

## Chapter 1: Sustainable Production of 100-Bushel Wheat



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Reaching 100-bu/acre routinely will take compiling the collective wisdom of professional agronomists and farmers alike. This chapter represents a starting point. Hints for reaching this goal are provided in Table 1.1. Each of these topic areas is addressed in this chapter—as well as related chapters throughout the book.

**Table 1.1. Hints to produce 100 bu/acre.**

- Pay attention to the details.
- Use high quality seed and plant a uniform stand with good disease and lodging resistance at an appropriate rate.
- Use soil sampling to monitor soil nutrients and try to return more nutrients than those removed in the harvested grain.
- Consider a split application of N to minimize lodging and improve wheat quality.
- Control pests in a timely manner.
- Scout and apply fungicides as needed.
- Minimize yield losses during combining.
- Adopt practices that increase the length of the grain filling period.
- Plant field peas prior to wheat and use rotations to reduce disease, insect, and weed problems.

### Sustainability and meeting food production goals

The long-term sustainability of the South Dakota wheat industry depends upon profitability, soil and water stewardship, and the personal satisfaction experienced by growers. The “optimization of wheat production” and the “sustainability of the wheat industry” are interlinked and are much more than yield alone. Obtaining sustainable wheat production requires a personal commitment by a producer to manage production for long-term profitability, which may be different than short-term maximum production. Long-term profitability is heavily dependent upon a producer’s care for the soil and water resources.

Maintaining soil health involves management to maintain or increase soil organic matter, a stable and well-aerated soil structure, and an active microbe population, all while minimizing the conditions that lead to soil erosion.

Management options such as crop rotations, genetics, pest control, tillage, cover crops, and fertility all impact long-term productivity and the ability to optimize yields for a given environment or a soil

landscape. Optimizing wheat production in South Dakota is dependent upon producers making good management choices for the sustainability of their individual farms and the state's wheat industry.

### Growing 100 bu/acre wheat

As human populations increase, producers must seek ways to economically push yields to higher levels. Growing wheat for yields that exceed 100 bu/acre will involve close attention to details. One practice by itself will not achieve high yields. We believe that routinely achieving 100 bu/acre requires the adoption of a systematic and advanced production program.

Weekly or biweekly scouting is necessary to monitor weeds, insects, diseases, and nutrient deficiencies. As the crop progresses through the growing season, circumstances may either justify, or make impractical, additional inputs or practices that could further enhance yield. A list of key management practices needed to achieve 100+ bu/acre wheat yields are discussed in other chapters of this book.



**Figure 1.1. A wheat field with a very high yield potential.** Producing fields that look like this requires an attention to details.

### Crop rotations

A long-term crop rotation offers diversity, both in terms of crop type (cool or warm season, grass or broadleaf, nitrogen fixing or nitrogen consuming, tap or bunch root type) and water use intensity (length of time using water). Diversity disrupts disease, insect and weed cycles, and it may improve soil quality. Including high residue crops in the rotation, such as corn, helps build organic matter, which, in turn, helps to improve the resilience of the entire system. Wheat following field peas often out-yields wheat following wheat. Carr et al. (2005) reported that wheat or barley yields were increased by 20% when following field peas rather than small grains. The reason for this rotational effect is not well understood.

### Variety selection

SDSU and other wheat breeders are continuously releasing varieties with enhanced yields as well as improved insect and disease resistance. For current information, obtain the most recent copy of SDSU publication EC774, “Small Grains Variety Recommendations” or ExEx8136, “Winter Wheat Variety Yield Results and Planting Tips” at your local Regional Extension Office.

Results are listed by testing location and are summarized by region and state so producers can select varieties that perform well in their area. Most crop performance testing (CPT) plots are managed for moderate yield potential regarding planting rate, fertility and weed control without fungicide applications so as to evaluate impact of foliar diseases on the variety yields. On occasion, a foliar fungicide application is made to protect against Fusarium head blight.

### Seed source

Certified seed is a source of clean, disease-free seed of a known germination percentage, and it is guaranteed to be free of noxious weed seeds. Planting certified seed ensures that farmers are using seed that is genetically pure and has the highest yield potential.

## Seedbed

One of the goals of tillage is to provide a seedbed that favors quick germination and early plant growth while maintaining soil moisture as close to field capacity as possible. Improvements in planting equipment, such as no-till drills, as well as the development of disease tolerant cultivars and herbicides, which can be applied post-emergent rather than preplant, have made many tillage practices unnecessary. In South Dakota no-tillage has been adopted on over four million acres. When using no-till practices, seedbed preparation begins at harvest of the previous crop. The previous crop residue ideally should be chopped and uniformly spread across the width of the combine's header swath. Additional details for seedbed preparation using no-tillage are available in Beck et al. (2009).

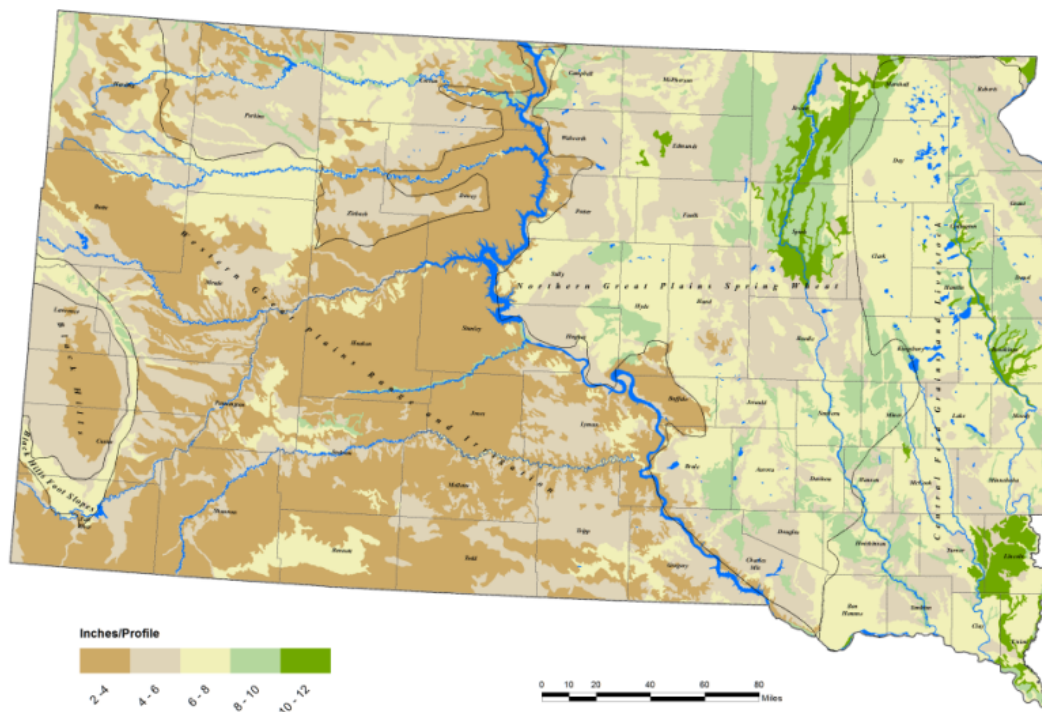
## Optimize available water

The ability of the soil to store and provide water has a large impact on the soil's productivity. In many locations, fall and spring rainfall are stored in the soil until the plant utilizes it. A map showing the potential of the soil to store water is provided in Figure 1.2. Soil surveys are available for all South Dakota counties. As a rule of thumb, the greater the soil profile moisture-holding capacity, the greater is the yield potential of that soil, assuming adequate drainage.

## Planting date

Adopting management practices that increase the length of the grain filling period is critical for increasing yields. For example, planting spring wheat early at uniform planting distances reduces competition between adjacent plants and allows heading and flowering to occur earlier, avoiding the hottest weather of summer.

Winter wheat should be established before freezing temperatures to attain cold tolerance and accumulate energy reserves for the following spring. Winter wheat planted too early can have disease problems, while if planted too late it can suffer from winterkill. Due to climactic variability, the optimum planting date will vary.



**Figure 1.2. Map of soil water holding capacity for South Dakota.**

(Reitsma, K.D., 2011. South Dakota State University, Plant Science Department. Source of Data: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. U.S. General Soil Map (STATSGO2). Available online at <http://soildatamart.nrcs.usda.gov>. Accessed [May 16, 2011]).

## Seeding rate

Seeding rates are dependent on the variety and soil productivity. On a producer's best soils, it is recommended to seed to a plant population (when using varieties that do not tend to lodge) of about 35 plants/ft<sup>2</sup>. For varieties that tend to lodge, aim for a plant population of 28 plants/ft<sup>2</sup>. For late planted fields it may be necessary to increase the planting rate. Currently, spring wheat varieties with good lodging resistance include Brick, Select, Briggs, Granger, and Traverse. Sampson has been rated as very good. Winter wheat varieties with excellent lodging resistance include Wendy (white), Wesley, and Art. Alice, Camelot, and Millennium are rated as good, and Expedition, Lyman, and Arapahoe are rated as fair.

The recommended planting rate is dependent upon seed size and germination rate. If the seed kernel size and test weight yield about 16,000 seeds/lb, and if 90% of seeds become viable plants, this will require about 1.8 bu of wheat seed/acre. Wheat yield is determined by the number of kernels per pound of grain, kernels per head and heads per square foot. Wheat kernel counts can vary from fewer than 10,000 to over 20,000 kernels per pound due to kernel size and test weight. Kernels per head can vary widely as well.

A key to high wheat yields is to produce a high population of large heads and maximize the grain fill period. Secondary tillers are smaller and flower later than the main stem. The yield from tillers is less than the yield from the main stem because of a shorter grain fill period and smaller seed size. Producers can somewhat control the number of tillers per plant by adjusting the seeding rate. Higher plant populations will minimize tillering.

## Seed treatment

Fungicide seed treatment is a practice that is considered good insurance against a variety of seed and soil-borne diseases that can decrease yield (Hall et al. 2011). Longer and more diverse rotations help to minimize soil-borne diseases, but do not affect seed borne diseases. Seed treatment is a necessity when pursuing high yields.

## Fertilizers

To maximize yields, nutrient deficiencies must be minimized. As a rule of thumb, a bushel of wheat contains (thus, removes from the field) 1.5 lb of N, 0.6 lb P<sub>2</sub>O<sub>5</sub> and 0.34 lb of K<sub>2</sub>O (Clay et al. 2011). Consequently, a 100-bu/acre wheat crop removes 150 lb/acre of N, 60 lb/acre P<sub>2</sub>O<sub>5</sub> and 34 lb/acre of K<sub>2</sub>O (Chapter 12, Clay et al. 2011). To maintain yields, nutrients removed in the harvested crop need to be replaced.

**Table 1.2. Critical times for N management in wheat.**

1. Seeding.
2. V5-stem elongation or jointing.
3. Preheading.

For N management, there are at least three critical times, seeding, V5-stem elongation/jointing, and preheading (Table 1.2). Splitting the N application between planting and post planting has proven very effective. The amount of N that should be applied preplant should range from 40

to 60% of the total N required to reach optimum yield (Total N, fertilizer + credits = 2.5\*100 bu/a=250 lbs/acre; Chapter 8).

If the soil contains above average soil test N (NO<sub>3</sub>-N), the percentage of preplant N can be lower than a soil that is short of soil test N. The purposes of splitting the N are to reduce tillering, reduce the potential for lodging, and to increase the number of kernels per head. Timing is important as applying the N too early will lead to excessive tillering and disease problems.

The date and amount contained in the second application depends on the wheat type (spring or winter wheat), the rainfall potential, and the soil moisture content. For winter wheat, the second application should be applied prior to stem elongation or jointing (Zadoks 31), whereas for spring wheat the N should be applied around the 5th leaf stage (Zadoks 14-16).

For this N to be utilized by the plant, rainfall is needed to move it into the soil, and, therefore, delaying the application runs the risk that it will not be available to the plant. Conversely, applying nitrogen too early will lead to excessive tillering, increased susceptibility to foliar diseases, delayed flowering (shortening the grain fill period) and lodging. There are also nitrogen fertilizer products that exhibit slow release properties that may be useful in delaying the nitrogen availability to when the plant needs it. Many fertilizer manufacturers recommend blending slow release fertilizer with conventional fertilizer.

Mid-row banding of nitrogen is another method of delaying nitrogen availability to the plant. Nitrogen availability is delayed because the roots need to grow to reach the band. High wheat yields are often associated with low protein because plant nitrogen is diluted over so many bushels. Additional nitrogen (typically ~30 lb/acre) applied after the boot stage results in low to no yield increase, but typically is effective in producing higher protein content.

Phosphorus and sulfur are critical for early season growth and root development (Chapter 13). Use a starter formulation with the seed of 15 lbs actual  $P_2O_5$ /acre and 15 lb S/acre (as an example, use 33 lb DAP 18-46-0 and 63 lb of ammonium sulfate 21-0-0-24 per acre, which is about 19 lb of N).

### **Soil organisms**

Earthworms, bacteria, and fungi can help recycle nutrients from one crop to the next (Chapter 17). Each of these organisms provides different contributions to the overall soil health. Earthworms create channels that improve water infiltration. Soil bacteria help decompose crop residues and reduce the residual effects of pesticides, while mycorrhizal fungi increase the effective length of the crop roots, which increases the ability of plants to utilize water and nutrients. Earthworms and fungi are very sensitive to management.

Mycorrhizal fungi populations, which are important in the transfer of some nutrients to plant roots, have been found to be influenced by crop rotation, residue management and tillage. Intensive tillage, fertilizers and short rotations suppress the population of some beneficial soil organisms. A variety of seed treatments and fertilizer additives are available and promoted by different companies. Let the buyer beware, as some of these commercial products have increased yield and some have not. Producers should consult research and evaluate these products to determine if they will result in enough yield increase to pay for themselves.

### **Weed and insect pest management**

Frequent scouting allows for timely action to manage weed and insect pests within the crop safety window. All treatments should be based on economic thresholds. A healthy crop can tolerate some pest pressure. Additional information on weed management is available in chapters 24, 25, and 26.

### **Foliar disease control**

High yielding wheat requires healthy plants. Plant health is achieved through a combination of crop rotation, clean seed, balanced fertility, planting disease resistant seed, and responsible use of chemical fungicides. A “yield bump” has often been experienced when applications of strobilurin and/or triazole fungicide products take place at the flag leaf emergence, Feekes 8. Most producers of high yielding wheat use a Feekes 8 application of a product such as Folicur® because of a typical yield bump and its low cost (chemical cost only of ~\$5/acre).

Additional yield bumps have been seen particularly in spring wheat with the application of triazoles at flowering, or Feekes 10.5. This practice should be driven by intense disease scouting and/or if weather conditions indicate a high probability of infection. On-farm research is encouraged to substantiate the value or lack of value of intense fungicide management. It should be noted that widespread use of any pesticide can contribute to resistance to the product.



## Harvest management

Once you have provided the management and inputs necessary to produce high yielding wheat, the final goal is to bring it home. The operation and setup of harvest equipment is critical for minimizing yield losses (Chapter 28). High yielding wheat will lead to much lower harvest speeds.

In some situations it may be desirable to accelerate the drying of wheat. This can be accomplished by windrowing after physiological maturity. The goals of windrowing wheat are to speed up the drying process, reduce shattering losses, and increase test weights (Chapter 27). Grain should be harvested at, or dried quickly to, a suitable moisture content: 14% for short-term storage (less than 6 months) and 13% for long-term storage. Considering the large number of acres farmed by today's producers, a pre-harvest application of a chemical desiccant at physiological maturity can be used in lieu of windrowing, with essentially the same result. Be sure to follow label directions and reference Moeching and Deneke (2009).

Producers may also consider harvesting at higher moisture contents (up to 16 to 18%) than is suitable for storage and then drying the grain (at \$2/gal for propane, energy-only drying cost is approximately \$0.06/bu per point). Producers considering windrowing or a pre-harvest application of a chemical desiccant should be aware that either practice initiated before physiological maturity has an adverse effect on grain maturation and can cause shrunken and light kernels.

Following these guidelines will help producers achieve greater profitability and long-term sustainability. Both of these are important to the future of South Dakota farmers and the wheat industry.

### **Additional information and references**

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