Wheat

Wheat occupies the largest acreage of any grain crop in Oklahoma, so it is likely that any no-till production system in the state will include wheat at some time. In the presence of a crop rotation, the agronomic and managerial requirements for no-till wheat production are similar to those of a conventional till system. Without a rotation, no-till wheat production requires much more planning and management than a conventional till system.

The level of planning and management required for no-till wheat will vary by producer, region, and production objective. There are, however, some ‘universal truths’ regarding no-till wheat production and no-till crop production in general. Even distribution of the previous crop’s residue, for example, is critical for no-till farming. Wheat farmers, especially those using custom harvesters, may not be accustomed to closely monitoring combines to ensure that straw choppers are engaged and working properly and that chaff spreaders are covering the entire header width. These farmers will quickly discover that incorrect residue management can negatively affect crops for years to come.

Another management technique that will likely apply to all no-till wheat production systems is the need for starter fertilizer. Numerous experiments at OSU have revealed the benefit of in-furrow application of phosphorus fertilizers. The benefits of starter fertilizer are greatest in low pH and/or low phosphorous fertility situations. Researchers have seen advantages to starter fertilizer in dual-purpose wheat even when soil phosphorus is already at sufficiency levels. It is likely that, because of cooler soils and nutrient stratification, the benefits of starter fertilizer will be even greater in a no-till system than in conventional till wheat.

How Important is Rotation?

As stated earlier, the difficulty associated with no-till production of wheat will depend largely on...
whether or not crop rotation is used (Figure 1). If a crop rotation is incorporated into the production system, then no-till wheat production techniques will be very similar to those of conventional till wheat. In fact, since most Oklahoma farmers are familiar with wheat production, wheat will likely be the easiest part of the cropping system. The challenge will be in production and marketing the rotational crops incorporated into the cropping system.

In contrast to farmers using a rotation, farmers wishing to grow no-till continuous wheat will likely encounter many challenges they did not face when growing conventionally tilled continuous wheat. Paramount among these issues will likely be weed and/or disease control, but other issues such as fertility, compaction, and residue management can also create challenges. Farmers in a continuous wheat system, for example, may have paid little attention to crop rotation restrictions in the past; however, many of the most popular wheat herbicides have restrictions regarding the planting of rotational crops. Planning for crops one or two years ahead of time will likely be a new experience for most wheat farmers. With careful attention to label restrictions and good recordkeeping, wheat farmers will likely find this task easier than they first thought.

**Weed Control**

Most Oklahoma farmers know of someone who has tried to no-till wheat and then reverted back to conventional tillage due to poor weed control. With proper planning and management, this does not have to be the case. Perhaps one of the most important components of this planning process is to begin with clean fields. Unless a strong crop rotation program is implemented, wheat fields infested with hard-to-control weed species such as *Italian ryegrass*, feral rye, or jointed goatgrass will likely become worse in a no-till system. Broadleaf rotational crops such as winter canola offer excellent opportunities to control these grassy weeds. Rotating herbicide modes of action helps to reduce the chances of weed resistance. In a continuous wheat system grassy weeds must be addressed with an aggressive, weed-specific management plan. Much of the Italian ryegrass in Oklahoma, for example, is resistant to ALS herbicides and is most effectively controlled with a two-pass, pre-plus-post herbicide program that incorporates multiple herbicide modes of action. Feral rye and jointed goatgrass can be managed using two-gene Clearfield® wheat varieties and their associated herbicide programs. Regardless of the weed being controlled or herbicide being used, emphasis should remain on controlling weeds when they are small and ensuring that weed problems are not re-introduced or worsened through contaminated equipment or seed.

**Disease Control**

Switching to no-till will lower the incidence and severity of some diseases but increase others. There is evidence that aphids, for example, are less attracted to wheat in heavy residue and that barley yellow dwarf virus transmitted by aphids might be less severe in no-till systems. Leaf and stripe rust incidence and severity are generally not affected by tillage, but foliar diseases such as powdery mildew, tan spot, septoria leaf blotch, and stagonospora glume blotch can be worse in no-till because of increased pathogen inoculum present on wheat residue. A diversified crop rotation will reduce the amount of wheat residue present to serve as a host for these diseases. In a continuous wheat system, producers might consider a two-pass spring fungicide system to address these diseases if justified by yield potential. This typically involves one pass with a low cost fungicide just after jointing and a second pass with a full rate of fungicide after flag leaf emergence.

**Using Graze-out as a Rotation**

Graze-out is a management system in which cattle are allowed to graze wheat pasture well into the spring and no grain is harvested from the field.
There is some evidence that graze-out can successfully be used as a rotation in a continuous wheat production system. Under this management strategy, farmers would typically graze-out two-thirds of their acreage and harvest one-third for grain. The advantage of this system is that the intensive grazing pressure can reduce the amount of wheat residue carried over from year to year. This reduces the amount of inoculum present for disease the following year. The commonality among farmers that have made this system work seems to be they are more cattle-oriented than crop-oriented and the wheat yield potential on their farm is typically less than 30 bushels per acre.

There are also many forage-only producers who have found success with continuous no-till wheat production. In this system, the majority of wheat residue is removed during grazing. Diseases are not generally as much of a problem as in grain only or dual-purpose systems. Likewise, since the emphasis is on forage production, weed control is generally not an issue and plants normally considered to be weeds are frequently utilized as a valuable forage source. Producers using this system are often cattle-oriented and may enjoy the flexibility and simplicity that a no-till system provides.

**What about Compaction?**

Cattle create compaction, and dual-purpose and forage-only wheat producers are often concerned about soil compaction in a no-till system. In conventional till systems, compaction from hoof traffic is normally alleviated via tillage operations; however, this compaction is quickly reintroduced once wheat fields are stocked with cattle in the fall. As a result, conventional till and no-till fields have similar amounts of compaction by the following spring. So, the primary difference in compaction between the two systems is during planting and forage establishment in the fall. The effect of this compaction on forage production is probably minimal and should not deter someone from no-till wheat production. A properly managed no-till system might actually have less compaction in wet years due to the greater load bearing strength of the soil.

**Variety and Seeding Rate**

It is best to review current variety trial results and variety comparison charts (www.wheat.okstate.edu) to select a high-yielding, well-adapted wheat cultivar for your area. If incorporating a rotational crop into a no-till strategy, there probably is little difference in variety performance under no-till or conventional till management. If continuous wheat is being grown, selecting a variety with Hessian fly resistance will reduce or eliminate crop losses from this pest. If sowing early for grazing, selecting a variety with Hessian fly resistance is extremely important, as early-sown wheat is most susceptible to injury.

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 the cool, wet conditions prevalent in no-tilled soils. This is especially true when planting after October 15.

### Soybean

Soybean production in no-till cropping systems is relatively simple and gives producers flexibility. Reasons for growing no-till soybeans such as conserving soil moisture and preventing soil erosion, are similar to other crops. No-till planting soybean also provides the opportunity to double crop after wheat. Double-crop soybean production is often practiced in Oklahoma when soil moisture is available following wheat harvest. Improved planting equipment and herbicides have made double-crop, no-till soybean production easier. Planting directly into wheat stubble reduces the risk associated with double-cropping by conserving moisture and cooling soil temperatures; therefore, a double-crop soybean-wheat rotation is often an excellent way to begin practicing no-till and provides an easy transition into no-till.

Just like any no-till system, no-till soybean production should include a crop rotation. Since soybean is a legume (fixes N), it is an excellent crop to incorporate in a rotation. Planting soybeans prior to wheat, corn, or grain sorghum are all excellent choices for most parts of Oklahoma because soybean residue is easy to manage. Rotation will also help control soybean cyst nematode populations. Finally, any rotation including both broadleaf and

“The no-till system is ideal for double-cropping soybeans behind wheat, since time is very limited to get the soybeans planted after the wheat is harvested.”

Brent Rendel
Miami, OK
grass crops (such as soybean/wheat) is ideal because weed populations are easier to control.

**Planting**

One advantage soybeans have compared to other crops is the ability to plant soybeans in several different row widths. Recommended row width for no-till planting is 30 inches or narrower, and crop response to row width narrower than 30 inches is inconsistent. Yield increases for row widths narrower than 30 inches are usually associated with early/short-season varieties (MG III or early MG IV). With row width not being a reliable yield-determining factor in Oklahoma, planting width decisions are often based on producer preference.

Soybean seed should be planted at a depth of 1 to 2 inches. Depth control needs to be precise; otherwise seed is more likely to be damaged by soil-applied herbicides. Seeded populations should be approximately 110,000 seeds per acre, which should allow for a final plant population of approximately 100,000 plants per acre. Several seed metering mechanisms are available including fluted, double-run, and wobble-slot. All require repeated adjustments to obtain the correct seeding rate. Typically, drills provide less uniformity in seed spacing and seeding rates than planters, but some adjustments will cause a grain drill to be closer in performance to a unit planter. Refer to Chapter 4 No-till Equipment on page 11 for more details on planting options and adjustments.

a. Adjust the metering mechanism to drop two to three viable seeds per foot in 7.5-inch rows or four to six viable seeds per foot in 15-inch rows. Generally, less seed damage occurs with 15-inch rows due to the large flute openings. Using a wider gate opening and slower rotation of the flute will usually give better distribution of seed in the row. Always calibrate the drill on the basis of seeds per row foot. Seeds per pound can vary tremendously between varieties and even within varieties depending on growing conditions under which the seed was produced.

b. Whenever possible, avoid large seed because seed damage increases as seed size increases. Use seed having at least 2,400 seeds per pound and increase the seeding rate to compensate for the seed damaged by the metering mechanism.

c. Increase seeding rate by 10 percent for a poor seedbed.

d. Increase seeding rate by 10 percent for early maturing varieties.

e. Increase seeding rate by 10 percent when planting late or after wheat.

**Weed Control**

Failure to control weeds is often the reason producers have a negative experience with no-till soybean production. As with any cropping system, early-season weed interference is the most damaging. Burndown herbicides, such as glyphosate or paraquat, should be used to ensure that fields are weed free prior to soybean emergence. This might be difficult in harvested small grain stubble, as harvesting removes much of the foliage from weeds thereby reducing the amount of available surface area for herbicide contact. This potentially reduces herbicide efficacy. Pre-emerge herbicides are effective at reducing early-season weed competition and provide a ‘buffer’ for post-emergence herbicide applications that are sometimes delayed due to weather or wet soil conditions. While Roundup® Ready programs are still very effective on some weed species, glyphosate resistant weeds have made them less effective as an easy, one-stop weed control program. Most weeds can still be managed with a well thought-out herbicide program. It is important to rotate herbicide modes of action to ensure that resistance is kept to a minimum.

**Cotton**

**Evolution of Reduced Tillage and No-Till Cotton**

Cotton is an excellent fit in no-till or reduced tillage systems because of its early-season sensitivity to environmental damage typically caused by high winds and blowing soil (Figure 3). Modern conservation tillage systems have evolved due to a convergence of important factors. Developments in transgenic varieties, boll weevil eradication, equipment, and other management practices have facilitated the adoption of no-till production techniques.
The synergism of these factors has resulted in record yields and quality in Oklahoma. This simultaneously allows producers to efficiently manage more acres in less time than ever before.

Reduced tillage systems in cotton were developed in the mid-1960s in Washita County, but due to difficulty in terminating the wheat or rye cover crops and weed control, they were not adopted by many producers. When row-till equipment and spinning blade cultivators were developed in the 1980s producer adoption increased. In the 1990s a program was initiated that was referred to as the “Oklahoma Interseeded Residue Management Program.” This program utilized a shielded drill to interseed wheat or rye between the cotton rows in late August or early September prior to cotton harvest. The small grains germinated, and when cotton was harvested, the cover crop was already established. In late winter or early spring, a row-till unit consisting of a ripper shank, coulters to move soil into the depression left by the ripper, and a rolling basket to firm the soil was used to till a strip of soil approximately 12 to 14 inches wide. The cover crop was allowed to continue to grow until it reached the hollow stem stage and was then terminated with glyphosate. At the hollow stem stage, the residue would remain standing and provide better protection from wind, heavy rainfall, and blowing soil. Cotton was then planted in the strips with a normal cotton planter. Weed control was accomplished by incorporating dinitroaniline herbicide in the strips, and cultivating between the rows. This cultivation operation was achieved with a spinning disk cultivator that would not be plugged by the high residue. This technique was a vast improvement over other strip-till systems, but weed control remained a season-long problem. This was primarily because soil mixing by tillage brought more seed to the soil surface and resulted in germination of additional weeds. Cultivation also resulted in root pruning of the cotton and increased mid-season stress to the plants.

In 1997, transgenic glyphosate-tolerant cotton was introduced by Monsanto and Roundup Ready® varieties became available. This first generation technology provided full vegetative, but limited reproductive tolerance to glyphosate. Higher equipment, diesel, and labor prices also discouraged tillage making no-till systems more feasible. Transgenic varieties containing Monsanto’s Roundup Ready Flex® trait were later developed which allowed over-the-top applications of glyphosate throughout the growing season. Later, Liberty Link® and GlyTol® herbicide tolerance traits were introduced by Bayer CropScience. GlyTol® and Liberty Link® technologies both allow essentially full-season over-the-top application windows of glyphosate and glufosinate, respectively. Varieties with GlyTol® plus Liberty Link® (“stacked” herbicide tolerance) technologies were recently released. Additional transgenic herbicide tolerance traits in cotton are expected in the near future. When properly managed, these technologies have resulted in weed control improvements and have likely contributed to yield increases.

Improvements in insect pest management have also contributed to higher productivity. The advent and success of boll weevil eradication reduced cotton production costs and subsequently increased yields. Transgenic traits based on Bacillus thuringiensis (Bt) technology decrease or eliminate yield losses due to many species of caterpillar pests, thus resulting in yield gains. Bt traits have essentially eliminated insecticide use for these pests in Oklahoma cotton. With the omission of in-season insecticide applications targeting caterpillar pests, disruption of beneficial arthropod populations is also prevented. The initial single-gene Bt technology, Bollgard®, was introduced in cotton in 1996 and followed a few years later by dual or “stacked” Bt genes (Bollgard II® from Monsanto and Widestrike® from Dow AgroSciences). Bayer CropScience also recently released TwinLink® varieties with their proprietary dual-Bt traits. In order to significantly reduce the likelihood of resistance in caterpillar pests, various triple-gene Bt products from the above companies are expected in the near future.

Highly efficient auto-steer tractors and large sprayers with guidance systems have enhanced management of various farming operations. Improved planters have also been developed, which allow highly accurate seed placement and facilitate seeding into high residue conditions.

No-till has quickly become the preferred technique of many Oklahoma cotton producers in dryland, and in center pivot and subsurface drip irrigated systems. Producers planning to initiate no-till production systems should develop a strategy that is specific for their individual areas and equipment inventories. Crop rotation programs, soil texture,
and rainfall patterns should all contribute to the decision making process. Most equipment that producers currently own can be modified for no-till production by adding attachments to facilitate planting into residue. Immediate input cost savings result from less equipment wear and less time spent per acre producing the crop. Soil benefits accumulate over a multi-year period, and increased organic matter and improved crop rooting potential are definite long-term benefits of no-till production.

Residues

One of the keys to successful no-till cotton production is having sufficient residue available during the early part of the season to protect young cotton plants from high wind and thunderstorm events. Many cover crops have been evaluated, but wheat or rye is generally the small grains species of choice with center pivot or subsurface drip irrigation. The cover crop should be planted as soon as possible following harvest and should be terminated with glyphosate immediately following jointing to eliminate water use. If the crop is terminated prior to jointing, it will not remain standing, nor provide as much protection to the cotton seedlings. Under marginal irrigation conditions, it is important to have the cover crop fully terminated prior to planting. With lack of rainfall, high temperatures and wind, cotton establishment can be difficult with low irrigation capacity. It is recommended to not allow a cover crop to compete for moisture during cotton stand establishment. When considering small grains cover cropping under non-irrigated conditions, producers need to be fully aware of any crop insurance challenges that might arise. It is important to discuss these issues with your crop insurance agent to determine the latest regulations that might impact compliance.

Planting

Planters should be equipped with coulters, residue managers, or disks to move surface residue from the row. If the small grains crop is harvested for grain, the combine should have a good straw chopper and spreader to evenly disperse crop residues. Cotton can be planted into a considerable amount of residue if the planter is properly equipped. Residue is always more easily handled when left standing and planter attachments should be able to “cut and roll.” Environmental conditions such as high humidity or dew may affect the ability of the planter to traverse the residue properly, so residue should be dry during planting operations. Disks on the planter which are normally used for clean till can be used if the residue is left standing and the soil is mellow. Heavy duty down pressure springs should be available for use on the planter under hard soil conditions. Good seed to soil contact is important, and a seed press wheel attachment immediately following the openers should be considered. Closing attachments are also very important and several types are available. “Baking” or crust formation in the row after planting is a challenge that can affect the typically weak cotton seedling. This generally occurs when high temperatures and winds are encountered immediately after planting. Managing the correct amount of dry soil at seed trench closure is important.

Cotton seed with transgenic trait technology is an expensive input cost. Seeding rate will vary if the field is dryland or irrigated. Generally a range of 30,000 to 40,000 seeds per acre is a good target for dryland fields, whereas a 40,000 to 55,000 seeds per acre goal is normally adequate for irrigated production. When planting low seeding rates, producers must have faith in their seed quality, planter, its adjustment, soil moisture and environmental conditions.

Weed Control

It is critical to “start clean and stay clean” when producing no-till cotton. When adopting no-till practices, herbicides are used as a replacement for tillage. Due to weed resistance to glyphosate and other herbicides – especially by Palmer amaranth, it is now required to mix herbicide modes of action during the growing season. The days of sole reliance on glyphosate for weed control in glyphosate-tolerant cotton are over due to these weed resistance issues. This situation is rapidly changing, so to obtain the latest information, contact extension personnel. Many cotton herbicides have soil residual activity. It is imperative to read the herbicide label and identify any potential issues with a future rotational crop. It should be noted that ideally, producers should have spraying equipment dedicated solely to use in cotton if possible. Phenoxy (2,4-D) and other herbicide contamination in tanks and hoses can be very damaging to cotton.

For no-till fields preplant burndown prior to planting is required. Horseweed is a major challenge in minimum tillage cotton, and glyphosate resistant populations of this weed have been identified in some counties. Horseweed should be targeted when the plants are in the rosette stage, prior to bolting or upright growth. Tank mixes of glyphosate and 2,4-D or glyphosate and dicamba are typically used. It should be noted that 2,4-D and dicamba both have critical application rate requirements and herbicide residue dissipation timelines prior to cotton planting. If planting restrictions for 2,4-D and dicamba cannot be met, then paraquat should be considered.
Roundup Ready Flex®, GlyTol®, and Liberty Link® transgenic traits have greatly reduced weed control challenges. Varieties containing the Roundup Ready Flex® and GlyTol® traits allow glyphosate to be applied over the top at any time from emergence to shortly prior to harvest. Liberty Link® varieties can be sprayed over-the-top with glufosinate.

A pre-emergence herbicide should be considered at planting. Several are available and the rate must be matched with the soil texture in the targeted field. Herbicides containing metolachlor or acetochlor can be used to improve annual weed control over-the-top of the crop. Staple LX® herbicide is another option as an over-the-top spray for control of broadleaf weeds.

Hooded sprayers are still very useful in cotton production and to address the challenges related to weed resistance. Overlapping in-season residual herbicides is recommended, especially if Palmer amaranth and morning glory challenges exist in the field. Application methods and timeliness are critical for success. Since some herbicides can adversely affect the cotton crop if improperly applied, it is necessary that growers read and follow all herbicide labels. Additional herbicide programs for use in no-till or reduced tillage cotton are being developed. For the latest information, contact your local Extension educator.

Volunteer cotton has become a legitimate challenge for producers adopting no-till production practices. Volunteer plants that are not located in the row cannot be harvested with the crop, and essentially should be considered “weeds” since they compete with the actual planted crop for sunlight, nutrients and water. Volunteer cotton often germinates at the same time the crop emerges leaving producers with very few options. The lack of height differential between the crop and the volunteer can make it difficult to safely and effectively control the volunteer with hooded or shielded applications. For this reason it is required that producers make every attempt to control any volunteer present prior to planting. There is a relatively small window of opportunity to effectively control volunteer cotton. This window is often overlooked. With good growing conditions seedling cotton can add an additional leaf every three days. One-leaf volunteer plants can turn into 4-leaf plants in a very short period of time (about 10 to 14 days). Once the volunteer exceeds the 4-leaf stage, effective chemical control is nearly impossible. Therefore, when relying on chemical control it is recommended to spray volunteers prior to the 4-leaf stage. Circumstances often require growers to control large volunteer cotton with some form of tillage. If volunteers pass the “easy to control” stage (one to four leaves), then shallow cultivation should be considered.

**Harvest**

Cotton harvest in no-till conditions should not be different from conventionally tilled fields. In most years, the wheat or rye cover crop is almost completely degraded and will not be gathered by the stripper harvester row units. In strip-till systems, no wheat or rye remains in the row and therefore cannot be picked up by the harvester.

In summary, conservation tillage management practices will substantially reduce environmental injury to the developing cotton. It is well documented that the first 30 to 40 days in the production season set the potential for maximum yield. When soil is not tilled, more water will infiltrate the field, soil erosion is greatly decreased, and organic matter is increased. The system might require more herbicide applications the first few years, but control costs will likely decrease if weeds are managed in an effective and timely manner. With recent advances in transgenic technology and modern equipment, adoption of a no-till cotton system is more easily accomplished than in the past.

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**Sorghum**

There are two important things to consider before switching to no-till grain sorghum. They are the history of herbicide and if a compacted layer (hardpan) is present. Herbicide carryover in a wheat only system can have rotation restrictions for grain sorghum up to two years from application. Therefore planning is crucial before trying sorghum in a rotation. For producers switching to no-till, taking care of a compacted layer should be the first step. The compacted layer will inhibit root growth and reduce yields in any production system. Shattering of the compacted layer by deep tillage or strip-till should be done before adopting no-till. Utilizing strip-till to break the compacted layer will also allow producers to apply fertilizer and prepare a seedbed similar to conventional tillage. Research at Kansas State University has shown a 3 F to 4 F increase in soil temperature for strip-till when compared to no-till. This increase in soil temperature may be important when planting sorghum during the last two weeks of April. Although with row cleaners on today’s no-till planters, this soil temperature difference will be minimal in a week to ten days.

Grain sorghum production utilizing no-till does not require drastic changes when compared to conventional till. The goal in both production practices is to obtain proper seed spacing and good seed-to-soil contact. For any successful production practice,
getting proper seed-to-soil contact is the first step. This allows the seed to germinate and grow without undue stress. The same planter can be utilized in both no-till and conventional till. The two major changes needed are row cleaners and more down pressure on the row units. The seeding rate for no-till is the same as for conventional till unless row cleaners are not used. If not using row cleaners, it is more difficult to get good seed-to-soil contact and therefore, the number of seeds germinating will be reduced. It is generally recommended to increase seeing rate by 5,000 seeds/acre when not utilizing row cleaners.

As reported in the popular press and journal articles, the benefits of no-till are not immediate. In a rotation study located at the Oklahoma Panhandle Research and Extension Center (OPREC), it was in year six before the first difference in grain sorghum yields was observed (Figure 4). One common misconception is that no-till means no yields—there was no difference in yields between no-till and conventional till the first five years of the study. Although no-till will not increase yields when no precipitation has fallen as in 2002 and 2011 when only 53 and 49 percent, respectively, of long-term mean rainfall was received. Since 2004, yields for the no-till grain sorghum have been significantly higher than for conventional till, with 2004 and 2006 yields being twice as high or more. In 2006, part of the yield difference is explained by the difference in test weights (Table 1). The difference for 2006 is explained by a short duration of drought stress observed in the conventional till grain sorghum that was not observed in the no-till. The duration of drought stress, although short and not very severe, delayed head emergence and flowering. The delay in flowering was long enough that grain fill and maturation was affected by a freeze, therefore more than 7 lb/bu difference in test weights was observed.

Figure 4. No-till vs. minimum-till grain sorghum yields in rainfed wheat-fallow-grain sorghum rotation at Oklahoma Panhandle Research and Extension Center, Goodwell, OK.

Table 1. Test weight of grain sorghum (lb/bu) for dryland tillage and crop rotation study at OPREC.

<table>
<thead>
<tr>
<th>Tillage</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Three-year</th>
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<tbody>
<tr>
<td>No-till</td>
<td>56.5</td>
<td>57.8</td>
<td>56.8</td>
<td>57.0</td>
</tr>
<tr>
<td>Strip till</td>
<td>56.7</td>
<td>57.0</td>
<td>52.9</td>
<td>55.5</td>
</tr>
<tr>
<td>Minimum till</td>
<td>55.8</td>
<td>56.9</td>
<td>49.6</td>
<td>54.1</td>
</tr>
<tr>
<td>Mean</td>
<td>56.3</td>
<td>57.2</td>
<td>53.1</td>
<td>55.6</td>
</tr>
<tr>
<td>CV %</td>
<td>0.8</td>
<td>1.6</td>
<td>4.2</td>
<td>3.7</td>
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<tr>
<td>L.S.D.</td>
<td>NS</td>
<td>NS</td>
<td>5.0</td>
<td>2.0</td>
</tr>
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</table>

Figure 5. Double crop grain sorghum following canola.

Corn

Given all the benefits no-till can offer, there are challenges as well. Crops grown under conservation tillage are subject to many different early season stresses that may limit the plant’s ability to take up essential nutrients. Crop residue acts as an insulating layer over the soil surface, which can contribute to lower temperatures in the upper soil profile (Johnson and Lowery, 1985). Soil temperature and moisture greatly influences the mineralization cycle,
which controls N release from soil organic matter (Kolberg et al., 1999). Cool wet soils slow down the mineralization process and contribute to poor early season growth due to the decreased amount of nutrients available to young plant roots. MacKay and Barber (1984) found the most profound effect of temperature on corn development was the rate of root growth. When soil temperature was increased from 64 F to 77 F, root growth increased by a factor of five. To address slow early crop growth associated with no-till soils, the use of starter fertilizer, usually containing N and P at planting, has shown to be a key management tool for corn production throughout the U.S. These factors mentioned previously make starter fertilizer very important for no-till corn production.

**Importance of Starter Fertilizer**

Several researchers have documented yield responses to starter fertilizer in no-till systems in Kansas and Missouri (Gordon et al., 1997; Gordon and Whitney, 1995; Scharf, 1999). The advantages to using higher N containing fertilizers include providing additional N supplies earlier in the growing season, reducing potential of volatilization and other N losses, flexibility in timing for future N applications, and enhanced P absorption (Lamond and Gordon, 2001). In addition, the method of applying starters has become more critical as the potential of physical incorporation of materials into the soil with tillage decreases. Deficiencies in secondary nutrients such

<table>
<thead>
<tr>
<th>Yield</th>
<th>Population</th>
<th>Dry Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>bu/ac</td>
<td>plants/ac</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Check 0-0-0</td>
<td>136</td>
<td>30,884</td>
</tr>
<tr>
<td>Method Means</td>
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<tr>
<td>In-furrow</td>
<td>146</td>
<td>23,330</td>
</tr>
<tr>
<td>2x2</td>
<td>180</td>
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<td>Dribble 2x</td>
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<td>30,864</td>
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<td>Row band</td>
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<td>840</td>
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<td>Starter Means</td>
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</tr>
<tr>
<td>5-15-5</td>
<td>156</td>
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</tr>
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<td>LSD (0.05)</td>
<td>10</td>
<td>849</td>
</tr>
</tbody>
</table>

*Source Barney Gordon Kansas State University*
as sulfur (S) are becoming more common in no-till systems as well. As with N, S becomes available to plants mainly through soil organic matter and residue decomposition and mineralization. If this process is slowed down by cool, wet soils, the early season S needs of a developing crop could be affected.

Various placement methods have been adapted to provide options for starter fertilizer application. Some of the more common starter placements include in-furrow, banded near the seed, or dribble over the seed row. In-furrow placement of fertilizer, commonly referred to as pop-up fertilizer, is intended to promote more vigorous seedling growth due to a readily available supply of nutrients to young plant roots. However, placing fertilizers in the seed furrow increases the salt concentration surrounding the seed (Figures 7 and 8). Under certain circumstances this can result in delayed seedling emergence, reduced seedling germination, and reductions in crop stand (Raun et al., 1986). With an increase in salt content, the plant’s capacity to absorb water is reduced until it cannot extract water even in wet soils. Another possible problem with in-furrow placement of urea-containing starters is ammonia toxicity.

Alternative placement methods for starter fertilizer have been developed with the purpose of placing the fertilizer far enough away from the seed so germinating seeds and seedlings are not adversely affected, yet close enough to allow early uptake of essential nutrients. Many starter fertilizers are now placed in a band 2 inches below and 2 inches to the side of the seed row. This placement method is commonly referred to as 2 x 2 placement. A band placement away from the seed allows more flexibility in the rates of fertilizer that can be safely applied, especially when higher N rates are desired. Subsurface band placements have generally been proven to be the most effective placement method for deriving the maximum benefit of the starter and greatest yield per unit of applied fertilizer in corn. A second option of a “safened” starter fertilizer application is a dribble placement (over the row). A dribble placement of starter fertilizer simply consists of dribbling fertilizer directly behind the closing wheel of the planter over the seed row on the soil surface.

**Planting Considerations**

In order to establish a good stand of no-till corn, close attention should be made to planting date, population, and planting depth. Planting date should be based on soil temperature. The effect of delayed planting date on grain yield can be easily observed (Figure 9). Corn will germinate at soil temperatures as low as 50°F, but germination may be delayed up to 21 days. The basic recommendation for planting is a soil temperature of 55°F at the 2” depth. Also, check the forecast to be sure that for the next three to five days the forecast is favorable. Soil temperatures can be found on the Oklahoma

![Figure 9. Four years of grain yields (114 Day Maturity) at Goodwell, Oklahoma.](image)

Figure 10. No-till corn in Garfield County.
Mesonet (http://www.mesonet.org/index.php/agriculture/monitor). This is the recommended method for determining optimal planting date.

Dryland corn should be planted at a population from 19,000 to 25,000 seeds per acre. Corn planted in the western part of the state should be on the lower end of the range. Corn planted in the eastern half of the state should be on the upper end of the range. Keep in mind that water requirements of corn only decrease if population is less than 18,000 plants per acre. Also, hybrid selection may influence planting density, so ask seed company representatives if your selected variety performs better at a lower or higher plant population. Seed should be planted at a depth of 1.5 to 2 inches for a fine textured soil and at a depth of 2 to 2.5 inches for a coarse textured soil. Planting depth is critical for proper germination.

**Canola**

Winter canola was first established in Oklahoma as a weed management option when utilized in a winter wheat rotation. Since its adoption, winter canola has become a major profitable crop and has shown to work great in a one-in-three year rotation with winter wheat in no-till and reduced till systems. Rotation with a winter broadleaf crop has given producers a wider range of herbicide chemistries to control many problematic winter annual grassy weeds. This rotation has also shown to improve certain soil characteristics.

The success of direct seeding winter canola into wheat stubble has been an obstacle for some producers. These issues often are related to stand retention throughout the winter rather than initial stand establishment. The decrease in stand may be due to several factors related to crop residue management, micro-climate differences at the surface in no-till, crown height of canola plants, etc. There are some general guidelines and recommendations that can increase winter survival in a no-till system.

From research during the last several growing seasons, we have identified that stand establishment is not the problem as long as equipment is set correctly at planting. In general, the rate of emergence and total percent emergence (based on 5 lb/acre seeding rate) has been similar between no-till and traditional tillage. In some cases, we have observed a higher rate of emergence in no-till systems due to higher soil moisture content near the soil surface. Higher soil moisture is a characteristic of no-till systems. We found 40 percent to 60 percent total emergence in our studies regardless of treatment, which is common, especially with a small seeded crop such as canola. Achieving a stand in no-till is not difficult, but keeping it is more challenging. Generally, winter survival will decrease 10 percent to 20 percent in no-till fields where the stubble is retained and not removed or burned.

**Seed Placement and Residue Thickness**

Getting good seed to soil contact is important, especially in heavier residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow-rooted canola plant. Often the roots may not even penetrate the soil surface and simply develop underneath the residue. Achieving uniform seeding depth is more easily done when residue has been evenly distributed the width of the combine header at wheat harvest. The use of a harrow (if possible) or burning the residue are useful management options, if residue is not evenly distributed or is too thick. If burning is deemed your best option, burn just prior to seeding to help conserve soil moisture. Unfortunately, minimum disturbance grain drills can lead to more winter stand loss in heavy residue fields if soil conditions are dry and early fall freezes occur. Utilizing equipment that is more aggressive at moving residue away from the seed furrow and/or tilling a narrow strip for the seed furrow is often preferred. More aggressive seeding options include shank or hoe type openers, wavy or fluted coulters, row cleaners (more options available on planters), or strip tillage.

**Crown Height**

Often in heavy residue, elongation of the canola hypocotyl is observed. The hypocotyl is defined as the part of the plant that is below the cotyledons and above the seed. An elongation in the hypocotyl will increase the crown height of the plant. The crown height is important because this is directly related to winter survival. The closer the crown is to the soil surface, the better your chances for winter survival. Crown height is a plant characteristic that should be considered when choosing a variety/hybrid. Most companies have good information or ratings for crown height.

**Soil Temperature**

Soil temperatures in no-till fields will be lower compared to conventional till fields with no residue on the surface. Wheat residue buffers soil temperature fluctuations at the 0.5-inch to 1.5-inch depth. Lower soil temperatures in soil with residue may reduce crop growth. For this reason planting in the early part of the “planting window” would be recommended. If possible, removing just a little of
the residue from the row will instantly increase soil temperature in that area. Using a more aggressive coulter or row cleaners may move enough residue to increase soil temperature in the seed zone.

**Soil bulk density**

Differences in yield between no-till and conventional tilled fields seem to be influenced by bulk density. Bulk density is the mass of soil divided by the total volume it occupies. A compacted soil has a very high bulk density. In a greenhouse study, to determine the effect of soil bulk density on winter canola root growth, root biomass decreased linearly with increasing bulk density for both sandy and clay soils. This means that higher bulk densities could reduce winter canola root mass, which may reduce winter survival. Canola plants rely on carbohydrates stored in the root mass to survive the winter months. This means that careful attention needs to be paid to soil physical properties in no-till fields. This especially true for young no-till fields (less than three years no-till) before seeding canola. It is common for bulk densities in young no-till fields to be 1.4 to 1.5 g/cm³. Caution should be used when seeding into a no-till field with a high bulk density. It takes several years (more than three years) for good soil structure to develop in no-till fields.

Yield of no-till winter canola is often influenced by the factors mentioned previously. Yield can be competitive with conventional till fields once you gain experience with no-till canola production. However, the risk for stand loss and yield loss is greater in no-till fields compared with conventionally tilled fields. Producers can be successful with no-till winter canola, but careful attention must be paid at planting time.