

Chapter 4: Winter Wheat Planting Guide



Thandiwe Nleya

Winter wheat planting in South Dakota begins in mid-September with the aim of establishing a healthy and vigorous plant that can survive winter temperatures (Fig. 4.1). A number of factors, some climatic and others under the direct control of the grower, affect the success of the winter wheat crop. The major concern at planting time is moisture availability for germination and seedling establishment. While planting early may help the soil moisture situation, it increases the risk of disease and insect damage from summer crops. Direct seeding winter wheat into standing stubble is recommended to reduce the risk of winterkill. If planting winter wheat into a conventional fallow field, it is important to minimize the number of tillage operations immediately before planting. This chapter discusses winter wheat adaptive mechanisms, planting dates, seeding rates, planting depths, variety selection, winterkill and reseeding considerations.



Figure 4.1. Wheat plants must be well established with 3-5 leaves and a well-developed crown before freezing. (Photo credit: C. Stymiest, SDSU)

Winter wheat characteristics

The vegetative characteristics of winter wheat and spring wheat are similar with the exception that winter wheat can withstand freezing temperatures for extended periods of time at the seedling phase. Winter wheat also requires a period of exposure to near freezing temperatures (vernalization) to trigger reproductive development. Hard red and white classes of wheat are available in South Dakota. Both classes generally have good milling and baking qualities.

Vernalization and cold acclimation

Winter wheat seedlings emerging in the fall are not tolerant to subfreezing temperatures any more than spring wheat. To cope with low temperature stress, winter wheat has evolved adaptive mechanisms that are temperature regulated. These adaptive mechanisms are known as vernalization and cold acclimation.

Cold acclimation, or “hardening,” is required before wheat plants can survive subfreezing temperatures in winter. During vernalization, wheat plants are exposed to near-freezing temperatures (near 400 F is optimum). The acclimation process is induced by the gradual decrease in average temperature during fall to early winter. This involves lowering of moisture content of the crown (area at the base of the shoot), slowing down of the growth process and accumulation of soluble carbohydrates, which helps to resist frost damage.

The soil temperature at crown depth (2 to 3 inches deep) determines the rate of cold hardiness. For winter wheat to fully harden, a temperature below 500 F at the crown depth for 4 to 8 weeks is required. After this exposure, winter wheat will maintain a high level of winter hardiness, provided the temperature at crown level remains below freezing. Generally 8 to 12 weeks of growth under field conditions are required for full development of winter hardiness. During the first 4 to 5 weeks, the temperatures should be above 500 F at crown depth. During this period of time, the plant produces the energy that is stored in the crown to survive winter and to initiate spring growth.

It is important to note that cold acclimation is genetically controlled by variety and that not all winter wheat varieties have the same winter hardiness level. Thus, it is possible to have winterkill in one field planted to a less winter hardy variety and to have a good stand in the next field over.

Management practices for increased winter survival

Stubble and snow cover during a cold spell can influence the extent of winterkill (Fig. 4.2). Direct seeding winter wheat into stubble or no-till is a recommended crop management practice in central and western South Dakota. Snow trapped by the stubble insulates wheat seedlings against cold temperatures, thereby reducing risk of winterkill. Research conducted in western South Dakota has shown that soil temperature at crown depth under stubble can be 5 to 7 degrees warmer than under conventional fallow; these differences in temperature can influence winter survival of wheat seedlings. Seeding winter wheat into broadleaf crop stubble is recommended to reduce insect, disease and weed problems. Even though seeding into wheat stubble is common, disease risks are associated with this practice.

If planting winter wheat into a conventional fallow field, it is important to minimize the number of tillage operations immediately prior to planting. Plowing, or other deep tillage operations, can reduce seedbed firmness, bury protective residues, and increase the risk of winterkill. Planting into a fallowed field can also leave wheat plants unprotected and more subject to winterkill. Tillage can lead to greater soil water losses, and, if done shortly prior to seeding, soil moisture may be inadequate for rapid and uniform emergence of seedlings.

Figure 4.2. Management techniques to minimize winterkill and improve plant health.

1. Direct seed into stubble.
2. Minimize tillage operations prior to planting.
3. Plant between September 10 and October 10.
4. Planting early can increase insect and disease problems.



Planting date

The optimal planting window for winter wheat in South Dakota is September 10 through October 10 (Fig. 4.3). Winter wheat germinates in the fall and survives the winter at the seedling stage. Wheat plants should be well established before freezing to attain maximum cold tolerance and to accumulate enough energy reserves for survival and early regrowth in the following spring. Generally, 8 to 12 weeks of growth is needed to condition the plants for the winter.

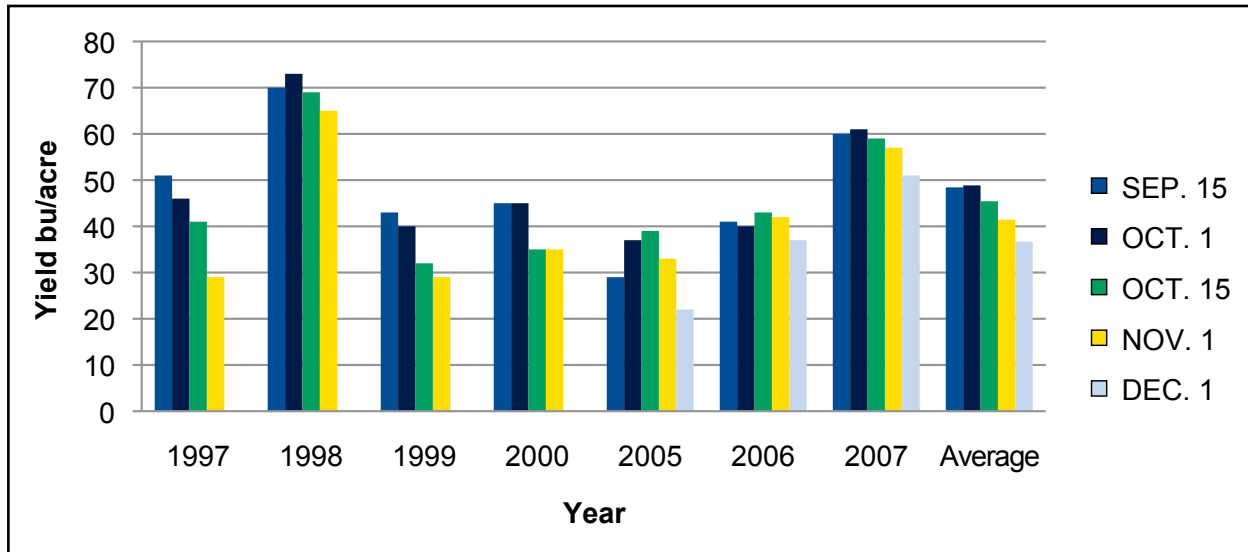


Figure 4.3. Winter wheat grain yield as affected by planting date in South Dakota. Data collected over seven different years and averaged over eight varieties. (Unpublished data of studies conducted in western South Dakota: Nleya, Rickertsen and Swan, 2005-2007; Stymiest, Rickertsen and Swan, 1997-2000)

Planting wheat too early may produce excessive fall growth reducing amounts of soil moisture and nutrients. Early planted wheat may also create a green bridge between wheat crops that serve as alternate hosts for important winter wheat pests. For example, winter wheat seedlings can be infected by barley yellow dwarf virus or wheat streak mosaic virus, which can lead to a significant reduction in yields. Research from western South Dakota has shown that grain yield is decreased and that the crop typically suffers substantial winter injury when planting occurs later than October 15 (Fig. 4.3).

Seeding rates

An important factor impacting yield is the number of spikes per unit area. Winter wheat should be planted at a rate of 960,000 pure-live-seeds per acre (22 pure-live-seeds per square foot) between September 10 and October 10. When seeding later than the recommended planting window, the rate should be increased.

However, properly managed winter wheat has a tremendous ability to tiller and can compensate for thin stands. To determine seeding rate in pounds per acre, a seed count per pound is necessary. Varieties or seed lots with a larger seed size will require higher seeding rates (lbs/acre) to achieve the required plant population (plants/acre). Guidelines accounting for dry soil and late planted seeds are provided in Figure 4.4.

Figure 4.4. Dry soil and late planting seeding guidelines.

1. Increase seeding rate to approximately 28 pure-live-seeds per square foot under dry conditions to account for poor seedling germination and seed mortality.
2. Increase seeding rate to approximately 28 pure-live-seeds per square foot when planting later than the recommended planting window.
3. Plant seeds at a depth of 1.5 to 2 inches under optimum conditions.

Seeding depth and seedbed preparation

Seeding depth can have a large influence on plant establishment, especially under conditions of poor soil moisture. Under optimum conditions, growers should plant winter wheat at a depth of 1½ to 2 inches into a firm seedbed. Planting deeper than two inches delays emergence and can result in weak, spindly

seedlings with a reduced ability to survive the winter. Under dry conditions, it may be necessary to plant deeper to place seed into moist soil. Under such conditions, growers should choose a variety with a longer coleoptile. It is also important to pay close attention to soil-to-seed contact under drier conditions. Poor soil cover of the seed can expose the crown and adversely affect winter survival.

Variety selection

Selecting a winter wheat variety to plant is one of the most important decisions a grower has to make (Chapter 6). When selecting a variety, growers should consider the various variety traits (Fig. 4.5). Winter wheat variety yield trials are conducted yearly by the South Dakota State University Crop Performance Testing program. Results from the trials are available at <http://extension.sdstate.edu>.

Information for Nebraska, Minnesota, and North Dakota can also be consulted at the following addresses:

Nebraska http://citnews.unl.edu/winter_wheat_tool/index.shtml

Minnesota <http://www.maes.umn.edu/10varietaltrials/redwinterwheat.pdf>

North Dakota <http://www.ndwheat.com/growers/default.asp?ID=478>

When considering yield, consider yield potential, wheat quality, and yield stability. While high yield is important, varieties that perform consistently under different climatic conditions may be more desirable. When selecting a high-yielding and good-quality variety, try to locate replicated data that summarizes several years and locations. Choose the variety that, on average, performs the best at multiple locations near you over several years. Information on different wheat cultivars is available in Hall et al. (2011).

Winter hardiness is a desirable characteristic. Most of the current winter wheat varieties have improved winter hardiness and are rated from fair to excellent. Regardless of the winter hardiness rating, winterkill can be reduced by seeding into protective cover.

The importance of a trait may depend on a grower's specific production system and farm location. For example, if a certain disease is expected to be a problem in a specific region in a particular year, using a winter wheat variety with resistance traits to that particular disease can minimize yield losses. Early maturing winter wheat varieties may be appropriate for drier environments as they are more likely to escape late season drought. In higher yielding environments, straw strength may be important to prevent the wheat crop from lodging.

Quick and uniform seedling emergence is important to achieve good plant stands. The coleoptile is the leaf sheath that surrounds the first true leaf. The length of the coleoptile is important particularly when planting under dry conditions. Varieties with longer coleoptile length emerge better when planted deep.

The major use of winter wheat grown in South Dakota is in bread making. Winter wheat grain is tested for milling and baking quality to make sure standards for millers and bakers are met. Hard white wheat can also be used for making noodles and tortillas.

Winterkill

Winterkill can result from inadequate hardening due to late emergence in the fall, or a sudden drop in temperature. Even fully hardened wheat plants can suffer winterkill, if temperatures drop below a crown temperature of 50° F. Injury or death, resulting from cold-induced desiccation, may also occur at temperatures above 50° F if the tissue moisture drops below 55%. In general, the crown is not exposed to killing temperatures if the plant is insulated by snow cover.

In addition, producers should be aware that it is not only the lowest temperature reached that is important in determining the level of winterkill, but also the length of the period of exposure to sub-lethal

Figure 4.5. Traits that should be considered when selecting a winter wheat variety.

Yield potential	Winter hardiness
Protein content	Yield stability
Maturity	Baking quality
Test weight	Lodging resistance
Disease and insect resistance	Coleoptile length

temperatures. For example, wheat plants exposed to a temperature of 0 degrees F will experience high levels of winterkill after a shorter period of exposure compared to plants exposed to a temperature of 5° F.

Determining the level of winterkill

Early in the spring, winterkill can be determined using the Bag Test (Fig. 4.6). The Bag Test can be used to provide an early indication of survival. If information is not required immediately, the best way to assess winterkill is to wait until plant growth commences.

Figure 4.6. The Bag Test for determining winterkill.

1. Carefully dig wheat plants from different parts of the field with a spade – remove up to three inches of soil containing the plant crown and roots.
2. Thaw the samples at room temperature.
3. Wash with cold water to remove soil from roots.
4. Cut leaves at about 1.5 inches from the crown and roots just below the crown.
5. Rinse crown with clean, cool tap water.
6. Place at least five crowns in a plastic freezer bag; inflate and tie shut.
7. Place bag in a lighted room but not in direct sunlight.
8. After 5–7 days, a healthy crown should show one-half inch or more of new growth.
9. Plants that are not growing after 6 days are assumed to be dead.

Spring freeze injury

In spring as temperatures warm up, plant growth accelerates and eventually plants lose the ability to tolerate cold stress. If low temperature stress occurs during spring growth, injury from freezing can occur. Factors that influence spring freeze injury include plant growth stage, plant moisture content, duration of exposure, wind and precipitation. Plants at the reproductive stages (late boot to heading) are most sensitive to freeze injury (Table 4.1). At this stage, temperatures slightly below freezing can severely injure wheat, causing considerable yield reduction. The degree of damage to the crop is also influenced by the duration of low temperatures. Prolonged exposure to low temperature causes much more injury than brief exposure to the same temperature.

It is important to know the symptoms of freeze injury and the plant parts that are affected at each growth stage. To evaluate damage, producers need to carefully monitor the crop three to five days after the low temperature event. It is also important to note that cool weather after freezing temperatures may delay the appearance of injury symptoms, thus damage symptoms are not immediately apparent. The symptoms are growth stage dependent and listed as follows:

1. At *tillering stage*, the growing point is just below the soil surface and is protected from injury. Most of the damage will therefore occur to the leaves, which become yellow in color and shows burning at the tips within one to two days after freezing. Injury at this stage will slow growth and reduce total tiller numbers. Growth of new leaves and tillers usually resumes with warmer temperatures and yield reduction may range from slight to moderate.
2. At *jointing stage*, leaves will show similar symptoms as the tillering stage but the most serious injury at this stage occurs to the growing point. Locate the growing point by splitting the stem just above the uppermost node. A normal growing point is bright yellow-green; a damaged growing point is white or brown and water-soaked in appearance.
3. At the *boot stage*, look for injury on the small head which can be found above the top node in the stem. A healthy head should be white or light green. An amber or watery appearance would indicate freeze damage.

4. At the *heading stage*, the most apparent symptom is bleaching (chlorosis) of the awns to a white instead of the normal green color. Other symptoms will be similar to those that occur at earlier stages of growth.
5. At the *flowering (anthesis) stage*, the plant is very sensitive to freezing temperatures. Exposure to freezing at this stage kills male parts of the flower, causing sterility. The anthers are white instead of the normal light green or yellow color.
6. More information on spring freeze injury can be found in the publication, *Spring Freeze Injury to Kansas Wheat*. <http://www.ksre.ksu.edu/library/crpsl2/c646.pdf>

Economic threshold for reseeding

Freezing injury or winterkill only affects plants in certain parts of the field, especially depressions or lower areas of the field. West or south facing slopes or hilltops that first lose snow cover also are prone to winterkill. Where main tillers have been damaged, secondary tillers may grow and enhance the stand. Where stands are poor and re-seeding is an option, seed cost, land preparation, and planting costs should be taken into consideration. In some instances it may be better to leave the land fallow and then plant it to winter wheat the following fall.

Depending on seeding rates, optimum plant stands are 20–28 plants per square foot. The general rule is that 50% or more of the optimum stand is adequate. Winter wheat has the ability to tiller to compensate for lower plant densities. When stands are thin or weakened, consider early nitrogen application to encourage tillering and early control of weeds.

Table 4.1. Temperatures, symptoms, and yield impacts from exposure to 2 hours of cool temperature at selected growth stages. (Adapted from Shroyer et al. 1995)

Growth stage	Temperature causing injury (2 hrs exposure)	Symptoms	Yield impact
Tillering	12° F	Leaf chlorosis; burning leaf tips; silage odor	Slight to moderate
Jointing	24° F	Death of growing point; leaf yellowing or burning; lesions, odor	Moderate to severe
Boot	28° F	Floret sterility; spike trapped in the boot; damage to lower stem; leaf discoloration, odor	Moderate to severe
Heading	30° F	Floret sterility; white awns or spikes; damage to lower stem; leaf discoloration	Severe
Flowering	30° F	Floret sterility; white awns or spikes; damage to lower stem; leaf discoloration	Severe
Milk	28° F	White awns or white spikes; damage to lower stem; leaf discoloration; shrunken, roughened, or discolored kernels	Moderate to severe
Dough	28° F	Shriveled, discolored kernels; poor germination	Slight to moderate

Reseeding options after a winterkill or hail

Reseeding options for a grain crop include proso millet, grain sorghum and sunflower (Table 4.2). Proso millet requires the least amount of water and produces grain in 80 to 90 days, which would allow winter wheat to be planted the fall after the millet. Grain sorghum and sunflowers would require mid to late summer rains to produce a good crop, and grain sorghum is best suited to elevations of 2500 feet or lower.

Options for forage crops include foxtail millet, sudangrass, sorghum-sudangrass and forage sorghum. In a rotation with fallow it may be more desirable to plant the alternative crop into fallow ground intended for wheat planting in the fall and to utilize the hailed wheat land for fall winter wheat planting. This would avoid problems with the decaying wheat residue interfering with crop growth and residual herbicides applied to the wheat crop injuring the reseeded crop. Latest dates for seeding these crops are given on Table 4.2. Information on seeding rates is available in Hall (2010), *Emergency Late-Seeding Options*.

It is important to cross-reference crops with prior herbicide usage to make sure they are compatible with possible herbicide carryover. Information on small grain herbicide cropping restrictions is available in Moechnig and Deneke (2008), *Replant Restrictions: After Herbicide Applications in Small Grains*.

If the crop is insured, it is important to consult with the crop insurance agents before re-seeding or abandoning the crop (Chapter 9).

Grazing winter wheat

If producers want to salvage their winter wheat as forage, they have to be aware of a few precautions. Winter wheat can be grazed or harvested as silage; however, haying is difficult due to the long curing time needed to reduce moisture content. Successful small grain grazing requires precautions because:

1. *Grass tetany* (sometimes known as wheat poisoning) associated with imbalances of magnesium and calcium nutrient can occur with older cows, calving cows, or lactating cows.
2. *Bloat*, though not as common as legume-induced bloat, can occur with immature wheat in the leafy stage, particularly in stocker cattle.
3. *Nitrates* can accumulate under drought stress or frost and hail damage.

Nitrate itself is not toxic to animals, but at elevated levels, it can cause a noninfectious disease called nitrite poisoning. All plants contain nitrates, but toxic nitrate levels for livestock are mostly associated with forages. Crops grown under “stress” conditions or on soils that have received high applications of manure or nitrogen fertilizer are suspect.

Usually nitrate levels tend to accumulate in forages immediately after a drought-ending rain. Since peak nitrate plant levels occur in the morning, delay haying or grazing until the afternoon of a sunny day can reduce this risk. Nitrate toxicity is most likely to occur when livestock are pastured or fed green-chop, followed by hay. Silage is the least hazardous feed. Ensiling forage usually lowers the nitrate level by 10 to 60%.

It is always a good practice to test for nitrate levels before you graze or feed. Commercial labs have the capacity to test for nitrate. Farmers should collect a representative sample to send to the lab. This could be done by taking 20 stems randomly picked by traversing in a zigzag pattern across an entire field. Clip the plants at ground level. A nitrate test level of less than 1500 ppm (0.15%) is generally safe for all conditions and livestock. For other interpretations of nitrate tests, consult with the Extension livestock specialist.

Also it is important to note that several cereal herbicides have restrictions on crop use for forages. More information is available in Moechnig and Deneke (2006), *Restrictions for Harvesting Small Grain Forages after Herbicide Applications*.

Table 4.2. Latest seeding date for reseeding crops after winterkill. (Hall 2006)

Crop Type	Latest recommended seeding date
Row Crops	
Corn	June 10
Sorghum for grain	June 30
Soybean	June 25
Sunflower	July 1, July 5 for southern half of the state
Alternative Crops	
Buckwheat	July 10
Foxtail millet	July 5-10
Proso millet	July 5-10
Forage Crops	
Forage sorghum	July 20
Brassica spp	July 15
Sudangrass and Sudan hybrids	July
Sudangrass-Sorghum hybrids	July 1-15
Winter Rye	July 15

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Acknowledgements

Support for this chapter was provided by South Dakota State University, SDSU Extension, South Dakota Experiment Station, USDA-AFRI, NCR-SARE, South Dakota Wheat Commission and South Dakota Oilseed Council.

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