SDSU Extension

iGrow Wheat

BEST MANAGEMENT PRACTICES

Chapter 3:
Winter and Spring Wheat Growth Stages

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The ability to correctly identify the various wheat growth stages is crucial for comparing studies and assessing management options. Many agricultural management products have labels that are based on growth stages. This chapter discusses growth stages according to the Zadoks (prefix Z) and Feekes (prefix F) systems as well as critical management questions at those growth stages.

Early growth stages

The early season growth of wheat is depicted in Figure 3.1. During these early growth stages, agronomists discuss growth and development in terms of leaves. The development of winter and spring wheat is comparable except the early development of winter wheat occurs in the autumn, while in spring wheat development occurs during early spring. Generally, the length of a given early growth season stage is shorter in spring wheat than in winter wheat. The wheat leaf stages are described below.

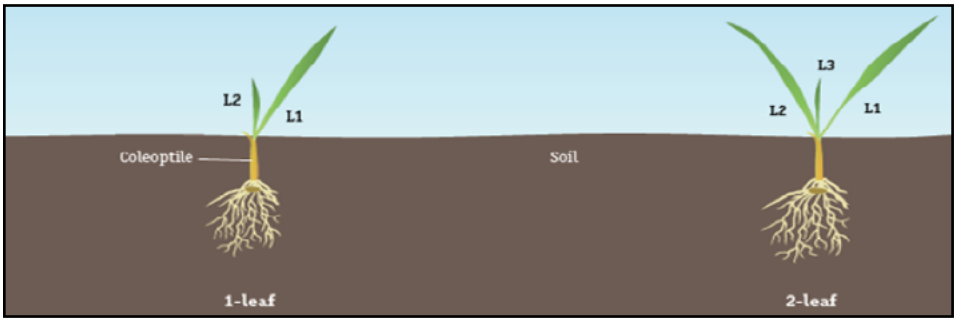

Figure 3.1. The earliest stages of wheat growth. (Source: SDSU)

1. *Early development*–begins with the seed imbibing water, swelling, and the elongation of the radicle or root, the seminal roots, and the main shoot enclosed within a shoot sheath or coleoptile. As the coleoptile breaks the soil surface, it ceases growth. Typically, the coleoptile can grow from 2 to 4 inches in length. Planting seeds deeper than the length of their coleoptiles can grow often leads to significant stand reductions at emergence.

2. *One-leaf stage*–shortly after the coleoptile breaks the soil surface, the first leaf (L1), at stages Z10 or F1 appears and continues elongating until its leaf collar is visible (1-leaf stage). A leaf is not counted until its leaf collar is visible. By this time the second leaf (L2) at stages Z12 or F1.2 is partially emerged.

3. *Two-leaf stage*–the second leaf elongates until its leaf collar is visible (2-leaf stage). The third leaf (L3) at stages Z14 or F1.3 is partially emerged.

4. *Third-leaf stage*–the third leaf (L3) elongates until its leaf collar is visible (3-leaf stage). During L3 elongation, the first primary tiller (T1) elongates and appears in the axis between L1 and the main stem (L2 and L3). It is between the 2- and 3-leaf stages that some wheat plants can develop differently. At this time, a tiller, called the coleoptile tiller, or T0, can develop in the axis between the coleoptile and main stem shoot (L1, L2, and L3). A fully developed T0 tiller is shown in Figure 3.3. The T0 tiller at stages Z20 or F2 is enclosed within the coleoptile sheath, and will eventually appear above the ground by the 6-leaf stage. The fourth leaf (L4) is partially emerged.

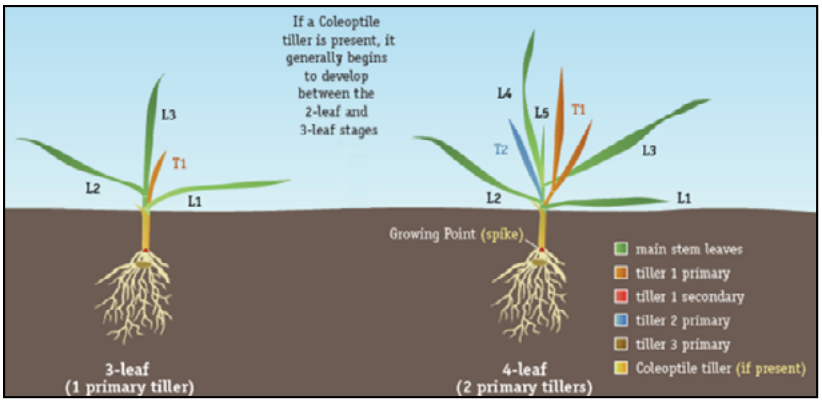

Figure 3.2. Wheat growth stages through the fourth leaf. (Source: SDSU)

5. *Fourth-leaf stage*–the fourth leaf elongates until its leaf collar is visible (4-leaf stage). During L4 elongation, a second tiller (T2) appears in the axis between L2 and the main shoot (elongating L3). The fifth leaf (L5) at stages Z22 or F2.2 is partially emerged.

6. *Fifth-leaf stage*–the fifth leaf elongates until its leaf collar is visible (5-leaf stage). During L5 elongation, the third tiller (T3) at stages Z23 or F2.3 appears in the axis between L3 and the main shoot (L4, L5, and the elongating L6). The sixth leaf (L6) is partially emerged.

7. *Sixth-leaf stage*–by the 6-leaf stage a number of changes have occurred (Fig.3.3). The sixth-leaf has elongated and its leaf collar is visible. A secondary tiller (T1.1) appears in the axis between the lowest leaf and next higher leaf on the T1 primary tiller shoot.

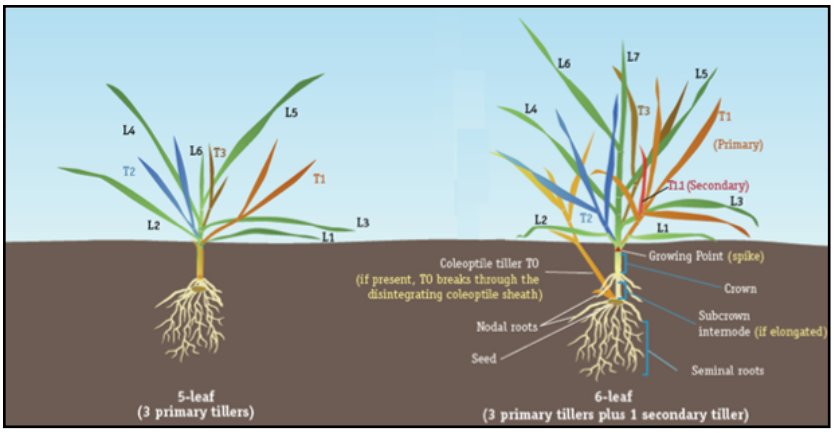

Figure 3.3. Wheat growth stages through the sixth leaf. (Source: SDSU)

Any T0 tiller initiated at Step 4, will grow, elongate, break through the coleoptile sheath, which has ceased growth, and eventually emerge above ground. The occurrence of T0 tillers is relatively low in wheat. Coleoptile tillers may develop to a small extent in spring, but more so in winter wheat. Recently, there has been an increased interest in breeding winter wheat plants with a higher occurrence of T0 development in their germplasm. Some researchers believe T0 tillers enhance the ability of the plant to increase yield and/or compensate for yield losses due to poor stands or winterkill.

Another feature that is depicted at the 6-leaf stage is an elongated sub-crown internode (SCI). In some wheat seedlings, the SCI elongates while in other seedlings it does not. In cases where a T0 tiller is present, elongation of the SCI will elevate the crown area above the seminal roots and T0 tiller (Fig. 3.1). However, if the SCI does not elongate, the crown area remains immediately adjacent to the T0 tiller (if present) and/or seminal roots where they are bunched together.

Systematic notation of spring wheat growth stages

This growth and development guide is shown in Table 3.1 and Table 3.2. Two accepted systems of growth stage definition (Zadoks and Feekes) are listed side by side. This chart format is intended to illustrate and discuss the various stages that a spring wheat and a winter wheat plant will accomplish in a typical Dakotas and Minnesota growing season. Tables 3.1 and 3.2 use both the Zadoks and Feekes systems as outlined in the Minnesota Extension publication, *Growth and Development Guide for Spring Wheat*, (Simmons et al. 1995). These plant staging systems are commonly used in wheat. Neither system is decidedly better than the other, but depending on growth stage, one might be better than the other. For example, the Zadoks system is more detailed from germination through the boot stage and from the milk stage through the late hard dough stage or physiological maturity, while the Feekes system is more detailed from head emergence through the flowering stages.

In addition, South Dakota historical climate data is given. Included in the charts is the average number of days and the range in days to a given growth stage after seed germination. Also noted in the charts are the average calendar date and range in calendar dates when 50% of the state spring wheat crop has attained a given growth stage. The general growth and development facts and management suggestions are listed by growth stage. The numerical information is not exact, and variables like the number leaves, nodes, and days may vary slightly.

Table 3.1. Spring wheat management guide – Zadoks and Feekes stage descriptions, days after emergence, and date that is 50% of the state crop acreage has reached a given stage.

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
0		**Germination**		**Acres Seeded**	H_2O, O_2, and minimal soil temperatures of 34 to 36°*F* are required	Use high quality seed. Plant as soil temperatures near 35°*F*.
01		Dry kernel.		*Range:* Apr 14 to Apr 23	The environment from planting through joining significantly affects the number of plants/ft^2.	Timely seeding by April 21 helps kernels to develop and fill before high July temperatures reduce yield and test weight.
05		Kernel absorb H_2O.				
07		Radicle emerged.		*Avg.:* Apr 22	Emergence – 6 to 8 d.	
09		Coleoptile emerged. 1st leaf at coleoptile tip.				
1	**1**	**Seedling development**			Early maturity varieties produce 7 while late varieties produce 9 leaves. A new leaf emerges every 3-5 d.	Semi-dwarf varieties have little if any SCI–seed them 1-2" deep.
10+		1st leaf through coleoptile.	**0**			Standard varieties may or may not have a SCI–seed them 1-3" deep.
11		1st leaf unfolded.	**7**/6-8		1st tiller appears as the 4th leaf elongates.	
12		2nd leaf unfolded.	**14**/11-16			Do not seed less than 1" or more than 3" deep depending on variety type (semi-dwarf or standard).
13		3rd leaf unfolded.	**19**/16-22		The crown and seed can be seperated by a short sub-crown intermode (SCI) in spring wheat; compared to a longer SCI in winter wheat.	
14		4th leaf unfolded.	**24**/21-28			A seeding rate of at least 1.2 but no million seeds/ acre is suggested.
15		5th leaf unfolded.	**29**/25-33			
19		9th leaf unfolded. *+ 2nd number=no. leaves 50-100% emerged.*				
2	**2**	**Tillering**			The MS + 3-5 tillers develop. Tiller that emerge after Z16 often abort. Cool-wet years may result in one or two additional tillers.	Seeding rates of 1.2 million seeds/acre, early seeding dates and a 1-3" seeding depth promotes tillering; while higher seeding rates, later seeding dates, and deeper seeding suppress it.
20++		Main shoot (MS) only.				
21		MS +1 tiller visible.	**19**/16-22		Cool weat weather/ high ferility increase tiller numbers while hot dry weather/low fertility reduce them.	Early-season fungicides, if warranted by disease pressure, are applied around this stage.
22		MS +2 tiller visible.				
23		MS +3 tiller visible.	**29**/25-33		The environment from tillering through jointing significantly affects the number of heads/plants.	Apply seasonal N before jointing (Zadoks 31) for maximum yield response.
24		MS +4 tiller visible.				
25		MS +5 tiller visible. *++2nd number=no. visible tillers*				Wheat tolerates most herbicides at the tillering stage.

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
3		**Stem Elongation or Jointing**			Internode elongation begins at the 4th node in a plant with about 9 leaves. The internode below the head (peduncle) is a major part of the stem. The environment from jointing through flowering significantly affects the total number of heads/plant. Moderate to severe yield loss at 24º*F* for 2 h.[4]	Fungicides, if justified by variety susceptibility or foliar fungicide disease pressure, are often applied as the flag leaves fully emerge at Zadoks 39 or Feekes 9. Do not apply herbicides after Zadoks 39 or Feekes 9. The developing reproductive organs in the head may be sensitive to herbicides, and if later exposed at flowering, may be injured. Read/understand labels if using herbicides from Zadoks 39 to 89.
31	**6**	1st node detectable.	**32**/28-36			
32	**7**	2nd node detectable.				
33		3rd node detectable.				
37	**8**	Last leaf (flag leaf, FL) just visiable.	**41**/38-44			
39	**9**	FL collar just visiable.	**44**/41-47			
4		**Boot**		**Boot** *Range:* Jun 3 to Jun 13 *Avg.:* Jun 11	The FL is more exposed to hail, frost, and pests The FL is a major photosynthetic surface. The environment from boot through late hard dough affects kernel wt. Moderate to severe yield at 28º *F* for 2 h.[4]	Because the flag leaf is a major photosynthetic surface and major contributor to yield–1st priority should be given to protecting it and the developing head until the wheat is harvested.
41		FL sheath begins to elongate.				
43		Boot begins to swell				
45	**10**	Boot swollen, “in boot.”	**9**/49-53			
47		FL sheath opens.				
49		First awns visible.				
5		**Head Emergence**		**Head fully visible** *Range:* Jun 14 to Jul 25 *Avg.:* Jun 23	Head is fully exposed to frost, hail. and pests. Plant attains final height Severe yield loss at 30ºF for 2 h.[4]	Air temperatures of 25-28º*F* with good soil moisture and higher temperatures of 30-32º*F* under water stress, often cause damage. Apply protectants if justified. Do not apply Strobilurian fungicides if risk of scab is high.
51	**10.0**	Tope of head just visible.				
53	**10.2**	25% of head visible.				
55	**10.3**	50% of head visible.				
57	**10.4**	75% of head visible.				
59	**10.5**	100% of head visible.	**54**/49-58			
6		**Flowering (anthesis)**			Single head take about 4 d. to pollinate. Temperatures nearing 30º*F* or lower can cause floret sterility; white awns or white heads, lower stem damage, leaf discoloration and a yield reduction.	Apply protectants if justified. Fungicides used to manage *Fusarium* head blight (scab) are best applied at about Zadoks 61 or Feekes 10.5.1 (flowering begins). Do not apply Strobilurin fungicides if head scab risk is high.
61	**10.5.1**	Flowering begins (anthers appear) in the middle of head.				
65	**10.5.2**	50% of florets have flowered, flowering is complete at top of head				
69	**10.5.3**	All florets have flowered, flowering is complete at base of head	**60**/55-64			

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
7		**Milk development**			Starch and protein content determination starts. Ten to 14 days after flowering protein and starch start to accumulate rapidly. Moderate to severe yield loss at 28°*F* for 2 h.[4]	Nitrogen used to increase grain protein should be applied after flowering and by the early milk stage at Zadoks 73 or slightly after Feekes 10.5.4.
71	**10.5.4**	Kernel watery ripe				
73		Early milk.				
75	**11.1**	Medium milk.				
79		Late milk	**69**/65-73			
8		**Dough development**			Best PM indicator – loss of green color from the head and peduncle. About 30 d. after anthesis the kernels reach maximum dry weight or PM with a 30 to 40% grain moisture level. Slight to moderate yield loss at 28°*F* for 2 h.[4]	Pre-harvest herbicides may be applied after PM at Zadoks 87-89, or when seed moisture is less than 35%.
83		Early dough.	**75**/70/78			
85	**11.2**	Soft dough.	**79**/75-83			
87		Hard dough. Head loses green color.	**84**/80/88			
89		Physiological maturity (PM).	**89**/85-93			
9		**Ripening**		**Ripe** *Range:* Jul 11 to Jul 29 *Avg.:* Jul 24		Clean and sanitize long-term storage facilities in order to prevent any incidence or storage disease or insect problems.
91	**11.3**	Kernel hard, difficult to divide by thumbnail.				
92	**11.4**	Kernel not dented by thumbnail, is harvest ripe.				
		Harvest		**Harvested** *Range:* Jul 22 to Aug 7 *Avg.:* Aug 5		Combine at about 13% to 14% moisture to avoid post-harvest drying costs. Dry to 12% moisture if storing for 30 days or longer.

[1, 3] Days after stage Z10, as reported in references 1 and 3; the bold number is the average date for a given stage and 00-00 is the range.
[2] Date when 50% of the state-crop acreage has attained a given stage as reported in reference 2, 1970-1994.
[4] Information on freeze injury was obtained from reference 4 – Spring freeze injury in Kansas wheat.

Table 3.2. Winter wheat management guide – Zadoks and Feekes stage descriptions, days after emergence, and date that is 50% of the state crop acreage has reached a given stage.

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
0 01 05 07 09		**Germination** Dry kernel. Kernel absorbs H_2O. Radicle emerged. Coleoptile emerged. 1st leaf at coleoptile tip.		**Acres Seeded** *Range:* Sept 5 to Oct 10 *Avg.:* Sept 15	The environment from planting through jointing significantly affects the number of plants/ft^2. Emergence – 6 to 8 d.	Use high quality seed. Recommended timing seeding dates of about Sept. 10 in the North, Sept. 15-20 in the Central and Sept. 25 to Oct. 10 in the South helps plants develop before severe weather sets in. Direct seed into standing stubble. Stubble traps snow and insulates young seedlings against cold temperatures reducing risk of winterkill. If seeding into a fallow field, minimize number of tillage operations.
1 10+ 11 12 13 14 15 19	**1**	**Seedling Development** 1st leaf through coleoptile. 1st leaf unfolded. 2nd leaf unfolded. 3rd leaf unfolded. 4th leaf unfolded. 5th leaf unfolded. 9th leaf unfolded. *+ 2nd number = no. leaves 50-100% emerged.*	**0** **7**/6-8 **14**/11-16 **19**/16-22 **24**/21-28 **29**/25-33	Sept 15 to Oct 7 *Avg.:* Sept 23	Winter wheat plants survive the winter in the seedling stage. About 4 to 5 weeks of active growth is required for seedlings to be well established before freezing to attain maximum cold tolerance and to provide enough energy reserves for spring growth. Early maturity varieties produce 11 while late varieties produce 15 leaves. A new leaf emerges every 3 to 5 d. 1st tiller appears as the 4th leaf elongates.	Don't seed too deep or too shallow. Seed at 1.5 to 2 inches deep in a firm seedbed. Planting winter wheat varieties with short coleoptile deeper than 2" can result in weak seedlings with poor ability to survive winter. In contrast, some winter wheat varieites with a long coleoptile may be seeded relatively deep, depending on the variety–but no deeper than 2.5".

Growth stage[1]		Description	[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code						
Zadoks	Feekes					
2	**2**	**Tillering**		Late fall to early spring *Avg.:* Oct 5	Cool wet weather/high fertility increase tiller numbers while hot dry weather/low fertility reduce them. The environment from tillering through jointing significantly affects the number of heads/plants.	A seeding rate of 960,000 seeds/acre or 22 seeds/ft^2 is suggested. Early seeding promotes tillering; Properly managed winter wheat has a tremendous ability to tiller and can compensate for thin strands. Early-season fungicides, if warranted by disease pressure, are applied around this stage. Fall nitrogen application may enhance rate of tillering, and potentially number of heads/sq.ft. Excess N applied at this time can lead to lush vegetative growth, which makes the crop susceptible to winterkill. Wheat tolerates most herbicides at tillering stage.
20++		Main shoot (MS) only.				
21		MS +1 tiller visible.	**19**/16-22			
22		MS +2 tillers visible.				
23		MS +3 tillers visible.	**29**/25-33			
24		MS +4 tillers visible.				
25		MS +5 tillers visible. *++ 2nd number = no. visible tillers.*				
3		**Stem Elongation or Jointing**		Apr 10 to Apr 30 *Avg.:* Apr 20	Feekes 6 or Zadoks 31 will not occure prior to vernalization, which is required for spikelet differentiation. The environment from jointing through flowering significantly affects the total number of heads/plant.	Fungicides, if justified by variety suspetibility or foliar fungal disease pressure, are often applied when flag leaves are fully emerged at Zadoks 39 or Feekes 9. Do not apply herbicides after Zadoks 39 or Feekes 9. The developing reproductive organs in the head may be sensitive to herbicides, and when later exposed at flowering, may be injured. Read/understand labels if using herbicides from Zadok 39 to 89.
31	**6**	1st node detectable.	---			
32	**7**	2nd node detectable.				
33		3rd node detectable.				
37	**8**	Last leaf (flag leaf, FL) just visible.				
39	**9**	FL collar just visible.	---	Apr 20 to May 10 *Avg.:* May 1		

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
4		**Boot**		**Boot**	The FL is more exposed to hail, frost, and pests. The FL is a major photosynthetic surface. Enviromental stress prior to flag leaf emergence can reduce number of spikelets/ head. The environment from boot through late hard dough affects kernel wt.	Because the flag leaf is a major photosynthetic surface and major contributor to yield–1st priority should be given to protecting it and the developing head until the wheat is harvested.
41		FL sheath begins to elongate.		*Range:* May 5 to May 25		
43		Boot begins to swell.				
45	**10**	Boot swollen, “in boot”.		*Avg.:* May 15		
47		FL sheath opens.				
49		First awns visible.				
5		**Head Emergence**		**Head fully visible**	Head is fully exposed to frost, hail, and pests. Plant attains final height.	
51	**10.1**	Top of head just visible.		*Range:* May 27 to June 23		
53	**10.2**	25% of head visible.				
55	**10.3**	50% of head visible.		*Avg.:* Jun 4		
57	**10.4**	75% of head visible.				
59	**10.5**	100% of head visible.				
6		**Flowering (anthesis)**			Single heads take about 4 d. to pollinate.	Apply protectants if justified. Fungicides used to manage *Fusarium* head blight (scab) are best applied around Zadoks 61 or Feekes 10.5.1 (flowering begins). Do not apply Strobilurin fungicides if head scab risk is high.
61	**10.5.1**	Flowering begins (anthers appear) in middle of head.				
65	**10.5.2**	50% of florets have flowered, flowering complete at top of head.	**60**/55-64	July 10 to Aug 10 *Avg.:* July 20		
69	**10.5.3**	All florets have flowered, flowering is complete at base of head				
7		**Milk development**			Starch and protein content determination starts. Ten to 14 days after flowering protein and starch start to accumulate rapidly. Moderate to severe yield loss at 28°*F* for 2 h.[4]	Nitrogen used to increase grain protein should be applied after flowering and by the early milk stage at Zadoks 73 or slightly after Feekes 10.5.4.
71	**10.5.4**	Kernel watery ripe.				
73		Early milk.				
75	**11.1**	Medium milk.				
79		Late milk	**69**/65-73			
8		**Dough development**			Best PM indicator–loss of green color from the head and peduncle. About 30 d. after anthesis the kernels reach maximum dry weight or PM at aboue 30 to 40% grain moisture. Slight to moderate yield loss at 28°*F* for 2 h.[4]	Pre-harvest herbicides may be applied after physiological maturity at Zadoks 87-89, or when seed moisture is less than 35%. Grain in hot dry weather will lose 2-3 moisture percentage points per day.
83	**11.2**	Early dough.	**75**/70-78			
85		Soft dough.	**79**/75-83			
87		Hard dough, head loses green color.	**84**/80-88	*Avg.:* July 27		
89		Physiological maturity (PM).	**89**/85-90			

Growth stage[1]			[1,3]Days after Z10	50% Date[2]	General Growth and Development Facts	Management Suggestions
Code		Description				
Zadoks	Feekes					
9		**Ripening**		**Ripe**	The plant is completely yellow. Kernel has about 20 to 25% grain moisture.	Clean and sanitize long-term storage facilities in order to prevent any incidence or storage disease or insect problems.
91	**11.3**	Kernel hard, difficult to divide by thumbnail.		*Range:* Jul 9 to Aug 7		
92	**11.4**	Kernel not dented by thumbnail, is harvest ripe.		*Avg.:* Jul 25		
		Harvest		**Harvested**		Combine at about 13% – 14% moisture to avoid post-harvest drying costs.
				Jul 1 to Aug 7		Dry to 12% moisture if storing for 30 days or longer.
				Avg.: Aug 5		

[1,3] Days after stage Z10, as reported in references 1 and 3; the bold number is the average date for a given stage and 00-00 is the range.
[2] Date when 50% of the state-crop acreage has attained a given stage as reported in reference 2, 1970-1994.
[4] Information on freeze injury was obtained from reference 4 – *Spring freeze injury in Kansas wheat*.

Additional information and references

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