No-till Wheat Production in Oklahoma

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Should I switch from conventional till to no-till wheat production?

This is one of the most common questions asked by Oklahoma farmers, but it is also one of the most difficult to answer. There are several considerations when making this decision, and there is certainly no one-size-fits-all program for converting from conventional till to no-till wheat production.

A few factors to be considered include management intensity, ability to include rotational crops, importance of soil conservation, labor availability and cost, equipment upgrade needs and fuel cost. Because of the need to change agronomic practices to meet changing environmental situations, the managerial requirements of a no-till wheat production system are generally greater than that of a conventional till system.

Equipment

While there are many similarities between equipment used for conventional and no-till systems, there are some distinct differences. In general, managing crop residue is one main difference. Residue management is important during harvest and seeding. Residue, including chaff material that comes across the cleaning shoe, must be spread as evenly as possible during harvest. Spreading crop residue at harvest improves seeding conditions of the following crop. Spreading straw and chaff can easily be accomplished with a straw

Table 1. Likely effect of switching from conventional-till to no-till on several management factors for small grains production.

Management factor	*Increases with no-till*	*Decreases with no-till*	*No change*
Managerial requirement	✓		
Importance of crop rotation	✓		
Labor requirement		✓	
Drill/planter expense	✓		
Horsepower requirements		✓	
Tillage equipment needs		✓	
Fuel expenses		✓	
Herbicide expenses	✓		
Long-term N-P-K requirement			✓
Short-term N requirement	✓		
Stratification of nutrients and acidity	✓		
Need for quality seed	✓		
Soil compaction during grain fill			✓
Importance of variety selection	✓		
Plant-available moisture	✓		
Soil erosion		✓	
Selected foliar and soilborne diseases (without crop rotation)	✓		
Overall insect activity	✓		

Figure 1. Some no-till drills use a coulter that slices through residue and performs a small amount of tillage in front of the disc-opener.

chopper and a chaff spreader. Depending on combine design, they are either optional equipment on newer combines or aftermarket add-ons.

Having well-maintained, high-quality seeding equipment is of paramount importance when attempting to no-till small grains. Originally, no-till drills were conventional drills with a coulter-caddy attachment or heavy-duty disc-openers. Often, these designs left much to be desired. During the past ten years to 15 years there have been several improvements in the design and durability of no-till drills. Perhaps one of the best innovations has been the introduction of heavier drills designed to effectively transfer the weight of the drill to the disc openers either by hydraulic or direct linkage. Two basic drill designs are available, those using coulters to manage residue (Figure 1) and those designed to simply cut through crop residue (Figure 2). Each has advantages and disadvantages, but both designs are equally effective at placing seed. More important than drill design, is adjustment and use.

Effectively cutting through residue, either with the coulter or opener, is crucial. A disc opener that effectively cuts through residue avoids hair-pinning, or pushing of residue into the seed trench. If residue is pushed into the seed trench, good seed-to-soil contact cannot be achieved and poor emergence often is the result, especially if dry or hot conditions are prevalent after planting. Drills equipped with coulters (Figure 1) have less hair-pining because residue is cut and mixed with soil ahead of the opener.

Figure 2. One of the most popular no-till drill designs uses a single disc opener that slices through residue and opens the seed trench.

Avoiding times when residue is tough, like early in the morning, reduces the chances of hair-pinning. Furthermore, drills should be adjusted for seeding conditions. Planting into a field that was grazed-out last year, for example, does not present the same residue management issues as a field that produced a 70 bu/A wheat crop or a 250 bu/A corn crop. The soil however, may be harder in the grazed field due to lack of moisture.

While there are many no-till drill choices and options, there is one commonality among models – they are generally more expensive than conventional-till drills. The greater cost associated with purchase of a no-till drill may be somewhat offset by decreased total equipment costs. A way to manage equipment costs is to consider a good used no-till drill. Since some of the newer designs have been in production for more than ten years, there are many options on the used equipment market. Take the time to inspect used drills. A wide range in the general condition of used no-till drills is available. Due to the higher cost of no-till equipment, it may be wise to survey neighbors and discuss their experiences or explore the possibility of leasing or borrowing equipment.

Management Tips

- Spreading crop residue at harvest improves seeding conditions of the following crop.
- Avoid hair-pinning of residue with properly adjusted equipment.
- Reduce initial costs of no-till equipment by purchasing well-maintained, used equipment.

Variety and Seeding Rate

If incorporating a rotational crop into the no-till strategy, there is little difference in variety performance under no-till or conventional-till management. Reviewing current variety trial results and variety comparison charts will be informative (www.wheat.okstate.edu).

As long as high-quality seed is sown, seeding rates for no-till wheat production should be similar to those for conventionally-tilled wheat. High-quality seed is characterized as being free from weed seed and foreign material, having good vigor, and having greater than 80 percent germination. High-quality seed is necessary to ensure adequate germination in cool, wet soil conditions prevalent in no-tilled soils. This is especially the case when planting after October 15.

Management Tips

- Sowing high-quality seed of a known variety is extremely important when no-till farming.

Rotation

Whether conventional or no-till seeding strategies are implemented, research has demonstrated crop rotation increases overall productivity in a wide variety of geographic locations and rotational strategies, but the yield boost from a crop rotation is generally greatest in no-till situations. Rotational crops and strategies vary according to location, production goals and yield potential.

Perhaps the most important criterion for choosing a rotational crop is the profit potential of the enterprise. From an economic standpoint, the rotational crop must be able to stand on its own and not be a drain on resources. Several factors influence whether or not positive cash flow is generated by a rotational crop. Knowledge level and competence of the producer in growing the rotational crop, availability and proximity of marketing points and yield and price stability with time all effect cash flow.

Corn or soybean, for example, might be the best rotational crop for a producer in northeastern Oklahoma, while cotton might be a more logical rotation for a producer in southwestern Oklahoma. Perhaps one of the best strategies for deciding on a rotational strategy is simply observing whether a rotational crop or strategy is working for others, then make a decision.

Management Tips

- Crop rotation is likely to benefit yield regardless of tillage practices.
- From an economic standpoint, the rotational crop must be able to stand on its own and not be a drain on resources.

Soil Compaction

Grain only

Soil compaction is often one of the biggest concerns raised by producers considering no-till wheat production; however, soil compaction in a no-till grain-only production system should be similar to a conventional-till, grain-only production system. In a conventional-till, grain-only system, new compaction can be a result of equipment traffic and tillage implements, but in a no-till, grain-only production system, new compaction is created exclusively through equipment traffic. Therefore, it is extremely important not to introduce any new soil compaction once a no-till production system has been initiated, as correction methods are limited.

To minimize new compaction, limit traffic and reduce tire inflation pressures or switch to radial-ply tractor tires. Reducing tire pressure to the minimum manufacturer's specification increases the contact patch of the tire and distributes the equipment's weight on a greater area, along with increasing traction. Equipment management techniques that spread the equipment load over a greater surface area become even more important during wet harvest years. It is important to remember ruts created during harvest can only be removed through tillage. If no-till is your preferred management, avoid field operation until the majority of field is dry so ruts are isolated to small areas that are easily managed.

Figure 3. In a wet year, cattle traffic frequently results in soil compaction regardless of the tillage system used.

Dual-purpose

Cattle traffic can cause compaction, with the most noticeable form being hoof prints 2 inches to 6 inches deep (Figure 3). Deep hoof prints are formed when surface soil strength is low, which allows wet soil to move up and around the animals' hooves. In a tilled system, the hoof will generally penetrate to the tillage layer, which is often already compacted. Therefore, hoof prints cause surface roughness and can result in damage to the wheat crop, they don't result in compaction of the soil.

In contrast, when soils are moist but not wet enough to allow for deep hoof prints, surface compaction of tilled soil can still occur. This will increase the bulk density of the soil, thereby decreasing its permeability to water inflation and root growth, negatively impacting grain fill after cattle are removed. In a conventional-till program these two forms of surface soil damage can be alleviated through tillage operations prior to seeding. Research conducted in Oklahoma indicates these forms of compaction reoccur each year in a conventional-till program by the time of cattle removal (i.e. March 1st).

Assessment of compaction in long-term (more than four years) no-till soils has not found significant compaction occurring except for high traffic areas such as cattle paths. These paths tend to form in the same location each year and don't produce much forage regardless of soil management. The lack of measurable compaction in no-till soils is due to the greater load-bearing strength of no-till soils. Despite the lack of compaction in long-term no-till, caution should be used during the first few years of no-till management. The compaction occurring during the season after the last cultivation will persist when tillage is no longer used. Reduced stocking rates or grain-only management is recommended prior to the first no-till crop. This allows for the accumulation biopores in the soil formed from root channels and burrowing animals such as earthworms. These biopores will allow for water infiltration and root growth, while the load-bearing strength increases in a young no-till soil. Increased load-bearing strength is why there is no cumulative effect of years of cattle traffic in no-till soils, and why they are capable of supporting cattle hooves during wet years.

Finally, residue management is an important consideration in all no-till systems including grazeout wheat. Severe damage has been observed in soils where overgrazing has left the soil surface bare during the fallow period. A lack of surface residue allows the soil to crust, which magnify the negative impacts of compaction caused by grazing animals. This is particularly important during the first two years to four years after no-till adoption. After four years to five years of no-till, there is potential for burrowing animals such as earth worms to maintain some level of soil aeration. If overgrazing occurs, consider planting a cover crop to regain surface residues.

Management Tips

- Reduce tire pressure or switch to radial tires to reduce compaction from equipment traffic.
- Avoid equipment and/or cattle traffic on water-logged fields.
- Do not overgraze no-till soils. Surface residue will reduce crusting and slow water movement on the soil surface.

Disease

The downside of residue

No-till operations in wheat production can significantly impact the incidence and/or severity of diseases, especially when residue left on the soil surface is from a previous crop of wheat. Increases in disease incidence and severity generally are more typical than decreases (Table 2).

Increases in disease incidence and/or severity occur due to a greater quantity of inoculum of the pathogen present on the wheat residue left on or above the soil surface. For example, with a disease such as take-all root rot, more residue results in increased amounts of inoculum. This is because the fungus causing take-all survives on the residue.

Other examples where increased residue on the soil surface leading to increased disease severity are the foliar leaf spotting diseases tan spot (*Pyrenophora tritici-repentis*), Septoria tritici blotch (STB), Stagonospora nodorum blotch (SNB) (*Septoria tritici* and *Stagonospora nodorum*) and spot blotch (*Bipolaris sorokiniana*). Although not a leaf spot disease, the foliar disease powdery mildew (*Blumaria graminis* f. sp. *tritici*) also is likely to increase as a result of more wheat residue. Figures 4 and 5 show inoculum on residue for tan spot. Note the small black bodies on the wheat straw from the previous crop containing the spores of the tan spot fungus.

During late fall through spring, spores discharged from these black bodies infect the lower leaves of wheat plants. If temperature and moisture favor continued sporulation, spread and infection of leaves by the fungus, the disease spreads through the wheat canopy (Figure 6). Hence, leaving wheat residue on the surface of the soil from a crop heavily infested with tan spot, STB, SNB, spot blotch, or powdery mildew provides large amounts of spores to infect the subsequent wheat crop.

The virus disease wheat streak mosaic (WSM) also could be increased in a no-till, high residue field. This increase would come about by not properly controlling the volunteer wheat, which likely would be greater in a no-till field. If not properly controlled, a greater incidence of volunteer wheat and certain grassy weeds could provide a green bridge for wheat curl mites, which carry wheat streak mosaic virus to survive between harvest and emergence of seedling wheat in the fall. In such a case, an increase in the incidence and severity of WSM is likely. For more information on WSM and other mite-transmitted diseases, consult Extension Fact Sheet EPP-7328, "Three Virus Diseases of Wheat in Oklahoma" available at www.wheat.okstate.edu

The upside of residue

With some diseases, increasing the amount of wheat residue left on the soil surface in a field may favor a reduction in disease incidence and/or severity. Such an effect often occurs as a result of altering micro-environmental conditions such as increasing soil moisture and/or decreasing temperature. This is especially true for some of the root rots such as dryland root rot (*Fusarium* spp.) and possibly common root rot (*Bipolaris sorokiniana*), which are favored in warmer and drier soils. In the case of strawbreaker foot rot or eyespot

Table 2. Effect of increased wheat residue* on the incidence and severity of various wheat diseases.

Disease	*Effect of increased residue* on incidence and severity of disease*	*Explanation for effect*
Tan spot	Increases disease	Increases pathogen inoculum
Septoria tritici blotch	Increases disease	Increases pathogen inoculum
Stagonospora nodorum blotch	Increases disease	Increases pathogen inoculum
Powdery Mildew	Increases disease	Increases pathogen inoculum
Aphid:barley yellow dwarf	Decreases disease	Fields with increased residue are less attractive to aphids
Take-all	Increases disease	Increases pathogen inoculum
Strawbreaker [also called eyespot, foot rot]	Decreases disease	Related to inhibition of spore dispersal hence, a reduction of infected plants
Other root rots including dryland root rot, common root rot, sharp eyespot and Pythium root rot	Increase or decrease, depending on the pathogen	Effect is through multiple factors, primarily soil moisture and temperature

*In this table, "residue" indicates straw from a previous crop of wheat as opposed to residue from a rotated crop such as canola or legumes, which would be non-hosts for these pathogens and diseases of wheat.

Figure 4. Black fruiting structures containing spores of tan spot on wheat residue.

Figure 5. Closer view of black fruiting structures containing spores of tan spot on wheat residue.

Figure 6. Spores on previous crop residue allow for rapid movement of tan spot into the wheat canopy.

(*Pseudocercosporella herpotrichoides*), the increased straw seems to inhibit the spread of spores from the soil to the base of young plants, resulting in less infection.

Increased residue also can affect the incidence and/or severity of barley yellow dwarf (BYD) by altering the behavior of the aphids transmitting the virus. These aphids are attracted to more openly spaced wheat plants. With the presence of large amounts of residue, the wheat plants are less appealing to the aphids. Therefore, a no-till field may attract fewer aphids, which may translate into a lower incidence of BYD.

Rotation is the key

Approaches to disease control are a major consideration when switching to a no-till operation. Therefore, rotation with a non-host crop is the single most valuable approach in helping to limit disease in no-till systems. Wheat-following-wheat in a no-till system will most likely result in significant increases in diseases such as the leaf spotting diseases, powdery mildew and take-all.

Rotation with a non-host crop for these pathogens (for example, canola or legume crops such as soybean or alfalfa) is highly desirable. Varieties with disease resistance (see www.wheat.okstate.edu for reaction of current varieties to diseases), application of fungicides and planting date also can help to limit losses from diseases in no-till fields. However, remember rotation is much more effective if the field is not planted with wheat for at least one entire season, as this provides sufficient time for the wheat residue to completely decompose.

Although switching to a no-till operation results in some challenges in controlling diseases, approaches are available to help alleviate these diseases. Among these approaches, crop rotation, variety selection, correct application of appropriate fungicides (including seed treatments) and planting date are the most important to consider. Knowing the effect that increased residue on the soil surface has on the diseases listed in Table 2 is the first step toward employing approaches to help alleviate losses from these diseases and should facilitate successful wheat production in a no-till operation.

Management Tips

- Rotation is the key to reducing disease incidence and severity.
- Increased wheat residue in continuous no-till wheat systems will increase pathogen inoculum for some foliar diseases of wheat

Insects

Arthropod pests are affected by many aspects of their environment, including tillage practices. Soil-dwelling pests are affected by tillage directly and indirectly. The mechanical disruption that heavy tillage imparts on the soil can directly affect the physical survival of soil-dwelling pests. For example, most grasshoppers overwinter as eggs in the soil. Mechanical tillage can destroy many grasshopper eggs. Less frequent and intense disturbance of the field allows social insects such as the red harvester ant the time to establish and build a colony (Figure 7).

Indirectly, changes in soil moisture, temperature, organic matter, bulk density and porosity resulting from reduced tillage can affect pest abundance. An arthropod such as the pill bug

Figure 7. Red harvester ant nest.

will benefit from low disturbance of the soil and crop residue because it results in a moderation of the field microclimate. This allows them to build in numbers and become a pest of emerged crop seedlings.

Some pests lie dormant in crop residue and may be more likely to survive in reduced tillage or no-till systems. An example is the Hessian fly. It overwinters, and oversummers in crop residue. Undisturbed residue provides a better habitat for the overwintering/oversummering life stages to survive. Often, reduced tillage systems allow undisturbed seed to germinate before the new crop is planted and produce volunteer plants. These can provide a green bridge for potential pests such as the wheat curl mite to develop and infest the new crop or transmit a plant disease.

Finally, reduced tillage systems are often combined with more diversified crop rotations that can change the makeup of the pest complex, and the importance of individual arthropod pests. Some become less problematic, while others may become more of a pest. Pests such as the white grub or wireworm may be numerous in a grass pasture system and become an important pest of a wheat crop planted as no-till.

While conservation tillage systems may present new arthropod pest challenges, integrated pest management (IPM) programs can be developed to control them regardless of the tillage system. Many tactics that could be included in such a program are effective across a broad range of tillage systems. Others, such as the tactic of burying residue may not be available as a management technique. Still others, such as longer-term crop rotations, may become more important because no-till can help break the status of some pests. The ability to control or not control arthropod pests should not discourage anyone from considering the adoption of no-till crop production.

Management Tips

- Switching to conservation tillage may cause a shift in the makeup of insect pest populations.
- Integrated pest management (IPM) programs can be developed successfully in any cropping system.
- Control volunteer wheat to eliminate the green bridge for pests such as the wheat curl mite.

Soil Fertility and pH

A successful no-till production system starts with proper management of soil pH and fertility. The acidification process and nutrient distribution in a no-till soil are somewhat different from those of conventional system due to limited mixing of soils under no-till; therefore, prior to adopting a no-till system, soil pH and nutrient levels should be tested.

A soil test provides guidelines for liming and fertilizer application. If the pH is low, lime should be applied to bring the pH to a normal range. The pH of soil in continuous no-till fields should be checked every two years. When lime is needed, the same amount of lime as recommended for conventional practices should be applied, but it may take longer to correct soil acidity in the lower portion of the tillage zone with a no-till system. Furthermore, nitrogen applied to the soil surface with no-till can produce very acidic conditions in the surface layer. This acidic soil not only effects crop growth directly, but also effects pesticide activity. Therefore, a set of samples from the top two inches may be needed to help identify a low pH problem on the surface soil.

If phosphorous (P) and potassium (K) are deficient, apply adequate amount of fertilizer before the switch to a no-till system. Similar to conventional till, banding P and K fertilizers is better than broadcasting in a no-till system. In fact, banding may be even more advantageous in a no-till system because P and K movement in the soil are very slow. Furthermore, P applied on the surface may be subject to erosion or runoff loss more easily than when (or if) it is band applied.

Crop residue covering the soil surface with continuous no-till increases water infiltration, reduces runoff and decreases water losses from evaporation. This same residue however, may also increase nitrogen (N) loss due to volatilization, if N fertilizers are broadcast over the surface of residue. However, placing N fertilizer just below the soil surface with a coulter can effectively reduce volatilization loss.

Additionally, some N may be temporarily tied-up by microorganisms as they decompose crop residue with a high carbon to nitrogen (C:N) ratio. This may reduce plant-available N during the early stage of plant growth, but applying 1/3 to ½ of the total N pre-plant, preferably injected into the soil, should avoid residue-decay-induced N deficiency. If managed properly, the amount of N needed for no-till should be similar to a conventional tillage system.

Management Tips

- Identify and correct soil pH problems prior to switching to no-till.
- Band-apply fertilizer to increase efficiency.
- Inject 1/2 to 1/3 of nitrogen pre-plant to reduce residue decay-induced nitrogen deficiency.

Weeds

Much of the tillage expense saved by no-till wheat production will be spent on chemical weed control practices, but by planning the switch through the course of time, producers can keep their weedier fields in tillage and only move cleaner fields into no-till production. Producers should avoid no-tilling fields infested with weeds that do not have good in-season chemical control measures (e.g. jointed goatgrass, feral rye, rescuegrass etc.). There are still solutions to these problem weeds, such as rotating to a summer crop or winter canola, or using the Clearfield® wheat production system.

Summer weed infestations should be managed with non-selective herbicide mixes, such as glyphosate and 2,4-D or some other broad-spectrum herbicides. It is always important to consider tank-mixtures when making chemical fallow applications to prevent herbicide resistance. Along with the cost of these applications, one should also consider the potential of off-target movement of these summer fallow treatments onto nearby susceptible vegetation and whether or not successful summer herbicide applications will be possible.

Historically, one of the primary reasons Oklahoma wheat producers have not switched to no-till production was lack of good weed control tools. Today, producers have a wide array of herbicides to control many common in-season weed problems. For example, producers now have Finesse Grass® and Broadleaf®, Maverick®, Olympus®, Olympus Flex® and Powerflex HL® to control cheat, other grasses and broadleaf weeds in the wheat crop. In-season control measures are also available for Italian ryegrass and wild oat control as well as a host of problem broadleaf weeds. In addition there are residual herbicides now on the market including Zidua® and PrePare® for preemergence and early postemergence control of these weedy grasses.

Management Tips

- Manage summer weed infestations using non-selective herbicide mixtures, such as glyphosate (the active ingredient in Roundup) and 2,4-D or some other broad-spectrum herbicide.
- Off-target movement of nonselective herbicides can cause considerable economic damage. Always use drift-control measure and be aware of neighboring crops.

Economics

The economics of no-till are farm- and situation-specific. In addition to the cost of tillage, relative to the cost of herbicides, no-till drills and air seeders (as opposed to the cost of conventional drills and seeders) costs depend on farm size, soils, climate, crops grown and labor.

No-till is more likely to be economical in farm/soils/climate situations in which no-till enables farmers to increase the number of harvested acres per year on the farm. For example, in some regions of the U.S., a no-till system enables the successful double cropping of soybean or grain sorghum after wheat. The probability of a successful double crop with conventional tillage is not as great due to timing and loss of soil moisture.

In some situations, no-till enables the cropping of land too steep for conventional tillage. In effect, a no-till system may enable the conversion of pastureland to cropland. In both of these situations, the appropriate economic comparison is not between no-till and conventional tillage. In the first case it is between growing a crop and fallow, and in the second case it is between producing a crop and pasture. In both cases, no-till enables an increase in the number of harvested cropland acres for a given farm size, and the investment in a no-till drill or no-till air seeder may be weighed against the investment in additional land.

Figure 8. Soil erosion can be a problem in conventional tillage systems. Qualification for certain government programs is increasingly hinged on prevention of erosion.

The overall trend for government programs is one of increased emphasis on conservation tillage measures, and no-till production practices are generally regarded as one of the best soil-conservation measures available to farmers (Figure 8). It may be difficult for some farmers to find qualified labor to operate tractors and tillage equipment in a conventional tillage system. In contrast, fewer field operations and less machinery labor is needed for a no-till wheat production system and the horsepower requirements for a no-till drill are generally much lower than is required to pull large tillage equipment. Fuel consumption also can be considerably less.

However no-till drills are generally more expensive than conventional drills. The list prices of effective no-till grain drills are from two to three times greater than the list prices of conventional drills. No-till equipped air seeders list for 30 to 40 percent more than conventional air seeders of the same width, but the difference in drill/seeder cost decreases as the size of the drill/seeder increases.

For a more comprehensive evaluation of the economics of converting to a no-till system for a specific farm, Oklahoma

Management Tips

- Expect lower fuel costs and higher herbicide costs when switching to no-till.
- No-till drills are more expensive than conventional-till models, but the difference in cost between no-till and conventional models decreases as the size of the drill/seeder increases.

producers may use the Intensive Financial Management and Planning Support (IFMAPS) program provided by the Oklahoma Cooperative Extension Service. Specially trained specialists work one-on-one with Oklahoma farm families to evaluate the expected economic consequences of potential changes, such as changes in tillage and cropping systems. To determine if a change in tillage system is likely to be economical for your farm, contact your county Extension office, or call 800-522-3755 and ask to participate in the IFMAPS program.

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