EC929

Best Management Practices for Corn Production in South Dakota

Best Management Practices for Corn Production in South Dakota

South Dakota Cooperative Extension Service

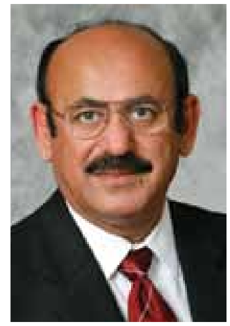
SDSU

Support for this document was provided by South Dakota State University, South Dakota Cooperative Extension Service, South Dakota Agricultural Experiment Station; South Dakota Corn Utilization Council; USDA-CSREES-406; South Dakota Department of Environment and Natural Resources through EPA-319; South Dakota USGS Water Resources Institute; USDA-North Central Region SARE program; Colorado Corn Growers Association; and Colorado State University.

Published by South Dakota State University, College of Agriculture and Biological Sciences, AgBio Communications Unit, Box 2218A, Brookings, South Dakota 57007

EC929. 2,000 copies printed and distributed by South Dakota Cooperative Extension Service at a cost of $8.68 each. May 2009.

About 5 million acres of South Dakota land—close to 10% of our state's land resources—are devoted to corn production. This fact alone makes it clear just how important corn production is to the economy of the state of South Dakota. But throw in recent developments in South Dakota's corn-based ethanol industry, and the result is an even further elevation of corn—an elevation to a most prominent position within the economy of our state.



For the last century, the intensity of farming management has continued to escalate. This best management practices manual has brought together some of the best of both old and new technology. It is my belief that this manual will be a significant reference and resource for every South Dakota corn producer.

To all who participated in the development of *Best Management Practices for Corn Production in South Dakota*, I both extend my appreciation and offer a commendation for a job well done.

Latif Lighari, Ph.D.
Associate Dean and Director
South Dakota State University
South Dakota Cooperative Extension Service
Professor of Agricultural Education
College of Agriculture and Biological Sciences

South Dakota corn producers are some of the most productive in the nation. Our state ranked sixth in the nation in production of corn for grain in 2007 and has led the nation in planted acres of genetically engineered corn hybrids since 2000. And yet, our corn producers face many challenges each year. Each producer must make the best decision on which corn hybrid to plant, choose the best fertilizer program, manage high input costs, expect seasonal hazards, deal with weeds and pests, and market the harvest for the greatest profit.

This manual presents the best management practices developed for the changing environment of corn production agriculture in South Dakota. From detailed, basic information on corn growth and development, through each phase of the corn production process, the authors and contributors have provided corn producers with an up-to-date and invaluable reference tool.

I extend my congratulations to the editors, reviewers, authors, and contributors for a job well done.

Bill Even
South Dakota Secretary of Agriculture

Editors

David E. Clay, Kurtis D. Reitsma, and Sharon A. Clay
Plant Science Department, South Dakota State University
Brookings, South Dakota 57007
For information, contact david.clay@sdstate.edu.

Coordination, Manuscript Editing, and Graphic Design

Eric Ollila, Publication Coordinator-Editor
Terry Molengraaf, Information Officer
AgBio Communications Unit
College of Agriculture and Biological Sciences, South Dakota State University
Brookings, South Dakota 57007

Reviewers, Authors, and Contributors (alphabetical order)

Troy Bauder, Research Scientist	Department of Soil & Crop Science, Colorado State University
Dwayne L. Beck, Research Manager	Dakota Lakes Research Farm, South Dakota State University
Sue L. Blodgett, Department Head	Plant Science Department, South Dakota State University
C. Gregg Carlson, Agronomist	Plant Science Department, South Dakota State University
Michael A. Catangui, Entomologist	Cooperative Extension Service, South Dakota State University
David E. Clay, Soil Scientist	Plant Science Department, South Dakota State University
Sharon A. Clay, Weed Scientist	Plant Science Department, South Dakota State University
Darrell L. Deneke, IPM Specialist	Cooperative Extension Service, South Dakota State University
Martin A. Draper, Plant Pathologist	Cooperative State Research, Education, and Extension Service
B. Wade French, Entomologist	Agricultural Research Service, United States Department of Agriculture
Billy W. Fuller, Entomologist	Plant Science Department, South Dakota State University
Robert G. Hall, Agronomist	Cooperative Extension Service, South Dakota State University
Curt A. Hoffbeck, Agronomist	Pioneer Hi-Bred International
Daniel S. Humburg, Biosystems Engineer	Agricultural and Biosystems Engineering Dept., South Dakota State University
Marie A. Langham, Plant Pathologist	Plant Science Department, South Dakota State University
Douglas D. Malo, Soil Scientist	Plant Science Department, South Dakota State University
Mike J. Moechnig, Weed Scientist	Cooperative Extension Service, South Dakota State University
Richard E. Nicolai, Biosystems Engineer	Agricultural and Biosystems Engineering Dept., South Dakota State University
Kurtis D. Reitsma, Agronomist	Plant Science Department, South Dakota State University
Bradley E. Ruden, Plant Pathologist	Plant Diagnostic Clinic, South Dakota State University
Thomas E. Schumacher, Soil Scientist	Plant Science Department, South Dakota State University
Dennis P. Todey, Climatologist	State Climate Office, South Dakota State University
Todd P. Trooien, Biosystems Engineer	Agricultural and Biosystems Engineering Dept., South Dakota State University
Hal D. Werner, Biosystems Engineer	Agricultural and Biosystems Engineering Dept., South Dakota State University
James A. Wilson, Pesticide Specialist	Cooperative Extension Service, South Dakota State University
Howard J. Woodard, Soil Scientist	Plant Science Department, South Dakota State University
Leon J. Wrage, Weed Scientist	Plant Science Department, South Dakota State University

Recognition and Acknowledgements:

South Dakota Corn Utilization Council
South Dakota Department of Agriculture
South Dakota Department of Environment and Natural Resources

Cover photos: USDA-NRCS and Kurtis D. Reitsma.

CHAPTER 5
Tillage, Crop Rotations, and Cover Crops

Historically, tillage and cultivation were used to manage residue, diseases, insects, weeds, and soil compaction. Tillage equipment that has been used includes molderboard plows, discs, cultivators, rippers, and chisel plows. Conservation practices and innovations in production tools (i.e., planters, herbicides, and genetically modified crops) provide farmers with the opportunity to minimize losses.

Table 5.1. Tillage systems for corn production

➤ Clean till <30% residue
- moldboard plow
- chisel/disk

➤ Conservation till >30% residue
- chisel plow
- disk

➤ Ridge till
- ridge building
- cultivate to maintain ridges

➤ No-till or strip till
- residue managers

Clean Till

Under normal conditions, clean tillage involves inverting the soil so that most of the residue is buried. Moldboard plowing followed by pre-plant disking is a common clean-till procedure (fig. 5.1).

Because crop residue is mostly buried, the soil surface is exposed to wind and rain, increasing the potential for erosion and loss of soil moisture. Of the tillage systems that will be discussed in this chapter, clean tillage carries the greatest potential for soil loss due to wind and water erosion (Table 5.2). Although erosion can be reduced by plowing in the spring, clean tillage still has a greater potential for erosion compared to conservation-tillage systems.

Clean tillage may be best suited for bottomland or poorly drained soils because it speeds soil heating and reduces soil water content. However, moldboard plowing can result in a plow pan that can restrict root growth. The use of deep rippers to overcome a plow-pan problem will provide only temporary relief.

Compaction can also be caused by grain wagons, combines, and trucks driving across the field. To minimize compaction, field traffic should be minimized. Excessive tillage can reduce soil water and can increase soil crusting and compaction. Due to erosion and compaction risks, moldboard plowing or excessive tillage is not considered a best management practice (BMP) for most crops in South Dakota.

Figure 5.1. Moldboard plowing wheat stubble in South Dakota

(Photo courtesy of Howard J. Woodard, South Dakota State University)

Table 5.2. Advantages and disadvantages of clean till

ADVANTAGES	DISADVANTAGES
Suited to most soils.	Erosion potential.
Well-tilled seedbed.	Compaction.
Pest control.	Fuel and labor costs.
Quick soil warm-up.	Soil moisture loss.
Mixes nutrients.	Reduced infiltration.

Conservation Tillage

Conservation-tillage systems leave at least 30% crop residue on the surface (Table 5.3). There are a number of implements that can be used in conservation tillage. The most common conservation-tillage systems are spring disking and chisel plowing (fig. 5.2).

Increasing the residue on the soil surface decreases the potential for erosion and soil water loss. Residue creates a barrier between the soil and the forces that cause erosion and soil water loss (i.e., wind, rain, and radiant heat energy from the sun). The amount of residue on the soil surface is directly related to evaporative water loss, available water, and the length of time needed for the soil to warm. Residue cover is indirectly related to the erosion potential. The amount of residue remaining on the soil surface can be increased by the following:

- Including a high-residue-producing crop in the rotation.
- Conducting tillage operations in the spring.
- Reducing the number of tillage passes.
- Using cover crops.
- Driving slower during tillage.
- Setting chisels and disks to work shallower.
- Using straight shanks and sweeps.

Figure 5.2. Chisel plowing wheat stubble

(Photo courtesy of USDA-NRCS)

Table 5.3. Advantages and disadvantages of conservation till

ADVANTAGES	DISADVANTAGES
Reduced erosion. Reduced cost. Mixes nutrients. Reduced water loss. Improved infiltration. Increased snow catch.	Stalk chopping may be necessary. Compaction (if disked in wet conditions). Delayed planting (if too wet).

Ridge Tillage

Ridge tillage is a conservation-tillage system where crops are grown on permanent beds (or "ridges") (fig. 5.3). With ridge tillage, the planter must be able to cut residue, penetrate the soil to the desired depth, and in many situations clear the ridge of the previous year's crop residue (stalks and root-balls). Following planting, cultivators are used to control weeds and rebuild and shape the ridges. Ridge tillage is well suited to relatively flat landscapes and is often furrow irrigated in arid climates.

In ridge tillage, crop residue and organic matter tend to accumulate between the ridges. If mechanical cultivation and ridge building take place during the growing season, these materials are generally mixed in the upper portion of the profile. Relative to clean tillage, ridge tillage will increase water infiltration and reduce runoff (Table 5.4). Nitrogen (N) leaching can be reduced by banding fertilizer into the ridge. Herbicides may be applied to the ridge, with cultivation used for between-row weed control. Two disadvantages of ridge tillage: 1) Specially designed equipment is needed. 2) Many view ridge-tillage as labor intensive.

In ridge tillage, it is recommended that soil samples for nutrient analysis be collected halfway between

Figure 5.3. Planting corn in a ridge-tillage system

(Photo courtesy of Keith Alverson, South Dakota corn producer)

Table 5.4. Advantages and disadvantages of ridge till

ADVANTAGES	DISADVANTAGES
Reduced erosion. Saves water. Lower fuel costs. Increased snow catch.	Light soils may crust. Not well suited to all rotations (alfalfa or small grains). Must have equal wheel spacing on all equipment and must have narrower tires.

the center of the row and the crop row. When applying fertilizers into the ridge, care should be taken to minimize direct contact with the seed. For sandy soils, the amount of N plus K_2O applied with the seed should not exceed 5 pounds per acre. This limit increases to 10 pounds per acre for fine-textured (clay) soils. The effectiveness of phosphorous (P) and potassium (K) applications is often improved by banding.

Strip Till

Strip till is a conservation tillage system where the seedbed (8 to 10" wide) is tilled and cleared of residue (fig. 5.4). Strip-till systems prepare a seedbed that is relatively free of residue, even in corn-following-corn situations. The spreading of residue at harvest can reduce residue interference at planting. Strip tillage may be conducted in the fall or spring. Spring strip till uses a tillage tool that tills strips ahead of planter seed openers. If strips are tilled prior to planting in a separate operation, it can be challenging to consistently follow the strip with the planter. If strips are tilled in a separate operation from planting, it is recommended to track the direction of travel of the tillage implement, following the same direction with the planter. Strip-tilled fields tend to warm faster than no-till fields.

Figure 5.4. Strip-tilled corn in South Dakota

(Photo courtesy of Dwayne Beck, South Dakota State University)

Table 5.5. Advantages and disadvantages of strip till

ADVANTAGES	DISADVANTAGES
Reduces soil erosion and runoff. Saves moisture. Reduced compaction. Increased snow catch.	Specialized equipment needed. Greater reliance on herbicides. Potential for disease and insect outbreaks. Reduced crop residue interference.

Strip tillage does not eliminate erosion, and following rainfall, erosion can occur down the strip (Table 5.5). Contour strip tillage should be considered in high-slope situations. In some strip-till systems, when strips are tilled in the fall or spring, fertilizer is applied in a band. Failing to follow the strips with the planter can affect fertilizer placement with respect to the seed. If P or K fertilizers are needed, they can be fall banded into the strips. As with any tillage system, N fertilizer should not be fall-applied until soil temperatures are below 50°F. Starter fertilizer can be used; however, the total amount of N + K_2O applied in contact with the seed should not exceed 5 pounds in a sandy soil and 10 pounds in fine-textured soils. Many producers have problems when attempting to plant into fall-created strips in rolling terrain. If the seed row is either too close or too far away from the fertilizer band, early growth can be compromised.

No-Till

Of the tillage systems discussed, properly managed no-till systems leave the most residue on the soil surface (fig. 5.5). Compared to other systems, no-tilled fields retain the most moisture, have the highest infiltration rates, and have the lowest erosion potentials (Table 5.6). The effects of no-tillage on erosion are attributed to increased water infiltration and reduced runoff. Considering the potential conservation and production benefits, no-tillage should be strongly considered by South Dakota producers.

In South Dakota, no-till systems have allowed for row crop production in the western regions. This expansion is the result of reduced soil water loss (compared with conventional-tilled systems). A consequence of no-tillage is reduced organic matter mineralization and higher water infiltration rates. Increased infiltration is thought to result from macropore development, as old root channels and earthworm trails are not disturbed by tillage. Increase N-fertilization rates are recommended (+30lbs. N/A) to overcome reduced soil organic matter mineralization rates.

No-till systems require optimization of planting and residue-management systems. Residue management begins at harvest, leaving as much residue in place as possible. Using stripper headers during grain harvesting both allows straw to remain upright and attached and prevents residue from being moved by wind or water. In corn this is accomplished by adjusting the strippers and rolls to keep the stalk intact and upright. Uniform chaff spreading is particularly difficult when using large headers. Straw and plant stems that are chopped into small pieces are difficult to distribute uniformly and have a tendency to be moved into piles by wind or water.

When planting in no-till systems, residue managers work best in situations where residue is uniform; when residue is not uniform, it is almost impossible to properly adjust residue managers on the planter. Moving residue is easier if it is cut before moving it. Single-disc fertilizer openers placed at the same depth and 2 to 3 inches to the side of the seed opener path can serve a dual purpose: cutting residue and placing the side-band fertilizer. When compared to conservation tillage, no-till soils generally remain cooler in the spring. Cooler soil temperatures can slow N and sulfur (S) mineralization. Placing nutrients like N and S as a side-band improves early season plant vigor.

The planter is the most important implement in a no-till system (fig. 5.6). Seed germination is improved when the seed is covered with loose material and firmly planted at the right depth in warm, moist soil. The basic corn planter was designed for use in well-tilled seedbeds. Consequently, modifications are needed to assure optimal seed placement. Almost all row-crop planters have openers that utilize 2 discs to open the seed slot. The seed-opener discs are often arranged so that the blades touch evenly at the front and have discs of equal size. Some manufacturers offset these discs so that one disc leads the other. Wiper/depth wheels can limit the problem of mud being brought to the surface and interfering with seed opener depth wheels. South American openers use offset double-disc openers with discs of different sizes; this design results in a differing angular momentum between the blades that is thought to improve the slicing action. All disc openers require sharp blades; if they are not sharp, the residue can be pushed (hair-pinned) into the trench, resulting in uneven germination and growth. Hair-pinning is worse when residue is cut into short lengths and soil structure is poor. Continuous, long-term no-till systems have less of a problem with this issue.

Once the seed is placed into the trench, it needs to be pressed into the soil and covered. In no-tillage systems, the best method is to separate the firming (seed pressing) and covering operations. Several companies make devices designed to press or lock the seed into the bottom of the trench. This speeds

Figure 5.5. No-till corn in South Dakota

(Photo courtesy of Howard J. Woodard, South Dakota State University)

Table 5.6. Advantages and disadvantages of no-till

ADVANTAGES	DISADVANTAGES
Greatly reduces soil erosion and runoff. Saves moisture. Lower fuel costs. Reduced compaction. Increased snow catch.	Specialized equipment needed. Greater reliance on herbicides. Slower spring soil warm-up and drying. Nutrient stratification. Potential for disease and insect outbreaks.

Figure 5.6. Planting corn in a no-till system

(Photo courtesy of Howard J. Woodard, South Dakota State University)

the rate at which the seed imbibes water and anchors it to the bottom of the trench. The lack of root penetration is often blamed on "sidewall" compaction, which can be traced to a poorly anchored seed. There are several companies that make aftermarket devices designed to press the seed into the bottom of the trench. In general, vertical wheels work better in most conditions; however, vertical wheels are more expensive and harder to mount than the type that uses a sliding piece of plastic.

Once the seed is firmly pressed into the bottom of the trench, the seed needs to be covered. Standard closing systems on corn planters are designed to work in tilled seedbeds by packing the area under and around the seed, while leaving loose material above the seed. Standard rubber or cast-iron closing systems normally do not function well in no-till systems because they have difficulty properly closing the trench in well-structured or wet soils. If the soil over the seed is packed too firmly, the corn plant may set its growing point too shallow; this makes the plant prone to damage from herbicides and late frosts. If the soil covering the seed is too loose, the seed trench may dry too fast, leading to stand loss. Many companies (e.g., Martin®, May-Wes®, Exapta®, Yetter®) make attachments designed to loosen the soil in the seed trench and place it over the seed. One reason that strip till may appear superior to no-till is that seed is planted into loose soil created by the strip-tillage operation, which allows for optimal operation of standard closing wheels.

Other attachments needed for conversion of a standard planter to a no-till planter are fertilizer openers and residue managers. The best fertilizer opener designs are single-disc openers with a depth-gauging and/or wiping wheel. These openers cut the residue and place fertilizer 2 to 3 inches to the side of the seed. In fine-textured soils, most of the N and P can be band-applied using this approach. However, in irrigated or sandy fields, limit N applied to one-third to one-half of the seasonal N requirement.

Using residue managers that cut residue before it is moved and replacing wide-depth wheels with narrow-depth wheels reduces the likelihood of planter plugging in heavy residue. Using a residue manager with a backswept design helps keep residue from wrapping. Cutting the residue allows the residue managers to split the mat of residue without tearing it apart, which is especially important under damp conditions. Cutting residue reduces soil disturbance because residue managers do not have to engage the soil, reducing problems with surface sealing or crusting, weed growth, and erosion.

There are many designs of residue managers. Test the ease of adjustment prior to selecting a residue manager. The bottom line with no-till seeding equipment is that it needs to work effectively. No-till systems are becoming increasingly popular. Additional information is available at www.sdnotill.com and at www.dakotalakes.com.

Compaction

Soil compaction decreases drainage and aeration, increases the potential for runoff and erosion, and can restrict root development. Wheel traffic and tillage can reduce pore space by crushing pores and by reducing pore size. Compaction can be most severe in wet clay soils. Tillage, especially moldboard plowing and disking, can lead to the development of a plow layer or plow pan (fig. 5.7).

Compaction caused by combines, grain wagons, trucks, and other equipment can cause problems in any system. To minimize yield losses due to compaction, field traffic lanes should be used and grain wagons and trucks should be left on the edges of the field. Once compaction occurs, it is very difficult to reverse.

Figure 5.7. Compaction created by a tandem disc

(Photo courtesy of Thomas E. Schumacher, South Dakota State University)

Deep tillage and incorporating deep-rooted crops can be used to remediate compaction problems. Deep tillage is most effective when soil is dry; however, deep tillage only provides a temporary reprieve. The best approach for managing compaction is to avoid unnecessary tillage and traffic, include deep-rooted crops in the rotation, outfit equipment with wide tires, reduce tire pressures, and leave grain carts and trucks at the edge of the field when harvesting.

Rotations

Weed, disease, and insect management can present challenges in all tillage systems. However, weeds that can be controlled with tillage in tilled systems must be controlled with herbicides in no-till systems. Corn-following-corn in no-till systems may be susceptible to disease and insect pressure because some of the pests may overwinter in last year's residues. These challenges can be addressed by using appropriate rotations. The use of genetically modified corn is helping to resolve weed and insect problems. A crop rotation is a sequence of crops planted year after year on the same piece of ground. Carefully planned crop rotations can help overcome compaction, disease problems, and weed species shifts. "Rules of thumb" for selecting rotation sequences are listed in Table 5.7.

Crop rotation and tillage need to be considered at the same time. Designing appropriate crop rotations is a mix of art and science. For any given situation, there will be a range of rotations that will be agronomically appropriate. Within this range there are rotations that have different characteristics in terms of risk (e.g., market availability, labor or machinery requirements, and other considerations specific to individual farming practices).

Management decisions must consider many different types of information. For example, potential yields and profitability must be considered when determining the rotational sequence. Many producers are considering increasing the amount of corn in the rotation. This decision should be based on the short- and long-term effects on profitability. There are several additional factors that should be considered when making this decision. First, there is a yield drag of about 5 to 15% for second-year corn relative to first-year corn (Duffy and Correll 2007). The greatest yield drags are typically measured between first- and second-year corn but can also be high when weather is unfavorable. Yield drags generally stabilize after third-year corn. Second, more N is needed following corn than soybean. The N-fertilizer recommendation for the crop following a soybean crop is reduced by the legume credit (40lb. N/acre), and this may be a substantial monetary saving compared to buying fertilizer. Third, soybeans generally yield more (5 to 8% more) when following 2 or more years of corn. Fourth, continuous corn can increase pest problems.

In the far southeast portion of South Dakota, corn yield is less likely to be reduced by water stress and is more likely to be reduced by disease and pest problems. Going from south to north increases the importance of soil temperature. Corn following a low-residue crop will experience warmer soil temperatures earlier than when following a high-residue crop such as corn. Water becomes more limiting as one travels from east to west.

In semi-arid climates, efficient water use is critical. Cropping more frequently with high water-use crops increases the cropping system intensity. Barley, winter wheat, field peas, and canola are low water-

Table 5.7. "Rules of thumb" for selecting a rotation sequence

- Grow only the crops that are suitable for your soil and climatic conditions.
- Understand the market conditions for your crops.
- To reduce pest problems, the same crop should not be grown in consecutive years.
- Select a rotation that minimizes pest problems.
- High-residue crops should be included in the rotation to store carbon.
- Estimate your cost of production and expected returns. Cost of production and expected returns can be estimated with a Web-based worksheet located at http://www.extension.iastate.edu/agdm/crops/xls/a1-20croprotation.xls.

use crops, while corn, soybean, and alfalfa are high water-use crops. Additional details for scoring water use and cropping intensity are available at http://www.dakotalakes.com/Publications/Div_Int_FS_pg6.pdf.

Increasing the crop-rotation diversity can improve the functioning of the agro-ecosystem (Table 5.8). When considering diversity, rotational crops need to compliment each other as much as possible to prevent problems with labor, equipment, disease, weed, and insects. Diversity increases by including as wide a variety of crop types as possible. Many commonly grown crops can be grouped:

- **Cool-season grass:** spring wheat, winter wheat, barley, durum wheat, oat, and winter rye.
- **Warm-season grass:** corn, sorghum, sudangrass, and millet.
- **Warm- and cool-season broadleafs:** field pea, lentil, canola, mustard, crambe, flax, safflower, chickpea, sugar beet, sunflower, dry edible, bean, soybean, and alfalfa.

Information for scoring rotational diversity is available at http://www.dakotalakes.com. When selecting a crop rotation, it is important to avoid potential conflicts between the seeding and harvest times of different crops (e.g., trying to seed one crop when harvesting another, or harvesting more than one crop at a time).

Table 5.8. "Rules of thumb" for increasing diversity in semi-arid regions of South Dakota

- Use soil survey information to evaluate soil water storage. Determine the appropriate cropping intensity based on this information.
- Manage crop residues to facilitate soil water storage.
- Manage crop nutrients to ensure strong crop competition with weeds and to achieve crop yield goals.
- Utilize legume crops and animal manure to increase energy efficiency and improve soil quality.
- Adopt techniques that minimize wind and water erosion.
- Anticipate the equipment and/or labor requirements for growing new crops.
- Cover crops can be used to increase crop rotation intensity and diversity.
- Perennial crops such as grass or alfalfa provide excellent weed suppression in a rotation, particularly if the crop following them is planted no-till with minimal soil disturbance.
- Consider the marketability of the commodity prior to planting a crop.

Cover crops

Typically planted during the summer or late summer to early fall, cover crops help reduce erosion and nutrient loss, and increase carbon storage (Table 5.9). Cover crops can provide forage for fall and winter grazing, but it is unlikely that a marketable commodity will be produced. Selecting a cover crop species or mix of species that germinates, emerges, and quickly establishes is essential to success. Equally important for the cover crop is the ability to cope with adverse growing conditions, while also being easy to kill before the commodity crop is seeded. Prior to planting cover crops, it is important to consider the following:

Table 5.9. Primary benefits of cover crops

- Improved soil quality
- Reduced erosion
- Improved carbon storage
- Reduced losses of nutrients
- Improved pest management

- The effect of the cover crop on water availability. In wet areas, cover crops can be used to reduce soil water content.
- The likelihood of cover crop establishment, considering growing season limitations.
- The cost of seeding and killing the cover crop.
- Establishment of a cover crop in dry or high-salt soils.
- The likelihood of the cover crop acting as a weed or harboring insects, diseases, and other pests.

The above concerns must be weighed against the benefits of improved soil health, reduced erosion, reduced nutrient loss, and improved insect and plant diversity.

Like any other crop, a cover crop will use water from the soil profile. In South Dakota, cover crops are most effective following a small-grain crop that is harvested early enough to allow for cover crop establishment. The difficulty of establishing cover crops following wheat or pea harvest is that there may not be sufficient levels of soil moisture to germinate seed and support crop establishment. Cover crop water use is usually not an issue unless a winter crop such as winter wheat is planned to follow and water is limiting. If a spring-seeded crop is planned, a cover crop can increase available water by acting as a snow catch.

Maximizing the return on investment from a cover crop requires paying attention to the cost of seed and killing the crop prior to seeding the commodity crop to follow. Cover crops can consist of a single species but are often a mix of several species. For example, a mix of oats, turnips, and radishes provides effective cover and grazing forage and reduces soil compaction. A legume blend including cowpeas, soybeans, annual sweetclover, and medic is an option that can add N as well as organic matter. Non-legume crops such as sorghum-sudangrass, millet, forage sorghum, or buckwheat produce more biomass, providing improved weed competition and soil tilth.

In many areas, high salts can limit seed germination and successful establishment. If soluble salts are not an issue, species selection is more flexible and may include clovers, medic, hairy vetch, dry bean, peas, wheat, rye, oats, turnips, radishes, and buckwheat. Species become more limited as soluble salt levels in the soil increase. For slightly saline soils, a mixture may include canola, lentils, and sugar beets; in 2007, the seeding cost for these crops was estimated at $9.30/acre. For moderately saline soils, a mixture may include sugar beets and barley; the estimated seeding cost for this group of crops was $6.30/acre in 2007. Strongly saline soils require crops that are more salt-tolerant, such as tall wheatgrass and barley; the seeding cost for this crop group was approximately $5.00/acre in 2007.

Planting cover crops in the northern Great Plains presents a number of challenges. Short growing seasons when planting follows fall harvest provides little time for establishment. Sowing in the spring is hampered by wet soils, cold conditions, and a short time to plant the primary crop. Integrating cover crops into cropping systems presents a number of benefits but requires additional management and investment. Cover crops should be planted as soon as possible, due to the short amount of time available for establishment. Considering the short growing period, seed production is unlikely and annuals in the cover crop will be killed by frost. Species that survive winter or cover crops sown before seeding a winter crop will need to be killed with tillage or herbicide, increasing the initial investment.

Depending on regional climate and cropping system, a cover crop may not be feasible every year. Opportunities for cover crops exist largely in systems where early harvested small grains are followed with corn, soybeans, or other spring-seeded crops. Many questions—regarding water, nutrient, and carbon cycling—associated with cover crops currently remain unanswered. Further study of these phenomena is required to develop refined recommendations. Characteristics of many potential cover crop species are shown in Table 5.10.

Table 5.10. Cover crops – common species and properties						
Species	**Erosion Reduction**	**Biological N Fixation**	**Supplemental Grazing**	**Reduce Soil Compaction**	**†Crop Type**	**Salt Tolerance**
Alsike Clover	Good	Yes	Fair	Good	CB	Poor
Annual Ryegrass	Fair	No	Good	Poor	CG	Fair
Barley	Good	No	Fair	Fair	CG	Good
Buckwheat	Good	No	Poor	Poor	WB	Poor
Canola	Fair	No	Fair	Good	CB	Good
Chickling Vetch	Good	Yes	Fair	Fair	CB	Poor
Cowpea	Poor	Yes	Fair	Fair	WB	Poor
Grain/Forage Sorghum	Good	No	Fair	Good	WG	Fair
Hairy Vetch	Good	Yes	Fair	Fair	CB	Poor
Lentil	Poor	Yes	Fair	Poor	CB	Poor
Millet	Good	No	Fair	Fair	WG	Poor
Mustard, Oriental/Brown	Fair	No	Fair	Fair	CB	Poor
Mustard, Tame Yellow	Fair	No	Fair	Fair	CB	Poor
Oat	Good	No	Fair	Fair	CG	Fair
Pea	Poor	Yes	Fair	Poor	CB	Poor
Radish	Poor	No	Good	Good	CB	Poor
Red Clover	Good	Yes	Fair	Poor	CB	Poor
Spring Rye or S. Wheat	Good	No	Fair	Fair	CG	Fair
Sugarbeet	Poor	No	Good	Good	CB	Good
Sunflower	Fair	No	Good	Fair	WB	Fair
Sweet Clover	Good	Yes	Fair	Fair	CB	Fair
Tall Wheatgrass	Good	No	Good	Fair	CG	Good
Turnip	Poor	No	Good	Good	CB	Poor
White Clover	Good	Yes	Fair	Poor	CB	Poor
Winter Rye or W. Wheat	Good	No	Fair	Fair	CG	Good

†Crop Type	CB	Cool-Season Broadleaf
	WB	Warm-Season Broadleaf
	CG	Cool-Season Grass
	WG	Warm-Season Grass

Adapted from USDA-NRCS, Cover Crop (Code 340), April 2008, Section IV, South Dakota Field Office Technical Guide.
Available online at eFOTG: http://efotg.nrcs.usda.gov/references/public/SD/SD340.

Additional Information and References

Dakotalakes.com. 2005. South Dakota State University, Dakota Lakes Research Farm. http://www.dakotalakes.com/.

Duffy, M. and D. Correll. 2007. The economics of corn on corn. Integrated Crop Management. IC-498. http://www.ipm.iastate.edu/ipm/icm/2007/2-12/economics.html.

Beck, D.L., D.E. Clay, and K.D. Reitsma. 2009. "Tillage, crop rotations, and cover crops." Pp. 21–30. In Clay, D.E., K.D. Reitsma, and S.A, Clay (eds). Best Management Practices for Corn Production in South Dakota. EC929. South Dakota State University, South Dakota Cooperative Extension Service, Brookings, SD.

Support for this document was provided by South Dakota State University, South Dakota Cooperative Extension Service, South Dakota Agricultural Experiment Station; South Dakota Corn Utilization Council; USDA-CSREES-406; South Dakota Department of Environment and Natural Resources through EPA-319; South Dakota USGS Water Resources Institute; USDA-North Central Region SARE program; Colorado Corn Growers Association; and Colorado State University.