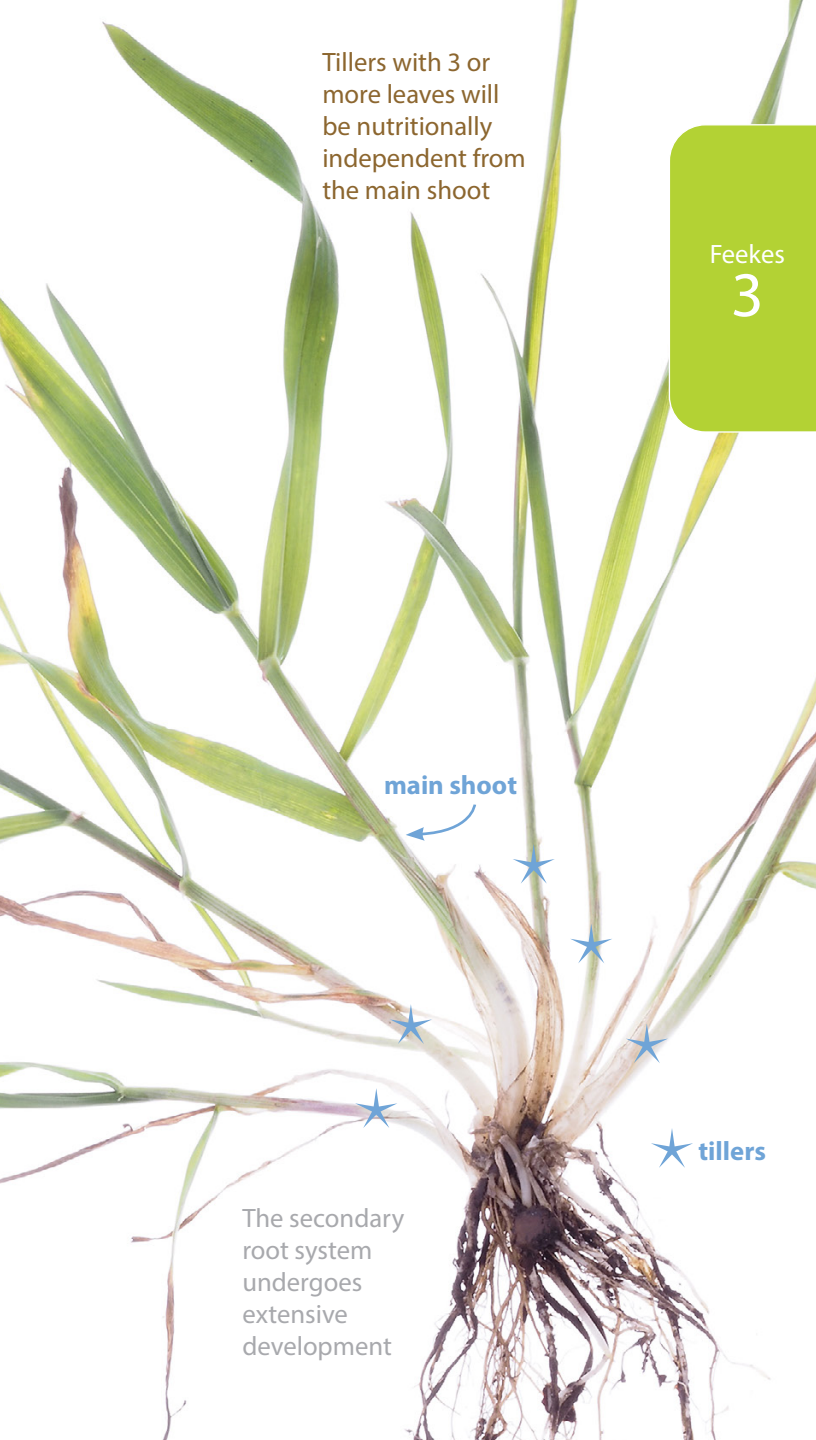


Zadoks
22-29

TILLERING | Feekes 3 | Tillering completed

Tillers with 3 or more leaves will be nutritionally independent from the main shoot

Feekes
3



main shoot

★ tillers

The secondary root system undergoes extensive development

FEEKES 3 CAN OCCUR IN FALL OR SPRING

because winter wheat development is dependent on both temperature and planting date

FEEKES 3 FALL

Tillering completes in fall,
winter dormancy occurs

FEEKES 3 SPRING

Tillering begins in the fall,
winter dormancy occurs,
tillering completes in the spring

Feekes
3

What happens during winter dormancy?

Vernalization!

When temperatures fall below 50 degrees Fahrenheit for typically 3-6 weeks, the plant initiates

differentiation

the growing point changes from vegetative or leaf producing to reproductive or spikelet producing

The growing point is at the **double ridge stage** and is still protected in the crown below the soil surface

The number of florets initiated during this stage will determine the **potential** number of kernels per head

KEY YIELD COMPONENT



Dig plants as soon as the soil thaws, bring inside and place in a warm (preferably moist) area for a few days, then check for root regrowth



regrowth

Root regrowth will develop from the crown and appear a vibrant white compared to the older roots

Feekes
3



FACTORS AFFECTING WINTER SURVIVAL

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

4 STEPS TO ASSESS STANDS IN EARLY SPRING

- 1 Venture out and get a general overview of the fields** — vibrant green patches may be interspersed with drab brown areas, but brown does not always indicate winter-killed plants
- 2 Check for winter survival** — identify several representative plants and 1) dig plants and bring inside to check for root regrowth or 2) wait a week and revisit to check for regrowth in the field
- 3 Do a plant count** —
below 12 live plants per square foot is an automatic replant; 12-15 live plants per square foot requires more consideration for a replant decision; 15-22 live plants per square foot may recover and reach maximum yield potential; over 22 live plants per square foot means you're good to go!
- 4 Consider a nitrogen application** — the optimal time to apply nitrogen to winter wheat in Wisconsin is during green up; for recommendations and rates, consult UW-Extension publication A2809 *Nutrient Application Guidelines for Field, Vegetable and Fruit Crops in Wisconsin*

In Wisconsin, the growth stage at green up can be **Feekes 3** or **Feekes 4** depending on planting date and environmental conditions

**GREEN
UP**

→ **How to do a plant count**

Count the number of plants in a 3-foot length

Do this for at least 3 areas

Take the average of the counts

Multiply that number by 4

Then divide by the row width (inches)

EXAMPLE

*The 3 counted areas have
40, 35 and 45 plants*

*Add 40, 35 and 45 and then
divide by 3, the average = 40*

Multiply $40 \times 4 = 160$

*Divide 160 by 7.5 inches =
21 plants/square foot*



Feekes
4

Zadoks 30

TILLERING | **Feekes 4** | Leaf sheaths lengthen,
pseudostem erection begins

**This is an important time for weed control
and/or nitrogen applications**

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 this stage, these leaf sheaths lengthen, making the plants stand more upright

Feekes

4



This is the last stage that some herbicides
can be used without risk of injury!

Always check and follow herbicide labels

Feekes

5



Zadoks 30

TILLERING | **Feekes 5** | Leaf sheaths fully
elongated, pseudostem strongly erect

Feekes
5

plants cut at
soil surface

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

less than 1/8 inch

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

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

KEY YIELD COMPONENT

Feekes
6

1st node

1st node

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

Zadoks 31

STEM EXTENSION | Feekes 6 | First node of the stem visible at the base of the shoot; jointing

1st node



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

1st node

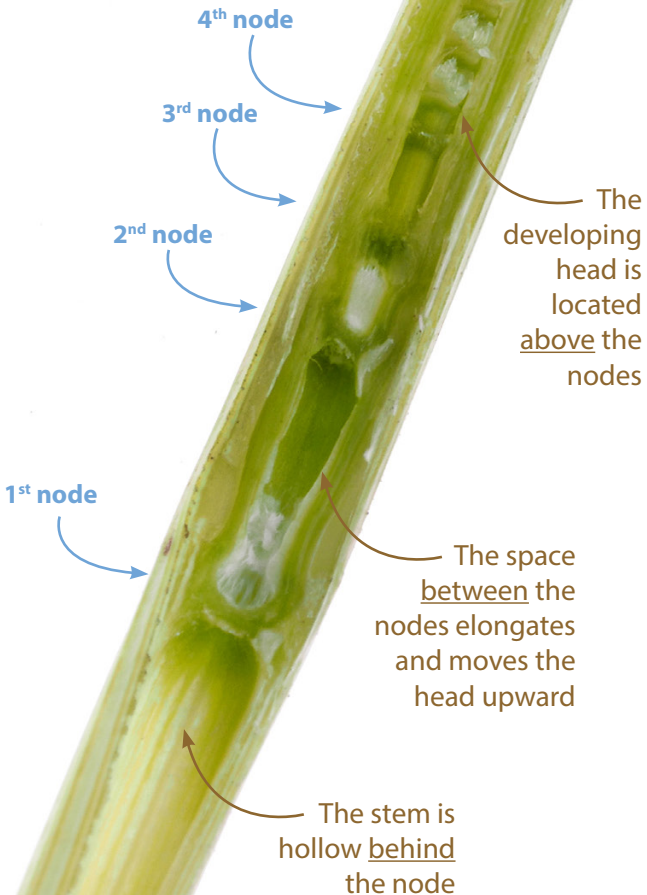


leaves removed to show nodes



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



Feekes 6 plant
shown with all
leaves intact



Feekes
6

*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 number of tillers that form heads
has been determined by this stage***

KEY YIELD COMPONENT

Feekes
7

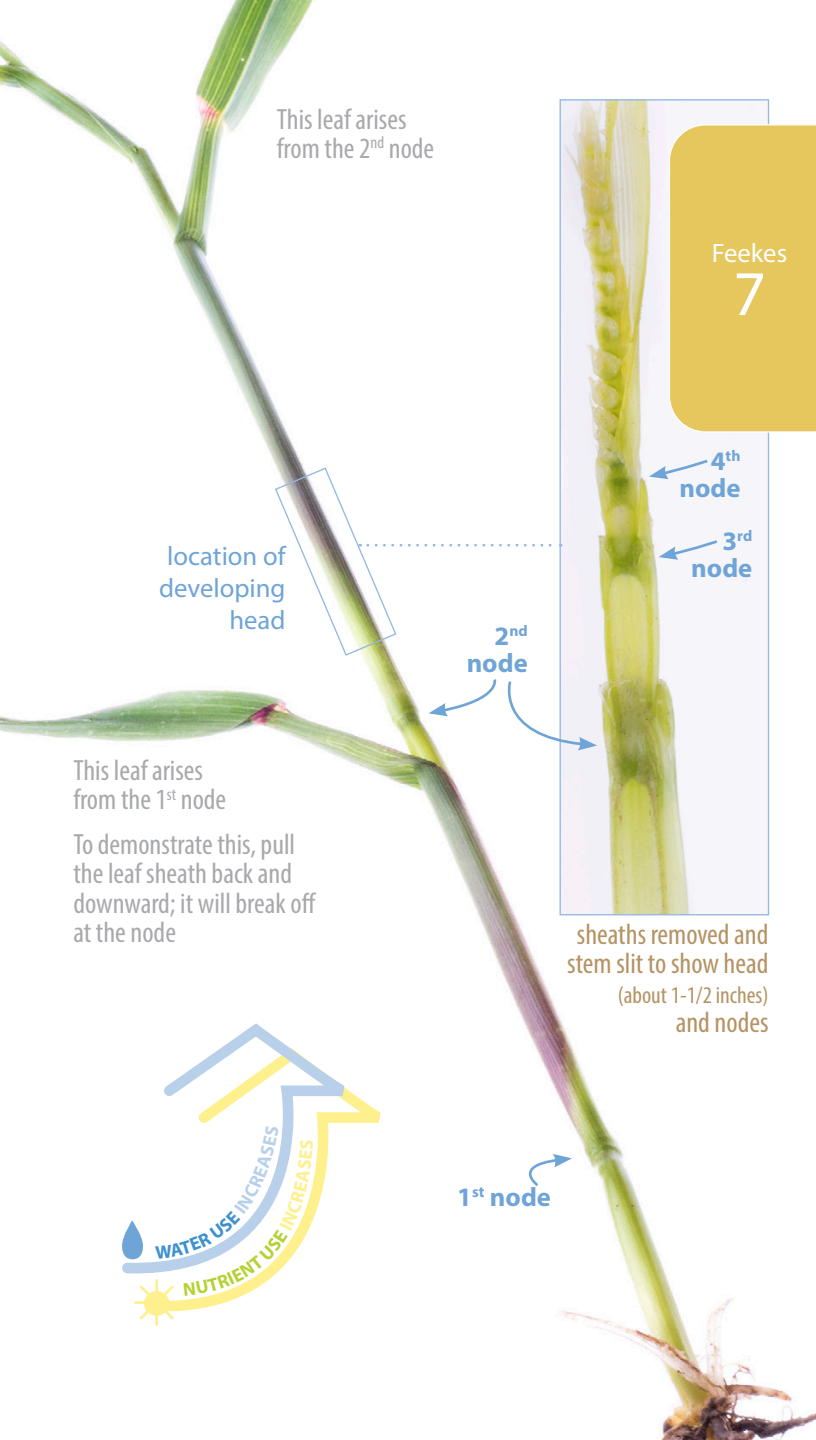
2nd node

SCOUT NOW!

THIS WILL GIVE YOU
THE INFORMATION
YOU NEED TO MAKE
GOOD MANAGEMENT
DECISIONS ABOUT
PROTECTING THE
FLAG LEAF AT THE
NEXT STAGE

1st node

STEM EXTENSION | Feekes 7 | Two nodes
visible above the soil line



This leaf arises from the 2nd node

Feekes
7

location of developing head

4th node

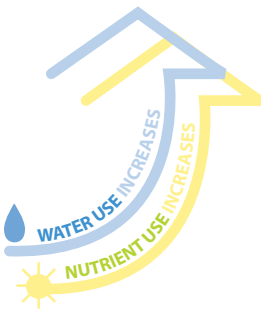
3rd node

2nd node

This leaf arises from the 1st node

To demonstrate this, pull the leaf sheath back and downward; it will break off at the node

sheaths removed and stem slit to show head (about 1-1/2 inches) and nodes



1st node

Feekes
8

flag leaf

This is a **critical time** to make foliar fungicide application decisions!

flag leaf



FLAG LEAF FACTS

The flag leaf accounts for over 50% 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

The **flag leaf** arises from the 4th node

#4

This leaf arises from the 2nd node

#2

This leaf arises from the 3rd node

#3

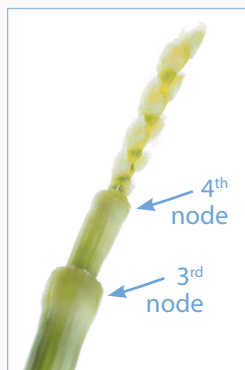
HOW DO YOU KNOW IF IT'S THE FLAG LEAF?

Identify the leaf arising from the 1st node

Call this leaf #1 and count upward

The flag leaf will be leaf #4

location of developing head



sheaths removed to show head and nodes

2nd node

#1

This leaf arises from the 1st node (see tip on Feekes 7)

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

Feekes

9



Zadoks 39

STEM EXTENSION | **Feekes 9** | Flag leaf fully emerged from the whorl; ligule just visible



flag leaf

ligule

Feekes
9

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

***CONTINUE TO SCOUT FOR
INSECT PESTS AND DISEASES !***

Feekes
10

**CONTINUE TO SCOUT
FOR INSECT PESTS
AND DISEASES !**



location of
developing
head

**At this stage, the Feekes
scale subdivides:**

- 10.1 Head emerging
- 10.2 Heading 1/4 complete
- 10.3 Heading 1/2 complete
- 10.4 Heading 3/4 complete
- 10.5 Heading complete

and then subdivides again

- 10.5.1 Beginning flowering
- 10.5.2 Flowering complete to top of spike
- 10.5.3 Flowering complete at base of spike
- 10.5.4 Kernels watery ripe

STEM EXTENSION | **Feekes 10** | Flag leaf sheath
completely grown out; head visible in the
leaf sheath; booting

Feekes
10

sheath
removed to
show detail
of developing
head

spikelets

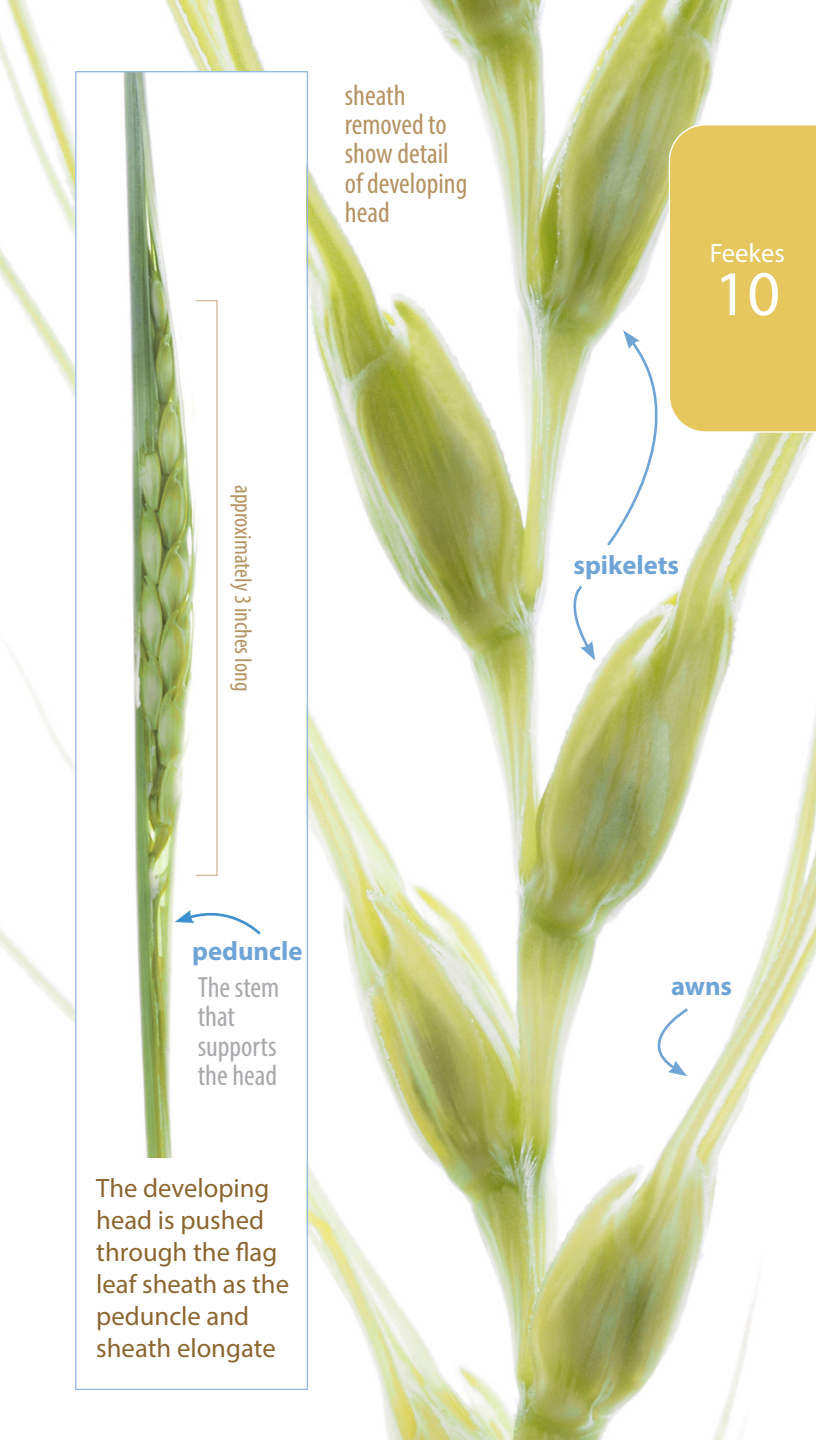
awns

approximately 3 inches long

peduncle

The stem
that
supports
the head

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



Feekes
10.1

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

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



Feekes
10.1



Feekes
10.2

Feekes
10.1



Feekes
10.2

Zadoks 53

HEADING | Feekes 10.2 | 1/4 of the head
emerged from the leaf sheath

Feekes
10.1

Feekes
10.2

Feekes
10.2

sheaths removed
to show
developing
heads



Feekes
10.3

HEADING | Feekes 10.3 | 1/2 of the head
emerged from the leaf sheath

Zadoks 55

spikelet

Subdivision of the head that contains the florets

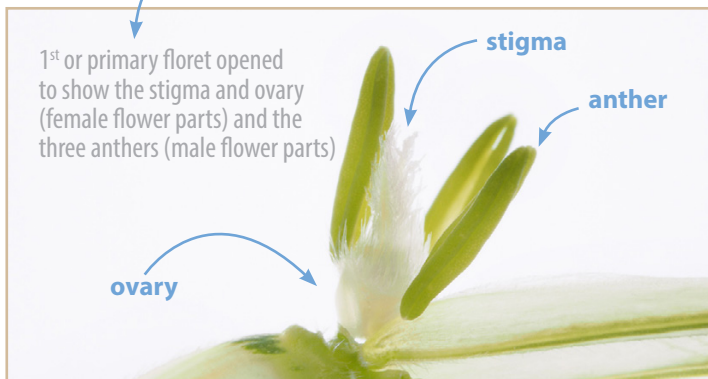
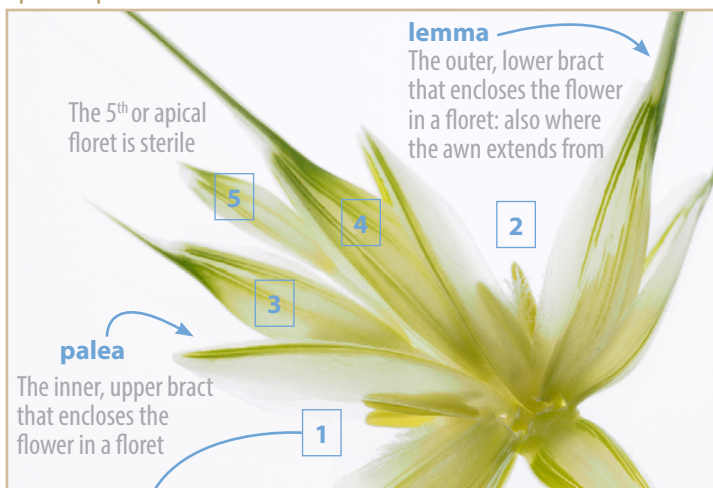
glumes

The pair of husks that contain the spikelet

pedicel

Connects the spikelet to the rachis (the stem of the head)

spikelet opened to show detail





Feekes
10.4

Zadoks 57

HEADING | Feekes 10.4 | 3/4 of the head
emerged from the leaf sheath

Feekes
10.4



head lifted out of sheath to
show elongating peduncle

Feekes
10.5



Zadoks 59

HEADING | **Feekes 10.5** | Head completely
emerged from the leaf sheath

This stage completes the heading process

Feekes
10.5



Feekes
10.5.1

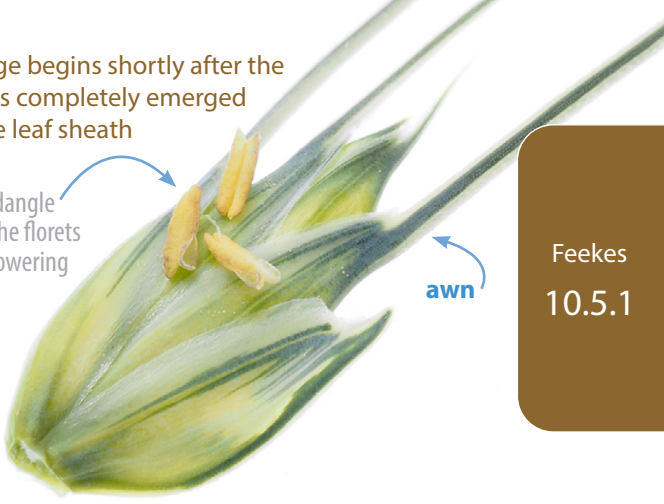
Starting now and continuing 5-7 days **after this stage** is the optimum time for fungicide application to suppress *Fusarium* head blight (FHB), also called head scab



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

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

Anthers dangle outside the florets during flowering



awn

Feekes

10.5.1

The number of flowers pollinated determines the number of kernels that will develop

KEY YIELD COMPONENT



anther

The male flower part that produces and releases pollen

pollen

The powder-like grains that enable fertilization

Feekes
10.5.2

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

Flowering continues toward the base

FLOWERING | Feekes 10.5.2 | Flowering complete to the top of the head



Anthers fade to white as flowering completes at the top of the head, while those toward the base are still brightly colored

Feekes
10.5.2



florete opened shortly after pollination to show developing kernel

Feekes

10.5.3



Zadoks 69

FLOWERING | **Feekes 10.5.3** | Flowering
complete at the base of the head



This stage
signals
the end of
pollination

Feekes
10.5.3



floret outer structure removed to
show developing kernel

This is the beginning of the **grain filling stages**; kernel length is established during this stage

Feekes

10.5.4



Zadoks 71

FLOWERING | **Feekes 10.5.4** | Flowering complete; kernel watery ripe



Feekes
10.5.4

When squeezed, *clear fluid*
is released from the kernel



developing kernel with
desiccated anthers
still attached

Kernel size increases
but not dry matter
accumulation



Feekes

11.1



Zadoks 75

RIPENING | **Feekes 11.1** | Kernel milky ripe;
milk stage



Dry matter accumulates
in the kernel

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





Feekes
11.2

Zadoks 85

RIPENING | Feekes 11.2 | Kernel mealy ripe;
soft but dry consistency; soft dough stage



Feekes
11.2

Green color 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





Feekes
11.3

Zadoks 91

RIPENING | Feekes 11.3 | Kernel hard; difficult to divide with a thumbnail; hard dough stage



Feekes
11.3

Kernels reach their **maximum dry weight** and are **physiologically mature**



Kernel
moisture
decreases from
40% to 30%



Feekes

11.4



Kernel
moisture
decreases from
30% to 15%



Zadoks 92

RIPENING | Feekes 11.4 | Kernel harvest ready;
straw dead

Green plant tissue fades to *straw*

Feekes

11.4



Other
cereals



To distinguish barley from wheat during the vegetative stages, check the auricles — barley auricles are long, slender and hairless, while wheat auricles are blunt and hairy



Barley

Auricles long, slender and hairless; leaf sheath and blade usually hairless (scattered hairs on some varieties); ligule medium length; leaf blades twist clockwise

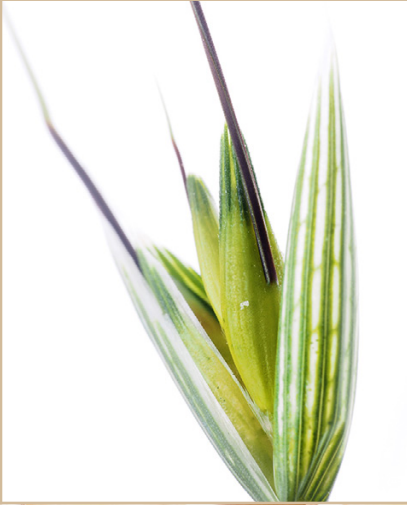


Other
cereals

Other
cereals



*To distinguish oats
from wheat during the
vegetative stages, check
the auricles — oats lack
auricles, while wheat
auricles are blunt and hairy*



Oats

Auricles absent; leaf sheath and blade hairless (scattered hair on some varieties); ligule medium length; leaf blades twist counter-clockwise



Other
cereals



Oats


A simple method to distinguish oats from all other cereals during the vegetative stages is to observe the twist of the leaves; when viewing from above, oat leaves will have a counter-clockwise curl, all other cereals' leaves curl clockwise



All other cereals



Other
cereals



*To distinguish rye
from wheat during the
vegetative stages, check
the auricles — rye auricles
are short and hairless,
while wheat auricles are
blunt and hairy*



Rye

Auricles very short and hairless; leaf sheath and blade have an inconsistent degree of hairiness; ligule short; leaf blades twist clockwise



Other
cereals

Other
cereals



The auricles of both triticale and wheat are blunt and hairy, so they are difficult to distinguish from each other during the vegetative stage

An alternative method is to remove a seedling from the soil and check the grain shell; triticale shells are oblong in shape and dark in color, while wheat grain shells are oval and lighter



Triticale

Auricles blunt and hairy, leaf sheath and blade hairy; ligule of medium length; leaf blades twist clockwise



Other
cereals

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