No-Till Grain Production in Wyoming: Status and Potential

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Introduction

1. Growth of corn-based ethanol production is expected to increase crop prices and intensify production of wheat and other non-biofuel crops as producers switch to corn and as wheat replaces corn for livestock feeding (Collins, 2006; Elobeid et al., 2006);
2. Incentives for carbon (C) sequestration may promote adoption of practices that store soil organic matter (SOM), especially conservation tillage (Lewandrowski et al., 2004);
3. Soaring prices for fuel and fertilizer will force producers to reduce inputs;
4. Cropping systems that reduce or eliminate tillage and fallow, and enable intensification, might become increasingly prevalent as producers respond to biofuel and carbon sequestration incentives;
5. Information is needed to help eastern Wyoming wheat producers adapt to these emerging production pressures.

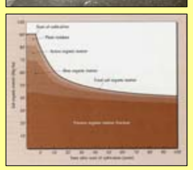
Conventional Crop-Fallow

Economic Stability in an Unpredictable Environment

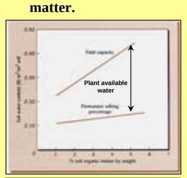
- Crop-fallow systems stabilize yields & create relatively predictable income;
- Excess water and nutrients stored during fallow create buffer for crop years.
- High available water at planting increases yield potential.

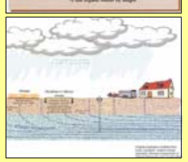
A Leaky System

- 75 percent or more of annual precipitation is typically lost to runoff, evaporation, deep percolation, and weeds;
- Nutrient supply is out of sync with crop demand. Nutrients accumulated during fallow are lost in the same ways as moisture, depleting soils and contributing to off-site pollution;
- Great plains soils have lost 30 to 60 percent of the SOM accumulated during millennia of grassland cover since intensive tillage began (Aguilar et al., 1988);
- SOM preferentially lost through erosion by wind and water;
- Tillage and fertilizer stimulate decomposition, leading to loss of mineralized nutrients and soil organic matter.



From Brady and Weil (1996).





Loss of Soil Quality

- Loss of SOM reduces soil water- and nutrient-supplying potential;
- Loss of soil structure reduces porosity impeding movement of air and water;
- Loss of aggregation leads to loss of previously protected SOM and increased vulnerability to wind and water erosion.

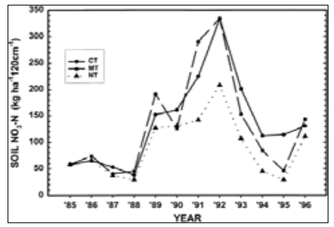
Changes with Conservation Tillage

A Tighter System

- Increased moisture under no-till allows continuous cropping;
- Soil organic matter content increases;
- Better use of in-season precipitation for moisture and SOM mineralization to supply late season nutrients;

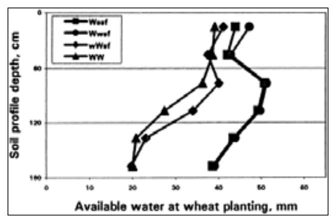
Less water and nutrient availability in spring

- In a North Dakota continuously cropped wheat-sunflower system, no-till had consistently lower spring soil nitrate even though total nitrogen (N) contents are higher under no-till;
- Reflects greater N mineralization from SOM under tillage than no-till and greater nitrate removal under no-till because of higher yields;

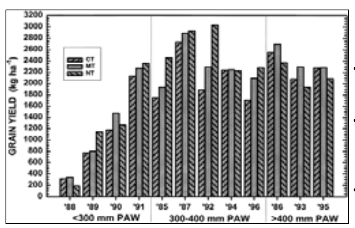


Spring soil nitrate in the 0- to 120-cm soil profile. Conventional till (CT), minimum till (MT) no till (NT). From Halvorson et al., 1999.

- In Kansas, continuous no-till wheat had lower available water at planting time (September) than reduced-till rotations that incorporate fallow, especially deep in the soil profile;
- However, over 80 percent of precipitation was lost during fallow years, reflecting notoriously low precipitation storage efficiency of fallow;
- Lower available water below the root zone, along with better storage efficiency of precipitation, means that more annual precipitation is supporting crop growth under continuous crop no-till than cropping systems that include tillage and fallow.



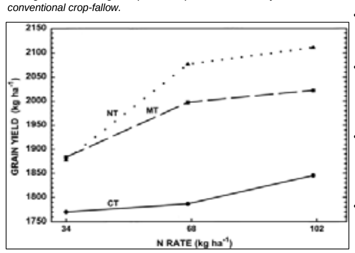
From Schlegel et al., 2002. Wheat at sampling (W), wheat (w), sorghum (s), fallow (f).



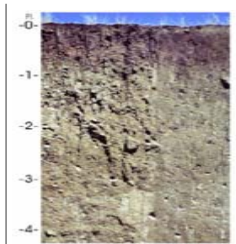
Winter wheat yields grouped by annual plant available water (PAW) over the 11-year study period. From Halvorson et al., 1999. Wyoming yields average about 1700 kg ha^{-1} (25 bu ac^{-1}) almost exclusively under conventional crop-fallow.

But higher grain yields over the long term

- North Dakota winter wheat yielded more grain under no-till in mid range available water levels;
- Yields during years with >400 mm PAW suffered from leaf spot disease, especially in the no-till treatments under low fertilizer rates;
- The authors emphasize importance of N fertilization in maintaining healthy plants under no-till conditions;
- No-till and minimum-till made much better use of moderate and high fertilizer N rates.
- Under these continuous wheat-sunflower rotations, no-till spring moisture levels were higher leading to higher yield potential and fertilizer need;
- Yield differences likely contribute to differences in spring soil nitrate content as no-till removes more nitrate and CT leaves more in the soil;
- Other studies show fertilization needs decrease with time as higher SOM contents stabilize under no-till.

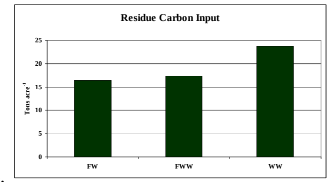


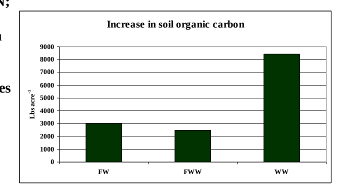
From Halvorson et al., 1999 (N rates: 30, 60, and 90 lb ac^{-1}).



Rebuilding Soil Organic Matter

- Improved yields despite lower early season moisture and nutrients result from increased SOM contents with reduced tillage;
- Increased SOM results from less aeration, which slows decomposition and conserves SOM;

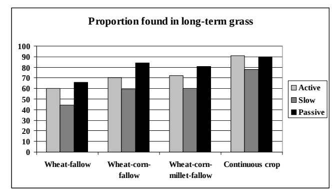




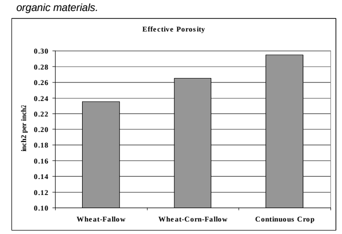
From Grant et al., 2002. Based on 34 years of data.

Rebuilding Soil Organic Matter

- Increased yields result in more crop residue over the long term;
- More residues stimulate microbial activity, which can tie up and reduce availability of nutrients, especially N;
- Contributes to higher fertilizer needs after conversion to no-till;
- More crop residue with slower decomposition increases SOM over the long term.



From Sherrod et al., 2005. Based on 12 years of data. Active SOM includes easily decomposable plant materials and microbial biomass that turn over within one to five years. Slow SOM includes SOM protected within soil aggregates and turns over on the order of decades. Passive SOM includes stable, mineral-associated organic materials.

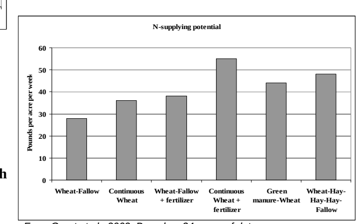


From Shaver et al., 2005. Based on 12 years of data.

- Over time, nutrient-supplying potential of soils increase under continuous crop no-till;
- Larger, more diverse microbial community in larger SOM content soils with more late-season moisture causes increased mineralization through the season, reducing fertilizer needs.

Rebuilding Soil Organic Matter

- Organic matter fractions corresponding with active, slow, and passive pools each increased under continuous crop no-till in long-term research in Colorado;
- More SOM improves soil physical properties including water holding capacity and infiltration rates.
- Increased water storage efficiency facilitates intensification/diversification.
- Leaching can increase without intensification.
- Crops rely on in-season precipitation and nutrient availability from decomposing residues.
- Late-season N availability boosts protein.



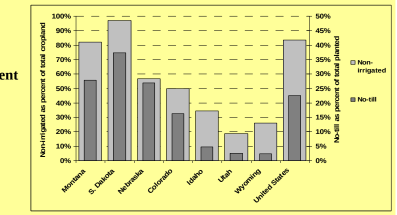
From Grant et al., 2002. Based on 34 years of data.

No-Till in the Northern Plains

Success includes new management approaches

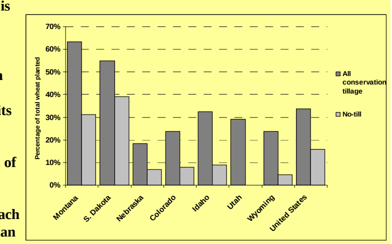
- Average yields increase but annual yields drop significantly;
- Lower fertilizer requirements to match annual yield;
- High C/N residue: incorporate fertilizer below to avoid immobilization;
- Becomes easy to over fertilize relative to available water, which can decrease yields, pollute water resources, and waste money;
- New approaches to determining soil nutrient supply may be necessary.

- Adoption of no-till practices ranges from 2.5 percent of all planted acres in Wyoming to 37 percent in South Dakota (CTIC, 2004).
- Rates of no-till usage reflect the amount of non-irrigated cropland (NASS, 2002).



Total 2004 cropland under no-till as percent of the total acres planted to all crops (right axis) and total 2002 non-irrigated as percent of all cropland (left axis) in Wyoming and surrounding states (NASS, 2002; CTIC, 2004).

- Data for wheat, which is mostly non-irrigated and is Wyoming's largest annual crop (by acres planted) show uneven adoption conservation- and no-till;
- One reason suggested for low rates of conservation tillage in Wyoming is that marginal yields and low residue production negate water conserving benefits (Dalrymple et al., 1993);
- However, wheat yields averaged over seven census of agriculture years (Table 1) show that Wyoming wheat yields were not significantly different from yields in Montana, South Dakota, and Colorado, each of which has higher rates of conservation tillage than Wyoming.



2004 wheat under conservation tillage and no-till as percents of the total wheat planted. From CTIC (2004).

Table 1. Average wheat acres harvested and yield over seven Census of Agriculture years. Compiled from NASS (2002).

	Average Harvest	Average Wheat Yield by Census of Agriculture Year							
		2002	1997	1992	1987	1982	1978	1974	Ave†
	Ac yr^{-1}	*Bu ac^{-1}*							
Montana	5,008,558	23	31	29	31	31	28	23	28 bc
S. Dakota	2,955,688	27	28	30	28	26	21	18	26 c
Nebraska	2,139,325	33	35	30	39	34	30	32	33 b
Colorado	2,484,287	23	30	30	34	27	22	25	27 bc
Idaho	1,366,970	65	77	68	67	58	51	41	61 a
Utah	202,909	34	43	35	37	28	26	24	33 b
Wyoming	**252,013**	**17**	**30**	**25**	**29**	**26**	**23**	**24**	**25 c**
United States	58,277,291	35	38	37	35	33	30	27	34 b

†Values followed by the same letter are not significantly different at P<0.05.

Conclusions

Wyoming's low adoption rates of conservation tillage systems may represent opportunities for intensified production systems that increase yields, conserve natural resources, and facilitate storage of soil organic matter. The challenge for researchers, agricultural educators, and Wyoming producers is to develop and commit to new management strategies necessary for success of conservation cropping systems.

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