1. Wheat planting date and seeding rate research in northwest Kansas

What is the best seeding rate to use for wheat? It depends, in part, on the planting date. A good example of this can be seen from the results of a 2009 study near Colby, using TAM 111. In this preliminary study, we used four seeding rates (60, 90, 120, and 150 lbs per acre) at four planting dates (September 26, October 9, October 28, and November 7). This study will be repeated for the next two years.

For the Colby area, September 26 would be considered an optimal seeding date most years, and October 9 is also within the range of ideal seeding dates. October 28 is late for that area, and November 7 is very late.

The following chart shows the results of the study.
The following conclusions can be made from this study:

* Wheat yields were much higher when planted at the optimal time: Sept. 26 or Oct. 9.
* At the earliest planting date, seeding rate had no effect on grain yield. This is because the plants have plenty of time to tiller, especially at the lower seeding rates.
* At the Oct. 9 planting date, also within the optimal time, seeding rate had no significant effect on grain yield, although there was a trend upward at the 90 and 120 lb rates.
* When planting dates were later than optimal, increasing the seeding rate did improve yields significantly, although not to the yield level of the optimal planting dates. At these later planting dates, the plants do not tiller as much because they do not have as much time to develop before cold weather begins. With less tillering, an increase in seeding rates has a bigger effect on yields.

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2. Crop residue decomposition and nutrient release rates

Crop residue is often considered by producers to be a valuable source of nutrients, especially when the residue is from a nitrogen-fixing legume. The nitrogen (N) and other nutrients released from plant residues can be available for use by subsequent crops. But residue can also tie up nutrients – N, in particular – as it is decomposed by soil microbes.

What determines how and when the N in crop residue, from either a cash crop or a cover crop, will be released into the soil? Before the N present in crop residue is available to a subsequent crop, the residue must be decomposed, and the N mineralized, or converted to ammonium.

How quickly residue decomposes depends on the ratio of carbon (C) and N in the plant material. The higher the concentration of C compared to N in the residue, the longer it will take for soil microbes to break down the organic material and the more soil N the microbes will use as they do their work.

The key factor to look at when determining the timing of N tie-up and release from crop residue is the C:N ratio of the residue. In residue with less than 20 parts C to 1 part N, a C:N ratio of less than 20:1, soil microbes have enough N available to them in the residue for them to do their work and residue decomposition proceeds quickly. In that case, organic N is mineralized or released, fairly quickly to the soil inorganic pool.

Most residue with a C:N ratio of less than 20:1 is either a legume or young, lush vegetation, such as wheat prior to jointing. The table below gives the C:N ratio of many common crops and organic materials.

<table>
<thead>
<tr>
<th>Typical C:N Ratio of Crop Residue and Other Organic Materials</th>
<th>C:N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop residue:</strong></td>
<td></td>
</tr>
<tr>
<td>Alfalfa residue</td>
<td>13:1</td>
</tr>
<tr>
<td>Soybean residue</td>
<td>15:1</td>
</tr>
<tr>
<td>Young, green rye</td>
<td>36:1</td>
</tr>
<tr>
<td>Corn stalks</td>
<td>60:1</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>80:1</td>
</tr>
<tr>
<td>Grain sorghum stalks</td>
<td>80:1</td>
</tr>
<tr>
<td><strong>Organic materials:</strong></td>
<td></td>
</tr>
<tr>
<td>Microorganisms</td>
<td>8:1</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>10:1</td>
</tr>
<tr>
<td>Rotted manure</td>
<td>&lt;20:1</td>
</tr>
<tr>
<td>Sawdust</td>
<td>400:1</td>
</tr>
</tbody>
</table>

With a C:N ratio above 20:1, N becomes a limiting factor for decomposition. The population of soil microbes needed to decompose the residue increases rapidly and the microbes take up N from the soil in the process, if it is available. This uptake of available inorganic N to decompose the residue is called immobilization, or N tie-up. This is a temporary process. The higher the C:N ratio, the longer the N will be tied up by microbes, and the longer it will take for corn or wheat residue to decompose as compared to soybean or alfalfa residue. When the available C or energy
begins to run out, the population of soil organisms using the residue as energy will die back, releasing N back to the inorganic pool (mineralization).

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3. Nitrogen cycling and production by cover crops

Cover crops can be grown for several purposes, but generally they fall into three main categories: an N trap crop, a source of cover and residue, or a source of nitrogen.

**Nitrogen traps**

Trap crops are used to absorb nitrogen from the soil. If the cover crop is not grazed or harvested, the N taken up by the crop remains on-site and is preserved within the residue for use by future crops. This helps reduce potential N losses from the soil (through leaching or denitrification) that may have occurred during the period between cash crops.

For trap crops, the use of fast-growing, N-demanding crops are ideal. Good choices would include millet or forage sorghum for planting in the summer after wheat; or cereal rye, wheat, triticale or canola for planting in the fall after summer crops. Keep in mind that the trap crops will use the soil N taken up to support growth. In most cases trap crops will have a high C:N ratio, so the release of the N to subsequent crops may be slow. In fact it may be the second or third subsequent crop that actually benefits from the trapped N.

The main benefit is that the trapped N is not available to move through the soil to contaminate groundwater.

**Sources of cover and residue**

Most trap crops also are also well-suited as residue cover sources. Remember, the rate of residue decomposition can be controlled to some extent by selecting a cover crop. If the goal is to produce a residue cover, a crop with high-carbon, low-N residue, such as forage sorghum, millet, or cereal rye would be a good choice. Letting it become fairly mature in an N-deficient environment will increase the C:N ratio, and slow decomposition.

**Sources of supplemental nitrogen**

If wanting to grow cover crops to provide supplemental N to future cereal or forages, legumes are preferred. But cereals can also be useful, especially due to lower seed costs, if killed at an early growth stage when the residue has a low C:N ratio and decomposes more quickly.
Legumes fix atmospheric N, if they are well-nodulated, but the amount produced will vary widely. The C:N ratio is important when determining how quickly the fixed N will be available to subsequent crops. Fine-textured, low-C:N plants, such as alfalfa, clover, soybeans, or peas, will decompose much more quickly, and release N much more rapidly, than coarse-textured, high-C:N plants, such as mature sunn hemp.

Nitrogen fixation is a very energy intensive process. That means conditions must be favorable to photosynthesis and high yield to achieve maximum N fixation. In many cases, short daylength, cool temperatures, and dry soils limit N fixation by many legumes planted after wheat or summer crops. Also, keep in mind that high soil nitrates will feed the legume crop and reduce N fixation. So the actual N fixation from many legumes can be less than expected.

**How much N can be expected to be trapped or produced by cover crops?**

Research in Kansas has shown that the amount of N that can be produced, or trapped, can vary widely.

For trap crops planted after wheat, 20 to 60 pounds of N can be trapped by crops such as millet, forage sorghum or sudangrass. In fields with a history of manure applications, or when planted after a failed wheat crop, values could be higher. But keep in mind that the vast majority of the N has already been taken up by the time the wheat heads.

Winter cereals planted after corn will often trap 20 to 40 pounds N per acre. Less will normally be trapped by cereals after sorghum.

The amount of N produced by legumes planted after wheat and terminated by frost can vary widely. Generally, long-season soybeans which stay vegetative and sunn hemp will produce the largest amounts, perhaps as high as 100 pounds N per acre. But what portion will become available can be a question, especially with very aggressive crops such as sunn hemp. Cowpeas would be expected to produce significantly less N.

The amount of N produced by winter legumes such as vetch and winter peas planted after corn or other summer crops is primarily determined by when they are terminated in the spring. Generally, the equivalent of 30 to 50 pounds of fertilizer N can be produced if winter legumes are allowed to grow until mid- to late-May. Killed earlier, N production is considerably less. Unfortunately, the cost of seed and planting the legume cover crop can exceed the value of N produced.
Forage soybeans planted as a cover crop following wheat harvest can add N to the soil. Photo by Kraig Roozeboom, K-State Research and Extension.

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4. Water repellency of no-till and continuous-cropped soils

Soil water repellency (SWR) refers to the ability of a soil to strongly or slightly repel water. The SWR has been widely studied under hydrophobic conditions (e.g., forest, sandy, peat, and volcanic soils; and immediately after burning), but few have given much thought to its extent in cultivated lands, particularly for no-till soils.

Recent studies have shown, however, that a certain level of SWR could be rather a common phenomenon in cultivated soils. Cultivated soils appear to absorb water readily, but detailed tests show that water entry can be slightly reduced under certain conditions.

The magnitude of SWR in cultivated soils will depend on soil type, management (e.g. no-till, manure application, and residue mulching), and climate. For example, residue removal from cultivated soils by baling or burning can change the SWR. Soil hydraulic conductivity and water infiltration rates may be lower in soils from burned plots than from unburned plots because of the
fire-induced increase in SWR. The impacts that burning or baling crop residues may have on SWR deserve further research.

The SWR in natural ecosystems is generally in the order of forest > grasslands > cultivated soils. While severely hydrophobic soils (such as fire-affected forest soils) may completely block water entry for extended periods of time (hours and days), SWR in cultivated soils is normally small. No-till soils, for example, can delay water entry by a few seconds over plowed soils in the upper 0 to 4 inches (10 cm) soil depth. But the effects of this small level of SWR on soil carbon and soil structure can be very significant.

Our data from four soils in the central Great Plains in Hays and Tribune, Kansas; Akron, Colorado; and Sidney, Nebraska, showed that SWR was present in all soils (Fig. 1A). SWR is measured in terms of water drop penetration, which is the number of seconds required for one drop of water to completely penetrate the soil. Mean water drop penetration was 1 second for plowed soils and 3 seconds for no-till soils at Akron and Hays, while at Sidney it was 1.5 seconds for plowed soils and 10.5 seconds for no-till soils. Similarly, a study across 11 soils in the eastern U.S. (Ohio, Kentucky, and Pennsylvania; Fig. 1B) found that long-term no-till systems retarded water penetration into the soil by about 4 seconds over plowed systems.

Continuous-cropped systems can also induce water repellency in surface soils compared to crop-fallow systems. In a 34-year cropping system experiment at Hays, continuous wheat had 5 times
greater SWR than the average across sorghum-fallow, wheat-sorghum-fallow, continuous sorghum in wide rows, and wheat-fallow under no-till at the 1-inch soil depth (Fig. 2).

In addition, SWR generally increases with a reduction in crop residue removal and with manure application and N fertilization.

What is the importance of soil water repellency?

While severe SWR can reduce water infiltration, increase runoff, and reduce crop production, the slight level of SWR observed in most no-till and intensive cropping systems can have positive effects on soil aggregation and C sequestration. A little bit of SWR can improve soil aggregate stability because the slow water entry into the soil reduces the amount of aggregate slaking, or disintegration. Our research has shown that soil aggregate stability is positively correlated with SWR. Wet aggregate stability increases with an increase in SWR in cultivated soils. Soils with stable aggregates are less susceptible to erosion than those with unstable aggregates.

The slight level of SWR in no-till soils can also promote long-term C sequestration because stronger and more water-stable aggregates protect C-rich materials stored inside the aggregates from rapid decomposition. Recent studies have suggested that no-till induced SWR may be one
of the key mechanisms responsible for long-term C sequestration in no-till soils. The SWR is positively and strongly correlated with soil organic C fractions and with the amount of C sequestered in soil aggregates. Indeed, our research found that SWR was positively correlated with soil organic C across the four soils in the central Great Plains \( (r = 0.62) \) and 11 soils in the eastern U.S. \( (r = 0.42; \text{Fig. 3}) \).

![Figure 3](image_url)

**What are the causes of soil water repellency?**

Soil aggregates and particles can develop a slight level of SWR by becoming coated with long-lasting and hydrophobic organic materials in the soil, such as fungal hyphae and humic and non-humic substances (e.g. peptides, resins, and waxes). Mucilages and exudates of soil organisms coat primary and secondary soil particles, inducing hydrophobic properties.

Changes in soil properties, water gradients, temperature, and microbial processes can contribute to the differences in SWR. No-till farming induces slight water repellency to soils due to the accumulation of residue-derived soil organic C near the surface layers and reduced soil disturbance. Plow-till, in turn, reduces SWR by accelerating oxidation of soil organic matter, disrupting microbial processes, and lowering the soil organic carbon concentration.

**Summary**

No-till farming can induce slight water-repellent properties to soil -- and that’s a good thing. Recent studies show that SWR in no-till soils is a common attribute. In addition, SWR is greater with an increase in crop residue return, manure application, and N fertilization. Unlike the severe SWR in hydrophobic systems, the slight water repellency observed in no-till soils can have
beneficial impacts on soil structure, C sequestration, and soil erosion. It can reduce rapid aggregate slaking, stabilize soil aggregates, and promote long-term C sequestration inside the aggregates. Intensive cropping systems combined with no-till can also induce some water repellency to soils over crop-fallow systems.

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, or Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader 785-532-0397 jshroyer@ksu.edu