Section 3

Cultural Practices

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Wheat grows best on well-drained soils. Since wheat does not tolerate waterlogged conditions well, yields and stands are reduced in fields prone to standing water, flooding, or poor drainage. Wheat can be grown successfully on moderately and somewhat poorly drained soils, but the long-term yields are usually reduced by five to ten bushels per acre due to stress placed on the wheat during wet springs, increased winterkill, higher nitrogen losses, and inability to access fields with application equipment. During springs with normal or below normal rainfall, yields on poorly drained soils approach those on well-drained soils.

Crop Rotation

Most of the wheat in Kentucky harvested for grain is grown in a cropping system of three crops in two years (corn/wheat/double-crop soybeans). Wheat following soybean generally yields more than wheat following corn (Figure 3-1). However, when wheat yields are high, the previous crop has less influence on wheat yield. Wheat is suited to the corn/wheat/double-crop soybean rotation system and offers both economic and agronomic advantages. Yields of all three crops in the rotation are increased over growing any crop without rotation.

Wheat is planted in the fall after summer annual crops are harvested and can be harvested early enough in the summer for a second crop to be planted (double-cropped). Double-cropping is an important economic component of the wheat enterprise in Kentucky. More than 85 percent of the harvested wheat acreage is double-cropped, primarily with soybeans.

Variety Selection

Choosing a wheat variety is one of the most important management decisions that Kentucky wheat producers make. Yield potential is clearly important, but the decision is complicated by such factors as the need for disease resistance; the double-cropping system, which requires early maturity; the extreme year to year climatic varia-

Photo 3-1. Wheat variety trials are conducted across the state to compare relative performances of varieties. Each variety is planted mulitiple times at each location to minimize field variability and to better predict performance potential.

tion in Kentucky, and the need to spread out the harvest maturity date so every variety is not ready to harvest at once. It makes sense to minimize risks by planting several varieties with good yield and test weight potential that complement one another in terms of disease resistance, maturity, and resistance to spring freeze damage.

Proper use of variety test performance data is the first step in making this important decision. The University of Kentucky Small Grain Variety Performance Tests provide the most comprehensive source of information on varieties tested under a broad range of environments. Results of the variety tests are published annually and are available at Cooperative Extension Service offices and online at www.uky.edu/ag/WheatVarietyTest. The best use of University of Kentucky variety performance data for variety selection can be achieved by applying the following basic principles.

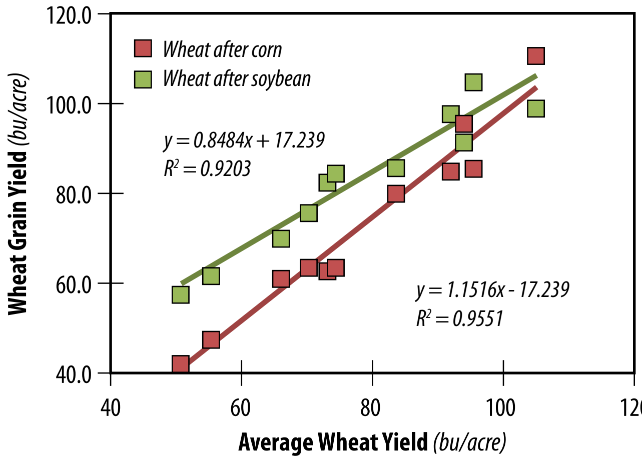

Figure 3-1. Wheat is commonly grown following corn in Kentucky. As overall wheat yield potential increases, the previous crop has less effect on wheat yield. (1998 through 2008 at Lexington, Kentucky, data provided by John Grove)

Conventional vs. No-till Testing

Based on 10 years of conventional vs. no-till data from the University of Kentucky variety testing program, variety performance can be assessed independently of the tillage system used. This fact enables growers to identify superior varieties based on performance regardless of the tillage system used.

Multi-year/Multi-location Data

While many growers ask about the variety that looked best in this year's test, it is more useful to know which varieties have performed well over a range of conditions. When interpreting the results in the variety performance report, it is important to note that variety yield is relative. This means that comparisons among varieties should only be made among those varieties in the same test or within the same analysis averaged across locations. The state summary table provides performance data averaged across test locations and years. It provides the best estimate of varietal performance, particularly the 2 and 3 year averages. When selecting varieties, growers should first utilize data from the state summary table. Once several candidate varieties have been selected, the grower should examine their performance in the closest regional test. After identifying a group of varieties with high grain yield potential, varietal selection can be based on secondary characteristics such as test weight, disease resistance, lodging, height, maturity and straw yield potential.

Wheat varieties that have performed well under diverse conditions are likely to perform well again. For growers who want to try a new variety, it is best to choose one that has been evaluated for at least one year. If a variety has been tested for one year only, it is best to use the state summary table, rather than using single year data from a single (regional) test. Depending on a grower's location, additional variety performance data may be useful from other (bordering) state variety testing programs. The University of Kentucky Small Grain Variety Testing Program website has links to these programs.

Economic Analysis of Varieties

Farmers are always interested in high yields, but the highest yielding variety may not always be the most profitable. One needs to consider other economic factors such as disease susceptibility (may require fungicides), lodging

Photo 3-2. While most wheat in Kentucky is grown for grain, some is grown for forages. The University of Kentucky tests wheat varieties for performance both in forage yields and grain yields.

(costs more to harvest), late maturity (delays soybean planting), potential straw yield as a secondary commodity, low test weight (discounts at the elevator) and seed cost. All of these factors require study and evaluation to determine the most profitable varieties for a particular operation. Maximum productivity and profitability begin with careful variety selection. Once varieties have been selected, the best guarantee of obtaining the quality seed necessary for the highest yields is to use certified seed or seed of proven high quality from an established, reputable dealer.

Table 3-1. Recommended number of wheat seeds to plant per square foot or per drill-row foot.

Row Width (in)	Row Length Needed for 1 sq ft (in)	Seeds/sq ft 30	Seeds/sq ft 35
		Seeds/row ft Needed[a]	
4	36.0	10	12
6	24.0	15	18
7	20.6	17	20
7.5	19.2	19	22
8	18.0	20	23
10	14.4	25	29

a If planting time is delayed, increase seeding rates by two to three seeds/sq ft (one to two seeds/row foot) for every two-week delay beyond the optimum planting date.

Table 3-2. Number of pounds of wheat seed needed, depending on seed size and seeding rate.

Seeds/lb	Seeds/sq ft[a] 30	Seeds/sq ft[a] 35
	lbs/acre	
10,000	131	152
12,000	109	127
14,000	93	109
16,000	82	95
18,000	73	85
20,000	65	76

a Based on 90 percent or greater germination.

Planting Practices

The target population for planting wheat is a uniform stand of 25 plants per square foot (225 plants per square yard) (Table 3-1). Usually planting 30 to 35 seeds per square foot (1,524,600 seeds/A) will result in the desired plant population. Planting methods include seedbed preparation or no-tillage planting (see *Section 4—Planting Methods*), planting date, seed placement, seeding rate, row width, and use of tramlines.

Planting Date. The recommended planting date for most of Kentucky is October 10 through October 30. This window is a compromise between early planting to ensure adequate fall growth and winter survival and later planting to decrease disease and insect infestations. Typically, these dates will fall within a period of one week before to one week after the expected date of the first fall frost. Soil temperatures are usually high enough during this window for the crop to emerge in seven to ten days or less. Also, the length of time between the first frost and winter dormancy for growth is critical for the development of an adequate number of tillers. Tillers developed in the fall are essential to producing high yields. A longer period of growth in the spring and more extensive root systems mean that fall tillers account for most of the grain produced in an intensively managed crop.

Late-planted wheat misses much of the critical fall growing period, generally suffers more winter damage, is more prone to heaving (uplifting of the plant and root system due to alternate freezing and thawing of soil), tillers less, has reduced yields, and matures later than wheat planted at the recommended time. It is difficult, if not impossible, to make up for late planting by management practices employed at later growth stages.

Planting too early, on the other hand, can result in excessive fall growth and create the potential for more winter injury (growth stages too advanced), greater risk of spring freeze injury, fall disease infection, and increased problems with aphids (which vector barley yellow dwarf) and Hessian fly infestations. Delaying planting until October 10 in northern Kentucky and October 15 in southern Kentucky generally averts Hessian fly damage. These dates are known as the fly-free planting dates. The Hessian fly-free date is based partly on the first fall freeze date, so if air temperatures are warmer in the fall, the effective fly-free date would actually be delayed that season.

Seed Placement. Plant seeds 1 to 1½ inches deep when soil moisture levels are adequate, slightly deeper if moisture is deficient. Do not plant wheat seed more than 2 inches deep. Rapid emergence and good root development start with good seed-soil contact.

Many wheat varieties have small seed, and when seed is planted deeper than 2 inches, emergence is delayed. Some semi-dwarf varieties with short coleoptiles might open the first leaf below ground and die. Deep seed placement delays emergence and reduces stand, resulting in plants with less vigor, less initial vegetative growth, and reduced tillering.

The other problem is not planting seed deep enough. Planting seed less than ½-inch deep can result in uneven germination and emergence because of dry soil. Shallow seed placement also can result in more winter injury and greater susceptibility to heaving. If seed is planted shallow and timely rains accompany planting, then adequate stands can be achieved.

Seed placement is especially critical for no-till planting. Seed must be placed in the soil at the proper depth and below all the plant residue or mulch. The mulch should be distributed evenly on the soil surface to help drills successfully slice through the mulch and place the seed in the soil. Poor seed placement is a major problem in no-tillage planting. Fast, uniform seedling emergence provides quick ground cover and erosion protection.

Seeding Rate. Wheat seed size varies dramatically among varieties and can be influenced by production environment and degree of conditioning. Using seeding rates expressed in terms of volume or weight (bushels or pounds) per acre—

Photo 3-3. Seeding wheat rows at a diagonal to the old corn rows is generally a good practice in no-till fields.

Photo 3-4. Corn residue that piles in the field can prevent the drill from placing the wheat seed under the soil surface. Seeds either fail to germinate or seedlings are killed during winter, leaving blank spaces in the field.

without consideration of seed size—can result in stands that are too low or too high. Proper stand establishment requires that the seeding rate be determined in terms of number of seeds per unit area (per square foot or linear row foot). Seeding rates below optimum may reduce yield potential, while excessive seeding rates increase lodging, create a greater potential for disease, and increase seed costs. The optimum planting rate is 35 seeds per square foot (1,524,600 seeds/A) with an objective of obtaining at least 25 plants per square foot. The seed rate and seed size should be determined to calculate how many pounds of seed per acre are needed. Seed sizes and the pounds needed can vary widely (Table 3-2).

For precise seeding, calibrate your planting equipment. Seeding rate charts on drills may not be precise and size and shape of seed can affect seed delivery. (See *Section 4—Planting Methods* for a five-step procedure for proper grain-drill calibration.)

Row Width. The most practical wheat row widths are normally 7 to 8 inches, combining the higher yield potential of narrow rows with the effective movement of planting equipment through the field. Research throughout the growing region of soft red winter wheat has shown 5 percent to 10 percent higher yields when wheat is planted in 4-inch rows versus 8-inch rows. Likewise, research has shown significant yield decreases for wheat grown in row spacings greater than 10 inches. Wheat must be planted at a uniform rate and depth, and conservation requirements must be met.

Drills with units 4 inches apart are likely to clog due to excessive surface residue or clods. Typically, drills with units about 7 to 8 inches apart have minimal clogging, but relatively high yield potential. Some farmers are choosing to use modified planters with units spaced 15 inches apart. These planters are normally used in soybean and corn. The cost of modifying the equipment is less than purchasing a drill, but the yield loss associated with the wider row spacings may not justify 15-inch rows.

Based on limited research in Kentucky, wheat in 15-inch rows will yield about 15 percent to 20 percent less than wheat planted in 7.5-inch rows. For wheat normally yielding 70 bushels per acre, that is a yield loss of 10.5 bushels per acre, or $63 per acre for wheat being sold at $6.00 per bushel. Based on these numbers, not very many acres are needed before a drill becomes more economical than a planter.

Tramlines and/or GPS. Tramlines are roadways placed in the wheat field at planting and used by equipment for applying pesticides and fertilizers. Tramlines should match the width of the applicator tires and be spaced to match the width of the applicator boom. Tramlines allow timely application of input and more uniform applications of nutrients and pesticides with no skips or overlaps.

Tramlines can be formed by blocking drill spouts and not planting wheat seed in specific rows. Tramlines can also be formed by planting wheat in all rows and then running over the same tracks each time an application is made. Tramlines formed by blocking seeding spouts will allow wheat plants in rows beside the tramlines to compensate some for the unplanted area. There is no compensation for plants that have been run over past jointing (Feekes 6, Zadoks 31).

When blocking drill spouts, using tractors with narrow tires so only one drill row needs to be blocked is a recommended practice. Devices that automatically close the selected drill spouts on the appropriate planting pass through the field are available for most grain drills. Fertilizer and spray booms should be at least 40 feet wide to be economical. The distance from the first tramline to the edge of the field should be one-half the width of the sprayer.

When running over wheat to form tramlines, use the same track for each application and do the first track (application) prior to jointing (Feekes 6, Zadoks 31) to allow plants in adjacent rows to compensate for the tramlines. Lightbars enabled with GPS (global positioning system) receivers can be very useful in helping to establish tramlines. Lightbars limit the amount of overlap and skips for nutrient and pesticide applications.

Photo 3-5. Wheat heads that are bleached white are a clear indication that heads were killed by a freeze event.

Photo 3-6. Wheat is regrowing after a freeze event. Normally, development of this regrowth will be delayed, pushing harvest to later in the season.

Winterkill and Freeze Injury

Wheat is subjected to adverse weather conditions during much of its growth period. Autumn frosts and cool temperatures actually help by hardening plants for the months of cold winter weather ahead.

Expect winterkill on poorly drained soils, with extreme temperature fluctuations, where poor fall root development occurred, and with sustained low temperatures (particularly with no snow cover). Extremely cold winters tend to cause more winterkill in varieties developed in more southerly locations because they have less winter hardiness. Heaving is a major cause of late winter or early spring damage to small plants due to extreme temperature fluctuations, especially on poorly drained soils.

Wheat seeded close to the recommended dates typically will receive little damage from a spring freeze. Spring freeze injury can occur when low temperatures coincide with sensitive plant growth stages (Table 3-3). The risk of spring freeze injury is greater when conditions cause wheat to break winter dormancy (greenup) and begin growing and those conditions are followed by freezing temperatures. These scenarios occur with unusually warm temperatures in February or March or from unusually late freeze events in April or May. Injury can occur across large areas of the field but usually is most severe in low areas or depressions in the field where cold air settles. A late spring freeze can reduce yield because of damage to the head and stem. Usually, a week to ten days of good warm temperatures and adequate sunlight are required before head and stem damage from a freeze event becomes visible. If cool, cloudy days persist, then more time may be needed to assess the damage. If the plants are damaged from the freeze, then the wheat stems will likely be damaged close to the ground. Heavy rainfall will knock over the damaged wheat and severely reduce yields.

Table 3-3. Freeze injury in wheat.[a]

Growth Stage	Feekes	Zadoks	Approx. Injurious Temp. (2 hrs)	Primary Symptoms	Yield Effect
Tillering[b]	1-5	20-29	12°F	Leaf chlorosis; burning of leaf tips; silage odor; blue cast to fields	Slight to moderate
Jointing	6-7	31-32	24°F	Death of growing point; leaf yellowing or burning; lesions, splitting, or bending of lower stem; odor	Moderate to severe
Boot	10	41-49	28°F	Floret sterility; spike trapped in boot; damage to lower stem; leaf discoloration; odor	Moderate to severe
Heading	10.1-.5	50-58	30°F	Floret sterility; white awns or white spikes; damage to lower stem; leaf discoloration	Severe
Flowering	10.51-.54	60-71	30°F	Floret sterility; white awns or white spikes; damage to lower stem; leaf discoloration	Severe
Milk	11.1	75	28°F	White awns or white spikes; damage to lower stems; leaf discoloration; shrunken, roughened, or discolored kernels	Moderate to severe
Dough	11.2	85	28°F	Shriveled, discolored kernels; poor germination	Slight to moderate

a Information in this table assumes timely rainfall events occurring after the freeze event.
b See Section 2 for more information about growth stages.

To check for damage to an unemerged wheat head, cut into the stem to find the growing point (developing head). An undamaged head normally appears light green, glossy, and turgid. A killed head is pale white or tan, limp, shrunken, and not developing in size. Spikelets within a single head can be damaged as well. Growing tissue of plants that have been frozen is dry, bleached, and shrunken. See the *Supplement* section for more pictures of freeze damage.

The temperatures and growth stages listed in Table 3-3 work well in most situations as a general guideline; however adequate yields may still be produced.

There is some evidence that timing of nitrogen fertilizer application in relation to the freeze event may help reduce the damage from a freeze event. The theory is that for a short period of time, as wheat takes up nitrogen the concentration of nitrogen in the plant cell will be high enough to act as a kind of anti-freeze agent. The problem is that there is no sound recommendation for applying nitrogen to help with this.

In addition, some wheat varieties may be a little more tolerant to spring freezes based on the mechanisms that determine flowering in wheat. Flowering in some wheat varieties seems to be controlled more by day length while flowering in others may be controlled more by temperature. Unusually warm temperatures could accelerate crop development in varieties more responsive to temperature more so than in varieties more responsive to day length. In these cases, varieties more sensitive to temperature would be at a greater risk for spring freeze. Assessing wheat damage from a freeze event can be difficult. In addition to evaluating the stems and heads for freeze damage, one also must look at extended forecasts. If rain is not in the forecast, farmers may be less likely to destroy a damaged wheat crop.

Photo 3-7. Using a hand lens or microscope to examine the growing point of wheat can help determine if the crop survived a freeze event.

Photo 3-8. A dowel road with specific lengths marked on it can be used to count plants and tillers on a square-foot-basis.

Determining Plant Populations, Tiller, and Head Counts

Plant Populations. After the wheat has emerged, make a stand count to determine if your target population was achieved and if the final stand is acceptable for maximum yield potential. Make fall stand counts one to two weeks after emergence. Make spring stand counts before greenup of the plants occurs to determine if winter damage has reduced the initial plant population obtained in the fall. Count only whole plants, not tillers. Fields with stand counts below 15 plants per square foot have less than 75 percent yield potential (Table 3-4) and probably should not be kept but used instead for planting corn or soybeans. If stand counts are adequate to keep but somewhat reduced from optimum, consider an early nitrogen application.

To determine the number of plants per square foot:

- Use a yardstick, or cut a dowel rod to a 3-foot length.
- Place the measuring stick next to an average-looking row, and count all plants in the 3-foot length of the row. Record the number.
- Repeat the counting process in at least five other locations well spaced around the field. Record all numbers.
- Average all of the stand counts from the field.

Table 3-4. Wheat yield potential based on plants per square foot.

Final Stand (%)	Plants per:		Potential Yield[a] (%)
	sq ft	sq yd	
100	30 - 35	270 - 315	100
80	24 - 28	216 - 252	100
60	18 - 21	162 - 189	90 - 95
50	15 - 18	135 - 162	75 - 80
40	12 - 14	108 - 126	60 - 70
20	6 - 7	54 - 63	40 - 50

a This provides an estimate of the relationship of wheat stand to yield potential and is only a guide. Many factors (plant vigor, weather, disease, fertility management, planting date, and variety) influence how a wheat stand ultimately responds to achieve its final yield potential.

Table 3-5. Length of row needed for 1 sq ft.

Row Width (in)	Row Length for 1 sq ft	
	(ft)	(in)
6	2.0	24.0
7	1.7	20.6
7.5	1.6	19.2
8	1.5	18.0
10	1.2	14.4
15	0.8	9.6

Table 3-6. Wheat stand count table.

Row Width (in)	Row Length (ft)	Area (sq ft)	Plants (or tillers) per counted area											
			10	15	20	25	30	40	60	80	100	120	140	160
			Plants (or tillers) per sq ft											
7	1	0.58	17	26	34	43	51	69	103	137	.	.	.	.
	2	1.17	9	13	17	21	26	34	51	69	86	103	120	137
	3	1.75	6	9	11	14	17	23	34	46	57	69	80	91
7.5	1	0.63	16	24	32	40	48	64	96	128	.	.	.	.
	2	1.25	8	12	16	20	24	32	48	64	80	96	112	128
	3	1.88	5	8	11	13	16	21	32	43	53	64	75	85
8	1	0.67	15	23	30	38	45	60	90	120	.	.	.	.
	2	1.33	8	11	15	19	23	30	45	60	75	90	105	120
	3	2.00	5	8	10	13	15	20	30	40	50	60	70	80
10	1	0.83	12	18	24	30	36	48	72	96	120	.	.	.
	2	1.67	6	9	12	15	18	24	36	48	60	72	84	96
	3	2.50	4	6	8	10	12	16	24	32	40	48	56	64
15	1	1.25	8	12	16	20	24	32	48	64	80	96	112	128
	2	2.50	4	6	8	10	12	16	24	32	40	48	56	64
	3	3.75	3	4	5	7	8	11	16	21	27	32	37	43

- Calculate plants per square foot with the following equation:

plant number =
(average plant count × 4)/row width in inches

A second method to counting stands is to determine the length of row needed to equal one square foot (Table 3-5). Mark the needed length on a dowel rod or stick and then count the plants in a row.

A third method is to count the plants, or tillers in 1, 2 or 3 feet of row and use Table 3-6 to determine stands.

Tiller and Head Counts. Taking a tiller count which includes main shoot and tillers at Feekes 3 (roughly Zadoks 22 through 26) is the first step in all fields for determining nitrogen needs in late winter or early spring. To determine tiller numbers, count all stems with three or more leaves. Tiller counts below 70 per square foot indicate the need for nitrogen at Feekes 3. At recommended populations, many plants will have only three to four stems (main shoot plus two to three tillers, Zadoks 22 or 23). Thus, 70 to 100-plus tillers (stems) per square foot at Feekes 3 are considered adequate.

Head counts can be taken late in the season after heads have fully emerged (Feekes 10.5, Zadoks 58 or later) to help estimate yield potential. An ideal count for maximum yields is 60 to 70 heads per square foot (540 to 630 per square yard) with 35 kernels per head and 16 to 18 spikelets per head. For adequate yields, 55 heads per square foot (500 per square yard) are needed. If the number of heads per square foot is too high (90 to 100), severe lodging can occur and seeding rates were probably too high. Use the same procedure to count tillers or heads as outlined above for plant populations.

Lodging Control and Plant Growth Regulators

Lodging can be a problem when too much fertilizer nitrogen is used, too thick of a stand is established and/or growing conditions favor excessive growth. Lodged wheat can result in decreased combine speed because of the amount of straw that must be processed through the combine, decreased grain recovery, delayed harvesting after rainfall and heavy dew, and more difficult planting conditions for double-crop soybeans that follow wheat.

Risk of wheat lodging can be reduced by choosing good varieties, establishing the correct stand and using the recommended amount of fertilizer nitrogen. Situations do occur, however, in which there is a large carryover of residual soil nitrogen or weather conditions produce very lush crops and the potential for lodging is high.

When the potential for lodging is high, consider using the growth regulator such as Cerone. Cerone prevents lodging by shortening the wheat plant and strengthening the straw. It does not increase yields if no lodging occurs. Correct application is critical and should be made between Feekes 8 and 10 (Zadoks 37 and 45). Never apply Cerone to crops with exposed heads. Research at the University of Kentucky showed best results when Cerone was applied at Feekes 8 or 9 (Zadoks 37 or 39). Carefully read the label, and follow all directions.