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Conservation TILLAGE Seeding Equipment

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Introduction

Conservation tillage is part of a system of crop production designed to minimize soil disturbance, maintain previous crop residue on or near the soil surface and minimize the number of field operations. Weeds primarily are controlled with herbicides and fertilizers are applied in ways that minimize soil disturbance. Conservation tillage seeding equipment often is designed as a "one-pass" system, combining minimum tillage with the planting operation or completely eliminating the need for tillage.

The primary reasons crop producers adopt conservation tillage practices are: 1) labor and fuel savings by reducing the number of passes across a field, 2) equipment cost savings and 3) yield increases. A number of studies have been conducted in North Dakota comparing conventional tillage systems to reduced and no-tillage systems. Research at Dickinson demonstrated that spring wheat yields increased an average of 45 percent with no-till (Table 1). Similarly, soybean yields at Carrington are higher with no-till than with conventional tillage (Table 2).

Table 1. Tillage effect on hard red spring wheat yields at Dickinson, N.D.
(Conventional till is less than 15% residue cover; reduced till is 30% or more residue cover; no-till is greater than 80% residue remaining after seeding). Carr et al, 2004

Tillage System	2000	2001	2002	2003	2004	5-year Average
Conventional Till	33	46	28	29	20	31.2
Reduced Till	38	47	30	30	24	33.8
No-till	48	56	39	49	32	44.8

Conservation tillage seeder

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Table 2. Soybean response to tillage systems – Carrington 2005-06.
Endres, G., and Schatz, B. 2006

	2005	2006	Average	2005	2006	Average	2005	2006	Average
Treatment	Plants/Acre			Seed Yield Bushel/Acre			Protein %		
Conventional Till	252,330	190,240	221,290	21.7	16.2	19.0	35.5	36.6	36.1
No-till	230,510	184,930	207,720	22.6	18.1	20.4	34.8	36.1	35.5
Strip Till (Fall)	238,100	181,280	209,690	23.4	18.4	20.9	35.2	36.4	35.8

Reduced tillage practices generally reduce water runoff, minimize soil erosion and reduce moisture loss from evaporation. Less tillage leaves more crop residue on the soil surface, which decreases the potential for pesticides and fertilizers to move into surface water and normally reduces weed seed germination. The presence of crop residue on the soil surface increases soil biological activity, which results in more efficient nutrient cycling and increases the potential to sequester carbon, compared with conventional tillage systems.

Basic Criteria for Effective Seeders

A seeder for conservation tillage must successfully meet the following criteria:

1. Precisely meter and place a wide variety of crop seeds at a uniform depth and maintain the soil environment for successful seed germination and seedling emergence
2. Seed through surface residue without destroying the residue, leaving it in an optimum configuration for soil, water and crop protection
3. Operate in varying soil types and field conditions
4. Provide excellent mechanical durability to maintain precise seeding performance, with minimal wear and maintenance
5. Have an economical purchase price relative to the drill's/planter's capability and durability
6. Optional criterion: the ability to place fertilizer in a band parallel to the seed row to provide the most efficient use of fertilizer by the plant while minimizing utilization by weeds

No-till soybeans

Which Opener Design?

The two basic opener designs used on conservation tillage seeders are disc and hoe openers. "Hybrids" of these two opener designs incorporate some of the same features of both disc and hoe type openers. Disc openers can be single or double disk, with gauge wheels mounted beside and in contact with the disc opener or with a trailing packer wheel functioning as a gauge wheel.

Hoe openers are available in various widths from less than 1-inch-wide spikes to 10-inch-wide sweeps. Some hoe openers are bolted on to the shank and others are "knock-on" without bolts.

The importance of the type and designs of openers and packer wheels varies, depending on soil type and conditions, the amount and type of crop residue, the crop being planted and the producer's management goals.

Crop producers usually have specific management goals that relate to the amount of residue to be maintained on the soil surface and the position of the residue after planting. Disc openers are superior to hoe openers if the producer's goal is to leave most of the crop residue from the previous year standing after planting. Hoe openers result in more of the crop residue mixed into the soil.

Hoe openers push residue aside to place seed in moist soil near the surface. Hoe openers cause more soil disturbance, which can promote both soil warming and drying similarly to a tillage operation. Hoe openers may cause bunching if the residue is wet or unevenly spread. More vertical clearance of the seeder helps prevent bunching.

Disc openers generally disturb soil less than hoe openers, maintaining moisture in the seed zone. However, this may slow soil warming after planting.

Important Issues in Conservation Planting

Seed and fertilizer delivery and placement

One-pass and no-till seeding with fertilizer application, including injecting anhydrous ammonia at planting time, is common in the northern Great Plains. However, most grain crops require more nitrogen fertilizer than can be placed safely in a narrow seed row.

The primary factors that affect the amount of nitrogen fertilizer that can be applied with the seed vary, depending on the distance between rows and the distribution of both the seed and fertilizer within the row. More fertilizer can be applied with the seed when the seeds and fertilizer are spread over a wider area, i.e., in a 6- to 8-inch-wide band behind a sweep (see NDSU Extension publication EB-62). Other factors that influence the amount of nitrogen fertilizer that can be placed close to crop seeds include soil texture, soil pH, soil water, precipitation, fertilizer placement, fertilizer form, fertilizer material and the type of crop.

The separation of fertilizer from the seeds needs to be greater in some soil conditions, such as in dry, cloddy soils. The risk of stand reduction is greater from nitrogen toxicity in sandier soils than in clayey soils. More than 20 to 30 pounds per acre (lbs/acre) of nitrogen fertilizer placed with seeds can result in reduced germination, low seedling emergence and poor stands, with subsequent yield loss.

Separate fertilizer delivery systems can be used to place fertilizer in a band to the side and below the seed. With disc openers, a separate disc can be mounted between two seed rows to place fertilizer in a band shared by two seed rows. This is called midrow banding. Midrow bands deliver nitrogen products safely.

However, midrow banding places phosphorus materials too far away from the plants to deliver a "starter" effect to young plants. A separate system to deliver phosphorus in or near the seed row is required to achieve "starter" phosphorus effects.

Some hoe seeders are designed with a fertilizer tube next to the seed tube that places fertilizer below and to the side of the seed row. This is referred to as double-shooting. Low-draft, double-shooting openers place seed and fertilizer at the same depth, which is designed to reduce power required to pull the seeder.

The air seed delivery system needs to have enough air to move the correct amount of seed to the farthest ends of the seeder but not blow seed out of the seed slot or cause damage to the seeds. This is accomplished by incorporating an air dissipation system in the air delivery system prior to the seed discharge into the opener.

Disc opener

Hoe opener

Managing crop residue

The previous crop residue is a resource to conserve and use. Crop residue limits evaporation from the soil surface and maintains humidity levels in undisturbed soils at between 90 percent and 100 percent, which is ideal for germinating seed. Even with excellent soil seed contact, at least 85 percent of the water enters the germinating wheat seed in the form of vapor. In dry conditions, low-disturbance, no-till planting systems preserve moisture in the seedbed, allowing uniform germination and plant establishment to occur. Crop residue also provides a food source for beneficial fungi, bacteria, insects and weed seed predators.

Emerging no-till wheat in crop residue

Managed properly, the beneficial aspects outweigh the negative aspects of crop residue in conservation tillage systems. When left in place, crop residue will protect the crop from wind damage during establishment and will continue protecting the soil if the crop fails to establish due to drought or flood. Crop residue readily decays and is incorporated into soils by earthworms and fungi once the growing crop canopies cover the interrow space.

Crop residue should be spread uniformly during the harvest operation. Uniform distribution of crop straw and chaff facilitates uniform seed placement during seeding. Spreading straw and chaff after harvest is difficult and ineffective. Harrows are a poor substitute for a combine that effectively chops and spreads crop residue. Moreover, harrows incorporate weed seed and shattered grain into soil, increasing the longevity of viable seed.

Straw chopper/spreaders and chaff spreaders work best to spread crop residue over the width of the combine header. During harvesting, continue to move the combine until all crop residue is cleared from the machine. Stopping combines before all of the straw and chaff have cleared the combine results in residue piles in the field that can interfere with seeders.

If disc openers are used for seeding, the combine header should be set as high as possible to leave a tall stubble but low enough to gather the grain. If shank or narrow hoe openers are used, combine headers need to be set low enough to cut straw to lengths that are no longer than the distance between the openers. This will allow straw to flow around shanks and reduce the likelihood of plugging from residue buildup. Uniformly spread residue allows for more uniform soil warmup, promotes moisture conservation and results in less interference with seeder opener penetration.

Grain stripper headers leave much of the small-grain residue attached to the soil surface and upright while removing the grain, which makes penetrating the soil easier for disc openers. This type of header is more energy-efficient because less crop material passes through the combine.

One of the most severe problems encountered in conservation tillage systems is slower warming of soils in the spring, compared with more intensively tilled fields, due to poor distribution of crop residue. Heavy residue keeps the soil cooler longer in the spring, compared with tilled soil. However, keeping residue on the surface also will maintain soil moisture closer to the soil surface, which is an advantage in drier conditions.

In the northern Great Plains, soil moisture is often the limiting factor in crop production. During dry years, the extra moisture available with direct seeding is often sufficient to germinate and establish the crop by saving the moisture that would have been lost from tilling the soil prior to planting. When crop residue is managed properly, soil temperature usually is not a limiting factor in low-disturbance, no-till seeding.

Disc openers may have difficulty cutting a slot through wet residue left on top of the soil, causing hair pinning of the residue under the disc. Hair pinning is a term used to describe straw stalks that are bent and pushed into the soil rather than cut by the opener disc. Leaving the majority of the straw intact during harvesting and connected to the soil and evenly distributing the straw and chaff from the combine reduces hair pinning problems at seeding time.

Moist residue is difficult to cut and may cause seed to be placed into residue rather than in contact with soil. This can slow seed germination and result in less uniform crop emergence. Row cleaners, usually spoked wheels mounted in front of disc openers, sometimes are used to decrease hair pinning. Row cleaners push some residue to the side, allowing the disc opener to penetrate the soil, and are particularly important when planting into high-residue fields.

Spoke-type row cleaners can become plugged in corn or sunflower residue, with the spokes acting like a trash collector. One solution to this problem is to use smooth disks for row cleaners to push residue aside. Another solution is to plant between the previous year's rows without using any row cleaner. Using one spoked wheel operated at 15 to 20 degrees from the disc opener operating plane, rather than two spoked wheels, may function better on equipment used to plant in narrow rows with higher crop residue.

Planting equipment must have adequate spacing between openers for residue flow and still be able to maintain the proper and uniform seeding depth. This is particularly important for seeders with hoe openers.

Other seeder design principles that improve operation in high residue include cutting coulters, multiple rows of openers, row spacing, vertical clearance and opener width. Mounting openers in more than one row across the seeder increases the distance between openers by staggering adjacent openers in different rows.

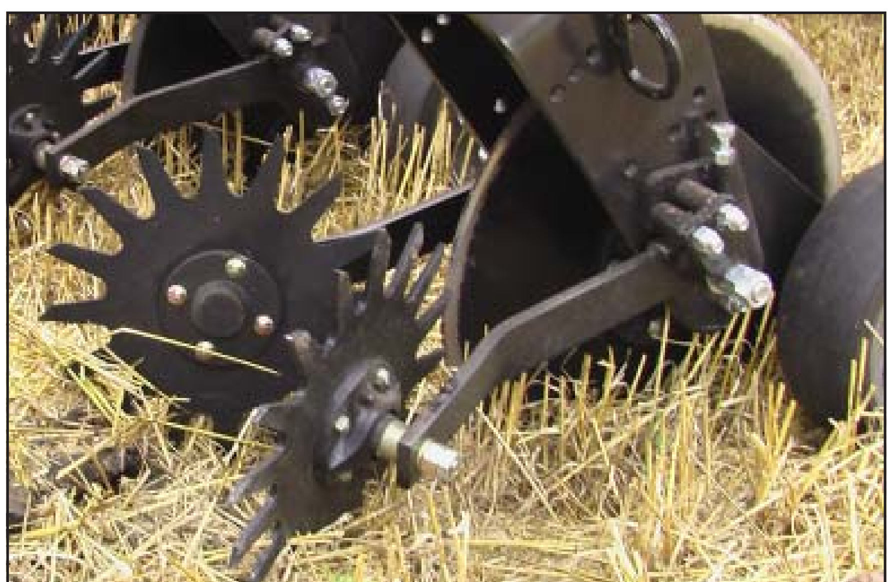
Hair-pinned residue

Either flat or fluted coulters mounted in front of disc or hoe openers to cut horizontal residue allow seeders to operate more effectively in heavier residue. Generally, seeders with more vertical clearance can operate in field conditions with more residue.

Crop rotations also can be used to effectively manage crop residue. Low residue-producing crops, such as peas, soybeans, lentils, flax, safflowers and sunflowers, can be alternated with high residue-producing crops, such as wheat, barley and corn. Rotations between crop types also increase the diversity of soil macro- and microorganisms and decrease the risk of disease and harmful insect pests.

Soil disturbance

Generally, reducing the amount of soil disturbance during crop production lowers carbon losses from soil. The Natural Resources Conservation Service (NRCS) has developed a Soil Tillage Intensity Rating (STIR), which assigns a numerical value to each tillage operation (Table 3). Crop management decisions implemented for a particular field affect the rating value. Lower numbers indicate less overall disturbance to the soil layer.



Row cleaners

Table 3. Soil disturbance and fuel consumption for various types of openers.

Opener configuration	Soil surface disturbance	STIR* factor	Fuel consumption to seed one acre
(spacing in inches)	%		gallons/acre
Double disc (7-10)	65	6.33	0.36
Double disc with separate fertilizer opener (7-12)	85	13.81	0.43
Double disc – fluted coulters (7-10)	55	7.15	0.43
Double disc – narrow offset	25	4.87	0.32
Double disc – very heavy direct seeding one pass	85	16.57	1.1
Double disc – very heavy direct seeding one pass with row cleaners	90	17.55	1.3
Hoe in heavy residue (10-15)	65	16.90	0.74
Hoe (6-12)	90	23.40	0.74
Inverted tee,.e.g., cross-slot (7-10)	15	1.95	0.40
Single disc (7-10)	15	2.43	0.35
Single disc with separate fertilizer opener (7-10)	35	5.68	0.48

Source: NRCS RUSLE2 Version 1.26 and Soil Tillage Intensity Worksheet, http://stir.nrcs.usda.gov/.

* STIR factor calculated for seeding spring wheat using a drill with the specified opener following sunflower in a four-year rotation of spring wheat-winter wheat-corn (grain)-sunflower in southwestern North Dakota. The overall STIR rating for the entire four-year no-till rotation will differ from that shown for each specific opener.

To qualify for NRCS no-till incentive programs, a STIR value of 10 or less is required. Values may range from 0 to 200, with lower scores preferred. The NRCS indicates other benefits of low STIR values, which include increasing organic-matter (OM) content of the soil, less OM breakdown and improved water infiltration rates. Under most soil conditions, disc-type openers cause less soil disturbance than hoe openers.

Disc openers on seeders generally cause less soil disturbance and maintain more residue on the soil surface, resulting in less soil temperature change, less soil erosion potential and a greater potential to conserve existing soil moisture, compared with hoe openers.

Hoe openers generally cause more soil disturbance than disc openers by partially burying straw and bringing soil to the surface. Disturbed soil exposed to solar radiation will warm sooner than undisturbed soil, but it also will cool faster.

Low-disturbance, angle discs on seeders have shown significant advantages in both wet and dry years in reducing weed germination. Increasing soil disturbance increased competition from weeds and decreased crop density. Weed seeds left on the soil surface are exposed to predation and environmental extremes, resulting in fewer viable seeds to germinate and infest the next crop. When low-disturbance no-till is used in combination with diverse crop rotations and appropriately selected and timed herbicide application, weed control costs can be reduced by 50 percent because lower weed density reduces the need for herbicides.

Depth control

Uniform depth placement of both the seed and fertilizer influences seedling emergence and, ultimately, crop yield. Factors influencing uniformity of seeding depth include independent hydraulic pressure on each opener assembly, gauge wheels, shank linkage and caster wheels. Individual opener down force can be controlled by adding or removing depth stops from each cylinder. Depth control wheels and packer wheels on seeders improve uniform seed depth placement. Packer/gauge wheels mounted close to the point of seed release will place seed more consistently at the proper depth, compared with wheels mounted farther behind or in front of the release point.

Accurate and controllable methods of depth placement are more important in small-seeded crops because seeds usually are planted shallower than in larger-seeded crops.

Gauge wheels either behind or beside the disc opener allow significant down pressure on the opener to penetrate firm soil and cut residue while maintaining the proper uniform seeding depth.

Some degree of packing almost always results in better crop emergence. Trailing press wheels are available in various widths. Narrow press wheels (1½ to 2 inches wide) may produce a narrow furrow in loose soil conditions.

Gauge wheel

This can create a problem if a rainfall occurs before the seedling emerges because rain can wash the soil between the furrows into the seed row, causing the plant to be covered too deeply. Wider press wheels reduce this problem.

An advantage to the use of narrow press wheels is that the furrow offers protection to the emerging seedling from strong winds. Seeding into a previous crop residue and maintaining residue on the soil surface also will provide protection for the emerging seedling. Usually, the press wheel should be about as wide as the seed strip. Wide press wheels can flatten the crop residue, exposing emerging seedlings to wind damage.

Seeders with the ability to monitor and alter pressure independently on openers and packer wheels function better to both place seed at uniform depth and accomplish even packing on seed rows. These systems detect contact of the opener assembly with the soil surface and automatically adjust hydraulic pressure applied to the openers to maintain the desired constant degree of contact with the soil as soil conditions vary throughout the field.

Varying soil and field conditions

Soil type and soil conditions influence how well openers operate. Neither hoe nor disc openers work as well in wet soils as in drier soils. Soils too wet to till are too wet to seed. Seeding or tilling wet soils compacts soil, damaging the rooting environment, which results in reduced crop growth and yield. Clay soils pack well but can become hard when they dry. Clay can build up on packer wheels, changing the seeding depth.

Openers can create a "glazed" furrow sidewall in wet conditions, which slows germination.

Packer wheels help firm soil around seeds and increase the likelihood that the seeds are in contact with soil in very wet seeding conditions. Machine weight can influence seeding depth when soil is firm. Some seeders are built heavier than others and some are designed to include added weight. Greater downward pressure requires positive depth control, which usually is accomplished with a gauge wheel running next to or directly behind the opener.

Seeders need to be flexible to function properly on irregular soil surfaces and sloping fields. Seeders with rigid frame sections larger than 12 to 14 feet generally do not follow the soil contour on sloping fields and when crossing drainage ditches, resulting in seed being placed too shallowly or unevenly on the soil surface. Parallel linkage has been used on row-crop planters for a number of years, and only recently has this innovation been applied to drills. Parallel linkage on individual openers operating independently of each other allow the opener

Parallel linkage

to track soil surface more accurately, giving a more uniform placement of seed at the desired depth.

Durability and maintenance

Time and cost of maintenance can be significant for both disc and hoe openers. Disc openers will require new discs and bearings. Hoe seeders will require new points or sweeps. Both will require time to replace opener parts, which may be an important consideration when deciding which seeder type to purchase.

Energy requirements

Fuel consumption is an operation expense that also should be considered in opener selection. Table 3 lists various types of openers with corresponding soil disturbance and the required fuel consumption per acre.

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For more information on this and other topics, see: www.ag.ndsu.edu

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