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1. The effects of residue removal on soil and water quality

Crop residue is in high demand in some areas of Kansas and other states, either as feedstocks for cellulosic ethanol production, industrial uses, livestock feed, or other uses. Producers can get paid for selling their crop residue for these uses. But is it really a good idea to remove and sell crop residue? What is the cost of crop residue removal in terms of loss of soil quality and productivity, and potential impairment of surface water quality?

Leaving crop residue on the soil surface is the best and simplest way of reducing water and wind erosion. Widespread residue removal for expanded uses may accelerate soil erosion and increase the loss of sediments, nutrients, and pesticides in runoff water. Sediment and nutrients leaving agricultural soils in runoff water are the main “non-point source” (NPS) pollutants of downstream water bodies, such as ponds, reservoirs, streams, and rivers.

But crop residue removal may not be all-or-nothing. The producer may want to remove some residue and leave some. How much residue can be removed from crop fields without creating erosion and runoff problems?

The answer is not fully known, and partially depends on the level of crop productivity. In some cases, particularly in semiarid regions such the Great Plains, not enough residue is produced most years to protect soil from water and wind erosion and maintain adequate levels of soil organic matter. In those cases, any removal of residues may further degrade soil quality, increase water pollution, and reduce crop production.

A study was conducted to assess on-farm impacts of variable rates of residue removal from wheat and sorghum fields on water erosion in two soils near Hays in late Fall, 2008. A 20-year no-till field under continuous winter wheat and a 3-year conventional-till grain sorghum field (plowed in the spring before planting) were selected. The soil in both fields is silt loam with a slope of 6% for wheat and 3% for sorghum.

The stubble remaining after harvest was removed at 0, 25, 50, 75, and 100%. The average height of the standing stubble was 12 inches for wheat and 23 inches for sorghum. The plots were parallel to the dominant slope. Simulated rainfall was applied to the plots to give the effect of a rainstorm with a return period of 25 years for western Kansas.

In addition, a second set of plots within each field was established by tilling the soil a few days before rainfall simulation. Concentrations of sediment, soil organic carbon, and nutrients in runoff were measured.

Results of this study showed that wheat and sorghum residue removal after harvest exponentially increased loss of sediment, soil organic carbon, and nutrients in runoff regardless of tillage system (Fig. 1A through 2B). The single rainstorm of high intensity caused large and immediate runoff loss of sediment and nutrient pollutants when residues were removed. Where most or all of the residue was left intact after harvest, the runoff water after the high-intensity rainstorm was clearer. Where half the residue was removed, sediment loss increased after the rainstorm.

Freshly tilled wheat plots (tilled immediately after the residue removal) lost more sediment, soil organic, and nutrients than no-till wheat plots for the same level of residue removal, suggesting that residue removal in combination with intensive tillage can accelerate soil erosion to unsustainable levels.

Differences in soil slope affected the amount of pollutants lost in runoff. More runoff, sediment, soil organic carbon, and nutrients were lost from the freshly-tilled wheat plots with 6% soil slope (Fig. 1A) than from the sorghum tilled field with only 3% soil slope (Fig. 1B).

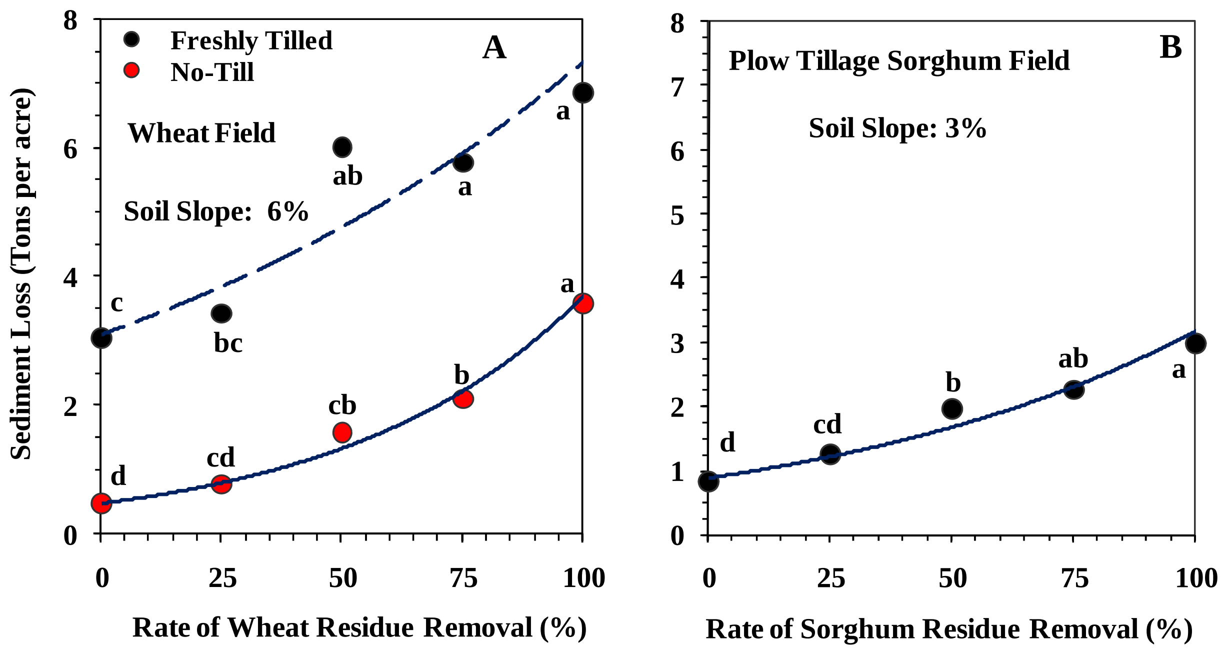

Fig. 1. Influence of wheat (A) and sorghum (B) residue removal on sediment loss in two soils in western Kansas. *Means followed by the same lowercase letter within the same tillage level are not significantly different*.

Another finding, which may surprise many, was that removing 75% or more of the residue after harvest can negate many of the benefits of no-till in reducing runoff. We found that the loss of NPS pollutants from no-till soils was equal to those from plowed soils when residues were removed at or above 75% (Fig. 1A). This indicates that no-till may be no better than plow tillage if residues are removed at high rates. Excessive residue removal from no-till soils can negate the erosion control benefits attributed to no-till. No-till benefits for controlling soil erosion are quickly lost when residue is removed at rates above 25%. Residue cover is needed to keep the soil in place.

Removing residue after harvest also has a negative effect on soil carbon, even in no-till wheat systems (Fig. 2A). The large losses of soil organic carbon with residue removal at rates as low as 50% indicate that a single rainstorm of high intensity could eliminate all the gains in soil organic carbon pool attributed to no-till.

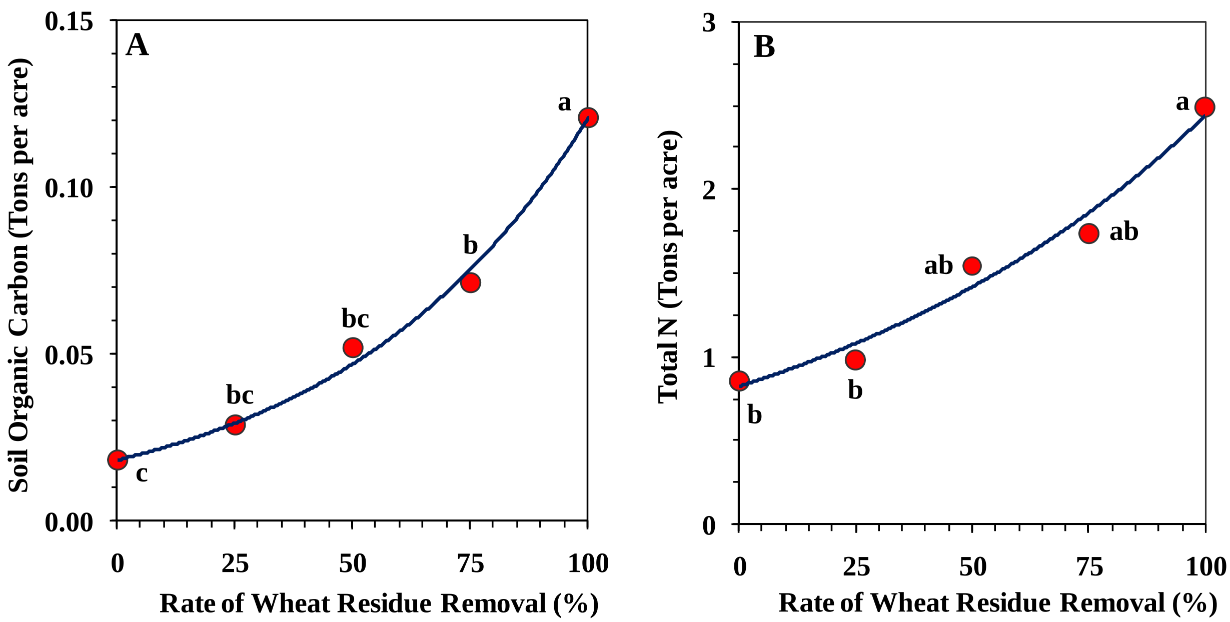

Fig. 2. Mean loss of A) sediment-associated soil organic carbon and b) total N in runoff under different levels of post-harvest wheat residue removal in a no-till system. *Means followed by the same lowercase letter within the same tillage level are not significantly different.*

The large losses of soil organic carbon with sediment may have large soil, agronomic, and environmental implications. Soil organic carbon is essential to increase the soil's ability to absorb and filter NPS pollutants and improve soil productivity.

Residue removal also increased losses of essential nutrients, particularly total N (Fig. 2B) and total P. Loss of nutrients in runoff increased with residue removal above 50% in no-till wheat. Residue removal reduces nutrient pools through two pathways: 1) nutrient removal with residues and 2) via increased runoff.

Results of this study show that crop residues are indeed essential to reduce sediment, soil organic carbon, and nutrient loss in runoff, regardless of tillage system. Crop residue removal is not recommended if soil and water conservation, NPS pollution control, and soil carbon buildup are high priorities. Residue left on the soil surface protects the soil against impacting raindrops, helps maintain the integrity of soil aggregates, and improves rain water infiltration.

A small fraction (about 25%) of residue may be available for removal from no-till soils, but further studies monitoring of pollutants losses under different scenarios of rainfall intensities and soil/topographic characteristics are needed to determine the amount of harvestable residue.

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(Editor's Note: The following two articles are from presentations made at the 2009 Cover Your Acres Winter Conference, held Jan. 20-21 in Oberlin.)

2. Weed control strategies in grain sorghum

Severe grass and broadleaf weed pressure can reduce grain sorghum yields by 55% or more, and make harvest very difficult. Good crop rotation and herbicide selection are essential components of managing weeds in grain sorghum.

In a wheat-sorghum-fallow rotation, it is essential that broadleaf and grassy weeds do not produce seed during the fallow period ahead of grain sorghum planting. It is equally important that winter annual grasses are not allowed to head in spring, before the sorghum is planted.

Fall-applied atrazine can reduce early-spring weed pressure ahead of sorghum planting. If winter annual grasses are present at the time of the fall application, the addition of glyphosate to atrazine will broaden the spectrum of weed control. When fall-applied herbicides are not used, an early burndown operation the following spring is almost always essential. Essential moisture and nutrients will be used by weeds if the first burndown operation is delayed too long. Delaying the first burndown operation allows weeds to grow and some species, such as kochia, Russian thistle, and common lambsquarters, will become increasingly difficult to control. Also, winter annual grasses can head and produce viable seed if the burndown is delayed too long.

In sorghum, the best choice of herbicides will depend on the weed species present. Broadleaf weeds generally can be controlled with a combination of preemergence and postemergence herbicides. With the development of herbicide-resistant weeds, however, this is becoming increasingly difficult.

Control of pigweeds in sorghum is an increasing concern across the state. Using a soil-applied chloracetamide herbicide with atrazine (such as Bicep II Magnum, Bicep Lite II Magnum, Bullet, Lariat, Guardsman Max, G-Max Lite, Degree Xtra, or generic equivalents of these products) will often aid in controlling pigweeds. Some of the broadleaf escapes producers can expect when using the chloracetamide/atrazine mixtures are devilsclaw, puncturevine, morningglory, atrazine-resistant kochia, and atrazine-resistant pigweeds. Using a product such as Lumax preemergence, which contains mesotrione (Callisto), will help control the triazine-resistant pigweeds and kochia. The chloracetamide/atrazine herbicides will also do a very good job of controlling most annual grassy weeds. A weakness of all soil-applied programs is that rainfall is required for activation. Without activation, poor broadleaf and grass control can be expected.

Grass control in sorghum can be a difficult task in many cases. If a field has severe shattercane pressure, planting grain sorghum is not recommended. For other annual grassy weeds, it will be important to apply one of the chloracetamide herbicides. Grasses that emerge before the soil-applied herbicides are activated will not be controlled. There are no herbicides currently labeled for postemergence grass control in grain sorghum. Although atrazine and Paramount have grass activity and can control tiny grass seedlings, it's generally not a good practice to depend on these herbicides for grass control.

K-State has recently released lines of grain sorghum that are resistant to ALS herbicides (such as Steadfast, Finesse, Glean, Pursuit, and many others) and the ACCase herbicide Select. When commercial hybrids with these herbicide-resistant traits are on the market, hopefully by 2011 or 2012, producers will have new opportunities for postemergence grass control.

Postemergence broadleaf weed control herbicides are available for grain sorghum. These products will be most effective when applied in a timely manner. Weeds that are 2-4 inches tall will be much easier to control that weeds than are 6-8 inches tall, or larger. Controlling weeds in a timely manner will result in less weed competition with the crop compared to waiting too long to control the weeds. Atrazine combinations with Banvel, 2,4-D, Buctril, or Aim (or generic versions of these herbicides) can provide excellent broad-spectrum weed control. The presence of certain weed species will affect which postemergence herbicide programs will be most effective. See the grain sorghum section in the K-State 2009 Chemical Weed Control Guide (SRP 1007) to help make the selection:
http://www.oznet.ksu.edu/library/crpsl2/SRP1007.pdf

The crop stage at the time of postemergence herbicide applications can be critical to minimize crop injury. Delayed applications risk injury to the reproductive phase of grain sorghum, thus increasing crop injury and yield loss from the herbicide application. Timely applications not only benefit weed control, but can increase crop safety. Always read and follow label guidelines.

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3. The value of soil profile nitrogen testing

Using a profile nitrogen (N) test to verify N credits can provide valuable information to producers. Most producers are unaware of the amount of N that may be present in their soils from the previous season. Plant available N can be present in the soil from fertilizer carryover, previous manure applications, or legume plowdowns.

Fertilizer N is applied based on production conditions and estimated yield potential. When the actual crop yield is lower than expected, or fertilizer N was over-applied, there is a high probability of some residual N being present in the soil. Under conditions of high rainfall, this N is prone to losses by leaching or denitrification. However, under conditions of low precipitation, this N will likely stay in the soil and become available for following crops.

Deep nitrate-N soil testing (24-inch profile) can provide information regarding the level of carryover N. Soil nitrate testing can be especially important after a crop failure due to drought conditions. Crop growth can be extremely limited during a drought, and therefore the applied fertilizer N, as well as mineralized soil N, is typically not fully utilized. This carryover N would be available for the next crop and in some cases, fertilizer N needs can be significantly reduced. The relative value of the profile nitrate test will depend on several factors affecting N carryover. Some of these factors include soil texture, rainfall, temperatures, crop rotation, and manure application history.

Proper soil sampling and testing is very important for a good assessment of residual soil nitrate. Annual sampling of each field is necessary for accurate residual N estimations. Annual sampling also helps evaluate current fertilizer application programs, providing information for fine-tuning future fertilizer applications. The key to good soil test results is a proper sampling protocol. Each sample should contain 15 to 20 cores of soil from a reasonably uniform area of approximately 40 acres. Producers who want more detailed information may want to reduce the area represented by each sample. Large fields should be broken into sampling units based on crop, yield, and fertilizer histories.

When taking samples for nitrate analysis, late fall or early spring is a good time to sample. Nitrate levels will fluctuate somewhat through the year, depending on soil temperatures and soil mineralization rates. The best time to take the sample is during cool periods after the previous crop has been harvested but before the soil warms up too much the following spring. This will give producers a good reading on how much N remains from the previous crop, before mineralization begins to increase nitrate levels.

In addition to residual profile nitrate, mineralized N from soil organic matter is also credited by the K-State soil testing lab, and many other labs. For warm-season crops, the credit given by the soil testing lab at K-State is approximately 20 pounds of available N per acre during the crop year for each one percent of soil organic matter. For cool-season crops, the credit is approximately 10 pounds of available N for each percent soil organic matter. Information regarding the level of soil organic matter can significantly improve the efficiency of N management. The sampling depth for organic matter is 6 inches, which is same as the sampling depth for phosphorus and potassium.

A. Profile N tests are most valuable under the following conditions:

* Medium- to fine-textured soils
* Recent history of excessive N rates
* The previous crop had lower-than-expected yields
* The field was fallow the prior year
* There was a drought the prior year
* A stand of alfalfa or clover has recently been on the field
* There is a history of manure application
* Previous years have had warm, late falls and/or warm, early springs

B. Profile N tests are less likely to find residual N in the soil under the following conditions:

* Sandy soils
* Previous N rates have been appropriate or insufficient for crop yields
* The immediate previous crop was soybeans
* The previous year had excessive precipitation
* No manure or biosolids have been applied
* Higher intensity crop rotations have been used

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