NO-TILL GRAIN PRODUCTION IN WYOMING: STATUS AND POTENTIAL

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ABSTRACT

In dryland cropping systems, optimal yields require that nutrient supply matches the soil's yield potential supported by available moisture. Conservation tillage systems that leave at least 30 percent of the soil surface covered by residue dramatically increase moisture retained in the soil compared to crop-fallow systems. This enables producers to plant two, three, or four consecutive crops, or continuously, without fallow, but water and nutrient needs are much more closely balanced with supplies, so more intensive management is required. As soil organic matter lost during decades of frequent tillage recover, soil water holding capacity, infiltration, and nutrient supplying ability increase. Crop nutrients come from organic residues decomposing in-season, often stimulated by fertilizer additions. Excess water and plant-available nutrients accumulated during year-long fallow periods are eliminated. This season-long nutrient supply increases grain protein. Since crop nutrient needs are more closely balanced with soil nutrient supply rates, in-season assessment of nutrient status and addition of fertilizer can be necessary. New technologies for nutrient assessment, such as specialized satellite imagery, are important tools in the intensified and diversified conservation cropping systems.

Rates of adoption of conservation tillage practices in Wyoming lag behind surrounding states. Relatively low cropland acreage has prevented development of a strong extension program in Wyoming, but collaborative research and educational programs, both on-farm and at Wyoming's research & extension centers, have potential to increase the number of producers using conservation tillage.

INTRODUCTION

With profits squeezed by rising costs of fuel and fertilizer, grain producers are asking how to maintain or increase yields and cut costs to stay in business. There are two ways to increase yields: increase the soil nutrients and water available to crops. Long-term research shows that conservation tillage, especially no-till, can achieve both while reducing fuel and fertilizer needs. But costs of conversion and perceptions about lower yields prevent adoption of no-till systems, especially in Wyoming.

This could be changing as increases in costs of fertilizer and fuel encourage a new look at minimum- and no-till crop production as alternatives to crop-fallow. No-till grain production has been in use for over thirty years, which means we're beginning to understand long-term advantages and disadvantages compared to crop-fallow.

This paper examines research on long-term effects of no-till farming, focusing on wheat production, and adoption rates in Wyoming and surrounding states.

SUSTAINABILITY OF CONSERVATION TILLAGE

Since the sod was broken, farmlands in the northern plains have lost 30 to 60 percent of the soil organic matter (SOM) accumulated during millennia of grassland cover (Aguilar et al., 1988; Bowman et al., 1990). After cultivation begins, SOM is lost through accelerated erosion by wind and water and through accelerated decomposition as repeated tillage increases aeration and breaks down soil structure, exposing previously protected SOM. Fertilization also speeds loss of SOM as nitrogen (N)-hungry microbes become active and use SOM as a source of energy.

Reducing or eliminating tillage so that more crop residue is left on the soil surface slows these processes and can even rebuild SOM, which increases yields and reduces fertilizer needs. No-till systems can increase the availability of water and nutrients so much that producers can switch from crop-fallow to continuous cropping.

The conventional crop-fallow system has created a stable production system because excess moisture is available in the cropping years, but it is very inefficient. Seventy-five percent or more of precipitation is lost to evaporation, weeds, runoff, or movement below the root zone. Nutrient supply is out of sync with crop demand so that mobile nutrients, which are valuable resources, move below the root zone.

In research by Halvorson et al. (1999), North Dakota soils under continuous no-till winter wheat had significantly less nitrate in spring than those under either minimum- or conventional-till systems. Schlegel et al. (2002) found less moisture, especially deep in the soil profile, beneath continuous spring wheat in Kansas than beneath systems that incorporate fallow. However, continuous, no-till cropping systems consistently produce higher yields over the long-term (Fig. 1) and no- and minimum-till systems make much better use of medium to high rates of fertilizer than did conventional crop-fallow systems(Halvorson et al., 1999).

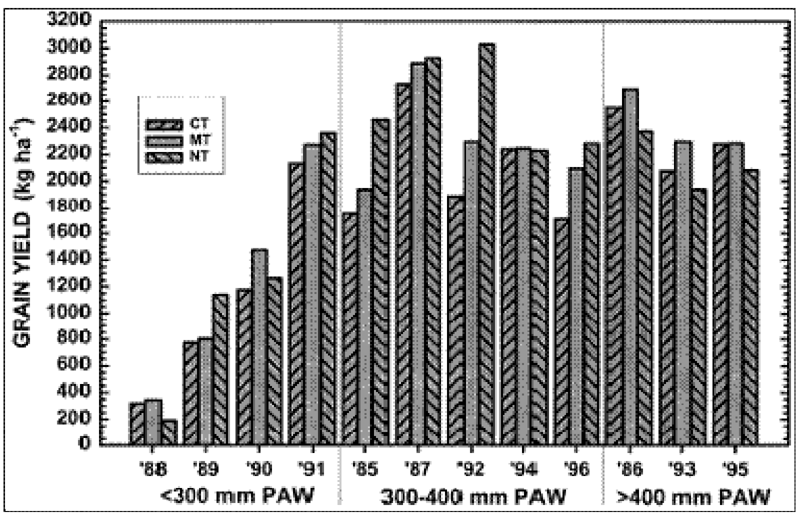

Figure 1. Winter wheat yields near Mandan, ND, under three plant-available water (PAW) regimes and three tillage systems: convential till (CT), minimum till (MT), and no till (NT) (from Halvorson et al. 1999). Wyoming winter wheat yields average about 1700 kg ha^{-1} (25 bu ac^{-1}).

This apparently anomaly – less moisture and available nutrients but higher yields and better nutrient use under no-till than crop-fallow – may be because soil properties change with less tillage. Shaver et al. (2002) found that, after 12 years of continuous no-till wheat, three different Colorado soils had higher total porosity than wheat-fallow systems on the same soil types (Fig. 2). They found that the continuously cropped systems also had higher annual and cumulative residue production than the wheat-fallow systems and they attributed the higher porosity to this increase in organic material. Grant et al. (2002) found significant increases in both organic carbon from residue and in total organic carbon in Canadian soils after 34 years of no-till continuous wheat than in matched soils under wheat-fallow.

Higher porosity from increased SOM leads to improved utilization of in-season rainfall, not only by crops, but also by microbes that decompose residue and release nutrients later in the season, which improves grain protein content (Grant et al., 2002).

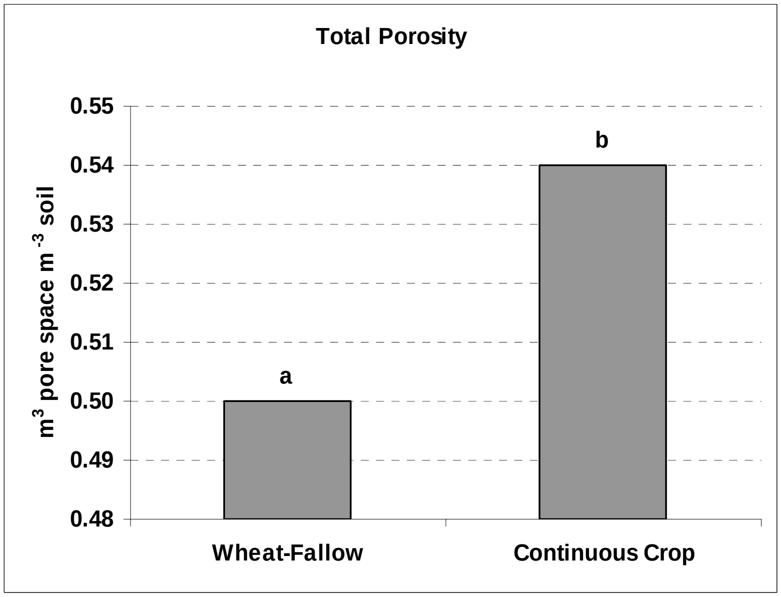

Figure 2. Average porosity in three soils at two slope position in eastern Colorado (from Shaver et al., 2002). Different letters indicate significant difference at P<0.05.

Many studies have measured higher SOM content under no-till than conventional tillage (e.g., Wienhold and Halvorson, 1998; Grant et al., 2002; Halvorson et al., 2002; Sherrod et al., 2003). Sherrod et al. (2005) compared SOM after 12 years under four cropping systems to SOM under long-term grass cover. They found that SOM in active, slow, and passive pools under no-till continuous wheat where significantly closer to levels found under grass than were those under the wheat-fallow system (Fig. 3). Active-pool SOM turns over on an annual basis to provide available nutrients, slow-pool SOM turns over on the order of decades, and passive-pool on the order of centuries to millennia (Parton et al., 1987). Slow- and passive-pool SOM is typically protected from aeration and decomposition within soil microaggregates or in tight association with mineral soil particles (Sohi et al., 2001).

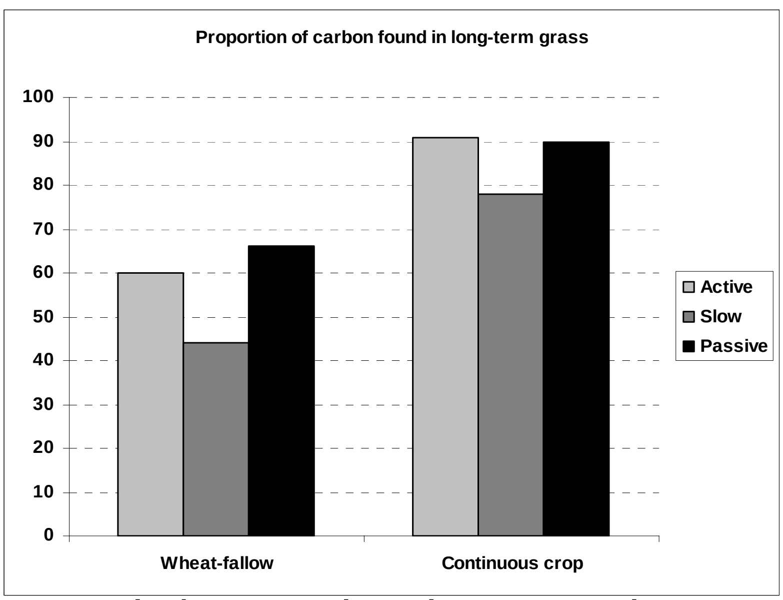

Figure 3. Soil carbon in active, slow, and passive SOM pools as a proportion of that found under long-term grass cover (from Sherrod et al., 2005).

Significant SOM increases, especially in slow- and passive-pools, after 12 years of no-till continuous cropping (Sherrod et al., 2005) are important indicators of recovery of soil quality in a relatively short period. During this rebuilding period the active, diverse, and growing microbial community rapidly immobilizes available nutrients so that fertilizer rates may be higher during an initial conversion period.

As SOM content stabilizes at higher levels, nutrient-supplying capacity increases and the SOM pool forms a season-long nutrient supply. Grant et al. (2002) compared the N-supplying potential (defined as the potential rate of N mineralization based on potentially mineralizable N concentration) after 34 years under wheat-fallow and continuous wheat with and without added N and phosphorus. They found significantly higher N-supplying potential in the no-till continuous wheat both with and without added fertilizer (Fig. 4). This suggests that fertilizer requirements drop as SOM increases.Continuous cropping with no-till creates a better-synchronized system that can require more careful management than crop-fallow. This approach may have potential to reduce input costs while maintaining or increasing yields, but adoption requires some basic paradigm shifts. *Average* yields under no-till can be higher than crop-fallow systems, but *annual* yields are often lower. Lower annual yield goals mean lower annual fertilizer needs for planted acres. High C:N ratio residue on the soil surface can immobilize surface-applied N, meaning that fertilizers should be incorporated below the surface. Lower spring soil moisture contents and better use of in-season rainfall make yield estimates less reliable and increase the chance of over-fertilization. With this tighter, more efficient approach, precision agriculture tools, such as low-altitude false-color aerial photography, detailed soil maps, and global positioning systems, become invaluable for nutrient management. Diversifying crop rotations in no-till continuous cropping systems, especially with legumes and deep-rooted crops can increase yields and make use of resources that have escaped below the root zone (Grant et al., 2002).

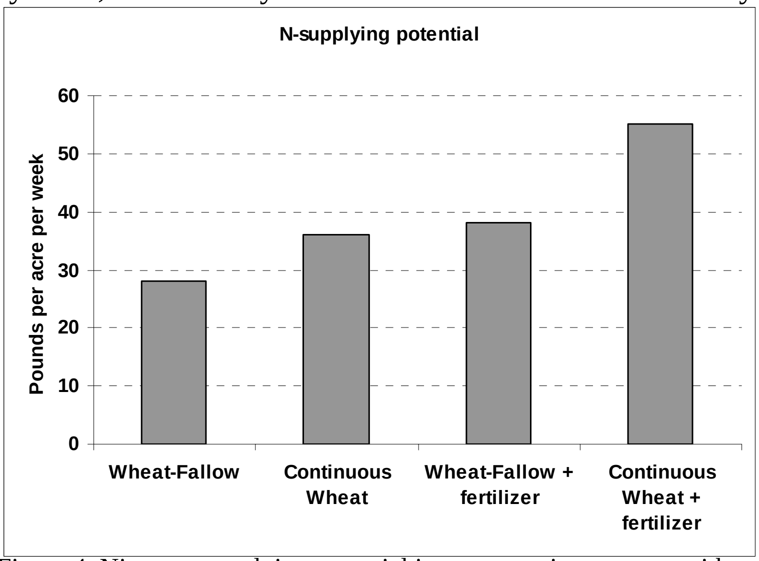

Figure 4. Nitrogen-supplying potential in two cropping systems with and without fertilizer after 34 years. From Grant et al. (2002).

NO-TILL FARMING IN WYOMING AND SURROUNDING STATES

According to the biennial National Crop Residue Management Survey (CTIC, 2004), adoption of no-till practices has been uneven across the High Plains and Intermountain regions, ranging from 2.5 percent of all planted acres in Wyoming to 37 percent in South Dakota (Fig. 5). Rates of no-till usage may, in part, reflect the amount of non-irrigated cropland because water conservation benefits are generally not as important under irrigation. Data compiled from the 2002 Census of Agriculture (NASS, 2002) show that dryland acres as a percent of total harvested acres (Fig. 5)

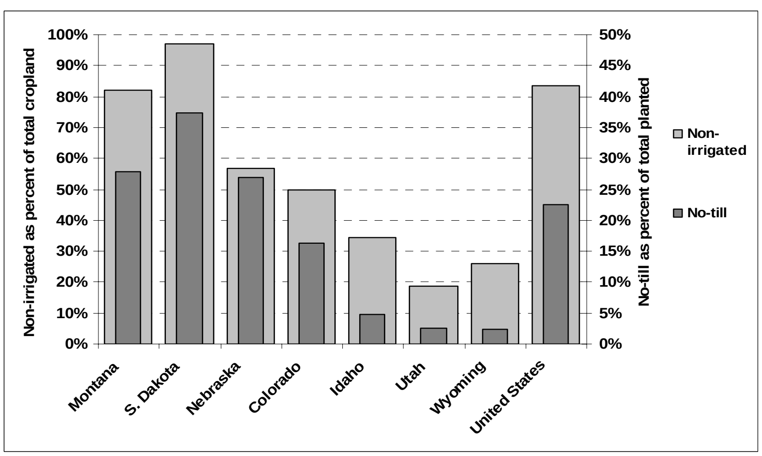

Figure 5. Total 2004 cropland under no-till as percent of the total acres planted to all crops (CTIC, 2004) (right axis) and total 2002 non-irrigated as percent of all cropland (NASS, 2002) (left axis) in Wyoming and surrounding states.

follow nearly the same trend as the no-till percentages.

Looking only at statistics for wheat, which is mostly non-irrigated and is Wyoming's largest annual crop (by acres planted) (NASS, 2002), the CTIC (2004) data still show uneven adoption of no-till and conservation tillage (Fig. 6).

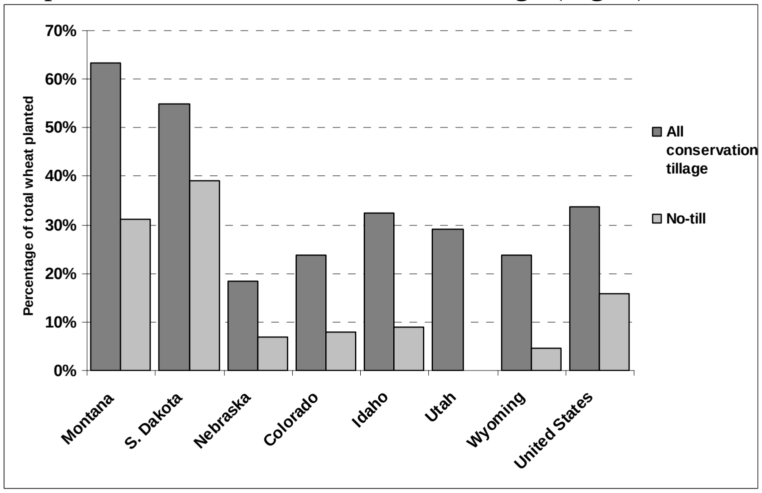

Figure 6. 2004 wheat under conservation tillage and no-till as percents of the total wheat planted. From CTIC (2004).

One possible reason for low rates of conservation tillage in Wyoming is that marginal yields and low residue production negate water conserving benefits. 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 (Fig. 6).

It seems likely that the rate of adoption of no-till practices in Wyoming is due in part to the lack of an effective extension program. Limited cropland acres in Wyoming have not warranted a strong statewide soil extension program, but this neglect may be expensive for Wyoming's soil resources. States surrounding Wyoming, especially Montana, Nebraska, and Colorado, have large, and active soil extension programs.

Commitments to agricultural systems research at Wyoming's Research & Extension Centers, especially the new Sustainable Agriculture Research & Extension Center (SAREC), as well as on-farm research should set the stage for collaborative programs with experts from surrounding states. This will expose increasing numbers of producers to conservation tillage practices.

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 $P<0.05$.

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