Reprinted from *1996 Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 961,* pp. 82-84, 1996
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

EFFECT OF ANNUAL BURN-NOTILL WHEAT ON SOIL ORGANIC MATTER CONTENT AND BULK DENSITY

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INTRODUCTION

Nothing in recent years is quite so controversial as stubble burning. Burning has the capability to increase crop yield under some cropping conditions, but if repeated consistently, has the potential to lower soil quality. Changes in soil quality take place very slowly, and it might be many years before they are detectable (Biederbeck et at., 1980). Stubble burning to facilitate no-till cropping may enhance yield in the short-term, but prove detrimental to soil organic matter (SOM) quality in the long-term.

Reports continue to appear stating that stubble burning is "maintaining or increasing soil organic matter (SOM) after 2 or 3 years in no-till systems." There are some biological considerations that suggest that burning is not likely to increase SOM in our area. Burning volatilizes from 50 to 70 percent of the crop residue into carbon dioxide where it is lost to the atmosphere. Long-term experiments indicate there is a direct relationship between the amount of crop residue incorporated into soil and change in SOM content (Rasmussen and Dick, 1995), so any reduction in residue should reduce SOM. Therefore, it is contrary to expectations that burning of crop residue will increase in SOM.

We are continuing to investigate the less-visually-evident effects of stubble burning to determine what changes really occur over time. Does burning affect SOM within 5 years? What fraction of the residue is burned? What is the quality of the material left on the soil surface after burning? Residue burning leaves behind black charred residues that are considered resistant to decomposition by soil microorganisms (Shindo, 1991). We report here on the influence of a 5-year burn/no-till study on SOM (soil C) content and bulk density in the top foot of soil.

MATERIALS AND METHODS

This study was located on the Columbia Plateau Conservation Research Center 8 miles NE of Pendleton. A crop rotation of winter wheat/spring wheat was grown from 1984 through 1988. All wheat was grown no-till (a one-pass seeding/fertilizing operation was the only tillage event), with herbicides used to control weeds. The experimental design was a randomized factorial with four replications. Treatments included four N rates (0. 50, 100, and 150 lbs N/acre) and two residue treatments (stubble burned, stubble flailed). Soil was a Walla Walla silt loam 55-inches deep. The site was nearly level (slope <1 percent). 'Stephens' winter wheat was grown in 1984, 1986, and 1988. Dirkwin spring wheat was grown in 1985, and WB906R hard red spring wheat in 1987. The site was fallowed in 1989, and Stephens winter wheat was grown no-till in 1990 without any treatments imposed.

Soil samples for C content and bulk density were collected in April 1991 from he 0-4, 4-8, and 8-12 inch soil depths of each treatment. Sampling intensity consisted of 6 cores/plot composited. Soil C was determined by dry combustion using a LECO CHN600 analyzer. Soil C was multiplied by 1.72 to obtain an estimate of organic matter. Soil bulk density was determined by extraction of cores with a bulk density sampler followed by drying and weighing. Bulk density is reported in pounds per cubic foot of soil.

RESULTS AND DISCUSSION

Five years of stubble burning had no effect on SOM content (Table 1). This result supports the prevailing opinion that many years are required for burning effects on SOM to be measurable (Biederbeck et al., 1980). Increasing N application did increase SOM slightly in the top 4 inches of soil, with no changes occurring at deeper depths. Nitrogen increased straw production, which increased the amount of crop residue returned to the soil, and accounts for the N effect on SOM. The effect of N was similar to results found in western Canada wheat regions (Campbell et al., 1989).

Neither stubble burning nor N fertilization had an effect on soil bulk density (Table 2). Surface soil (0-8 inches) after 7 years of no-till (1984-1991) had a bulk density only slightly higher than in nearby conventionally-tilled soil (79 vs. 77 pounds per cubic foot). Differences are considered inconsequential in terms of soil quality.

But even if burning has not reduced the quantity of SOM, has it changed soil quality? We are continuing to investigate that question. Initial laboratory incubation tests (Albrecht et al., 1995) confirm the supposition of Shindo (1990) that charred residues are only very slowly decomposed by microorganisms. Because we found no change in SOM content, it is likely that a substantial amount of crop residue remains in the soil as inert charred material and less residue is cycled through microorganisms into biologically-derived SOM. We are concerned about this trend. It seems inevitable that sustained stubble burning will eventually reduce soil quality, which might decrease water infiltration and increase the erodibility of soil. But we are not sure. There is data in the literature suggesting that some of the C components in charred residue might be chemically incorporated into SOM (Shindo, 1991; Haumaier and Zech, 1995). Thus, a chemical transformation might substitute for a biological one, and if true, it might help to retain a more porous structure in soil and

Table 1. Effect of nitrogen fertilization and stubble burning in no-till wheat from 1984 through 1988 on soil organic matter content in 1991. Pendleton, OR

Nitrogen Rate	Soil Depth (inches) and Burn Condition					
	0 - 4		4 - 8		8 - 12	
(lb/ac/yr)	Burn	No Burn	Burn	No Burn	Burn	No Burn
	Soil Organic Matter (%)					
0	2.30	2.40	2.13	2.08	1.64	1.67
50	2.37	2.25	2.08	2.05	1.66	1.74
100	2.48	2.36	2.14	2.08	1.73	1.66
150	2.43	2.47	2.09	2.10	1.69	1.68
Average	2.40	2.37	2.11	2.08	1.68	1.69
Comparison	Statistical Significance[1]					
N Rate	**[2]		NS[3]		NS	
Burning	NS		NS		NS	
NxB Interaction	NS		NS		NS	
CV (%)[4]	3.9		2.4		6.0	

[1] Statistical significance determined by multiple least-squares analysis (Steel and Torrie, 1980)
[2] ** = Differences significant at a probability of 0.05.
[3] NS = Differences are not significant.
[4] CV (%) = Coefficient of variation; values less than 7 percent indicate good precision in sampling and measureent.

Table 2. Effect of nitrogen fertilization and stubble burning in no-till wheat from 1984 through 1988 on soil bulk density in 1991. Pendleton, OR.

Nitrogen Rate (lb/ac/yr)	Soil Depth (inches) and Burn Condition					
	0 - 4		4 - 8		8 - 12	
	Burn	No Burn	Burn	No Burn	Burn	No Burn
	Soil Bulk Density (lbs/ft^3)					
0	77.8	75.4	81.8	82.7	80.8	79.6
50	77.7	78.7	83.2	82.8	80.0	80.8
100	74.7	78.1	80.6	81.9	80.0	79.3
150	76.7	76.9	82.0	82.7	81.8	80.4
Average	51.2	51.5	54.6	55.0	53.8	53.4
Comparison	Statistical Significance[1]					
N Rate	NS[2]		NS		NS	
Burning	NS		NS		NS	
NxB Interaction	NS		NS		NS	
CV (%)[3]	3.1		2.2		2.9	

[1] Statistical significance determined by multiple least-squares analysis (Steel and Torrie, 1980)
[2] NS = Differences are not significant.
[3] CV (%) = Coefficient of variation; values less than 7 percent indicate good precision in sampling and measurement.

mitigate some deleterious effects of burning. Fire might also reduce the population of microorganisms in the upper 2 inches of soil, thereby temporarily decreasing microbial activity and increasing the opportunity for soil crusting until populations return to normal. We must have the answers to these questions before we can lend even tacit approval to repeated stubble burning on steeply-sloping land. Investigations into soil quality are continuing.

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