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EFFECTS OF BURNING CROP RESIDUES

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Soil organic matter and soil nitrogen levels are influenced by several soil management and crop production practices, which include the kind of crop grown and portion of crop harvested, the addition of nutrients to increase total growth and application of manures and crop residues that are not by-products of the fields on which they are applied. Soil organic matter is important in crop production because of its effect on soil physical conditions and the role of organic materials in supplying plant nutrients, especially nitrogen. Agronomists generally agree that when organic matter levels are maintained at as high a level as practical, that the crop production potentials will be maintained at a high level.

Returning crop residues to the soil is a practice generally recommended by agronomists. The principal reasons for such a recommendation are to help maintain soil organic matter levels and to maintain or improve soil aggregation which in turn aids in erosion control. However, because of problems with tillage, cultivation or seeding operations or the possibility of reduced yields following incorporation of residues such as wheat straw, burning of fields is a common practice in many areas.

Numerous studies have shown that inorganic nitrogen is immobilized by microorganisms during the decomposition of carbonaceous materials such as wheat straw, resulting in decreased yields due to nitrogen deficiency of the succeeding crop. Russell points out that decomposition of crop residues in warm soils will immobilize more nitrogen than when decomposition takes place in a cold soil (p. 238). The optimum temperature for decomposition of organic residues is in the range of 86 - 115° F. When temperatures are above or below this range, the rate of decomposition will be decreased. Ferguson and Gorby, and Ferguson have reported that under conditions such as found in southern Manitoba, Canada, where cereal crops are seeded before soil temperatures are high enough for rapid straw decomposition in the spring, that the crop can compete successfully with the microorganisms for the available soil nitrogen. As a result, yields are not often affected by incorporation of straw. Data of grain yields as affected by straw and nitrogen treatments on several southern Manitoba soils are shown in Table 1.

TABLE 1 - YIELDS OF GRAIN WHEN STRAW AND NITROGEN WERE APPLIED ON MINIOTA & ASSISIBOINE SOILS, 1955-58, & MINIOTA & WASKADA SOILS, 1959-61 (OATS, 1955-58; WHEAT, 1959-61). (From Ferguson and Gorby, 1964, Canadian J. of Soil Sci. 44:286-291.)

Straw	N	1955	1956	1957	1958	1959	1960	1961	Mean 1955-61
lb/A	lb/A	cwt/A							
0	0	15.6	20.9	12.4	17.0	18.6	8.5	3.3	13.8
	60	26.3	35.3	18.1	17.5	20.8	12.4	5.1	19.4
1500	0	13.9	21.0	13.3	18.2	19.8	7.7	3.3	13.9
	60	26.6	34.7	19.1	16.1	24.2	14.2	3.9	19.8
3000	0	13.6	17.4	11.6	18.5	16.1	6.8	3.3	12.5
	60	25.5	35.2	18.8	13.9	21.4	13.2	4.0	18.9

Other studies have given similar results in the Northern areas of the United States. (Smith et. al., Oveson, Halsted and Sowden, Smith and Vandecaveye.)

Frequent fallowing in a rotation usually means a greater decline in soil organic matter than found under continuous cropping system. When considering the importance of returning residue to the soil, each year of fallow can be loosely related to burning the stubble during the same year since there is no residue to incorporate into the soil in either case. Ridley and Hedlin found that the organic matter and nitrogen content of a black lacustrine soil near Winnipeg, Canada, was maintained at a relatively high level by continuous cropping to cereal grains over a 37-year period. As the number of fallow periods in a rotation increased, the rate of organic matter loss also increased. Change in organic matter, soil nitrogen levels and resulting average yields per year are shown in Table 2.

In this study, yields after fallow were greater than yields of second or third crop, but greatest production per acre per year was obtained by continuous cropping. Use of farm yard manure applications reduced the rate of decline of organic matter and increased yields.

At the Northern Great Plains Field Station located at Mandan, North Dakota, a study of the total soil nitrogen levels after 30 years also shows how different rotations and soil treatments can affect the rate of organic matter loss (Table 3).

TABLE 2 - ORGANIC MATTER AND TOTAL NITROGEN CONTENT AFTER 37 YEARS OF WHEAT ROTATION AND AVERAGE YIELDS FOR THE SAME PERIOD. (From Ridley & Hedlin, 1967, Canadian J. of the Soil Sci. 48:315-322.)

	Organic Matter (%)		Total Nitrogen (%)		Yield (Bu/A/Yr)	
Crop Rotation	Control	Manure	Control	Manure	Control	Manure
Fallow-wheat	3.7	4.1	0.19	0.28	17.7	16.8
Fallow-wheat-wheat	4.9	5.5	0.26	0.30	20.3	22.9
Fallow-wheat-wheat-wheat	4.7	5.5	0.25	0.28	20.2	24.7
Wheat-continuous	7.2	7.6	0.36	0.38	24.1	26.7

TABLE 3 - EFFECT OF THIRTY YEARS CROPPING ON NITROGEN IN THE SOIL OF SELECTED PLOTS FROM THE NORTHERN GREAT PLAINS STATION, MANDAN, NORTH DAKOTA.

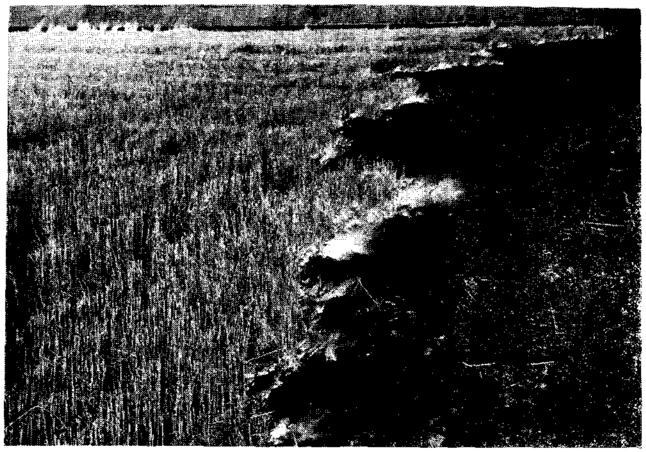
	Loss or Gain of Total Nitrogen as a Percentage of Calculated Original Value		
Cropping Sequence	0-6 Inches	6-12 Inches	12-24 Inches
	%	%	%
Corn, wheat	-30	-10	+ 1
Corn, wheat, oats	-29	- 8	+ 1
Manured corn, wheat, oats	0	+10	+ 6
Corn, wheat, fallow, oats	-30	-12	- 4
Corn, wheat, manured fallow, oats	- 7	+ 4	+ 6
Corn, wheat, Sw. clover plowed under,oats	-29	- 9	- 2
Corn, wheat, rye plowed under, oats	-32	-14	- 8
Corn, wheat, bromegrass- 3 yrs. or more, oats	-25	- 6	0
Corn, wheat, alfalfa- 3 yrs. or more, oats	-19	+ 2	+ 4
Alternate wheat and fallow	-26	+ 4	0
Wheat, continuous	-20	+ 4	0
Alternate oats and fallow	-28	-10	- 9
Oats, continuous	-20	0	+ 2
Corn, continuous	-36	-14	-12
Alternate corn and fallow	-40	-18	-14

There are many other studies showing similar effects of cropping systems on soil organic matter, nitrogen levels, and various soil amendments on yields. (Smith et. al., Oveson, Spratt, Pratt, et. al., Larson, et. al., Smith and Vandecaveye, Young et. al., Sander.)

Luebs reporting on a 10-year burning and tillage study at the Fort Hays (Kansas) Branch Experiment Station found that burning did not affect average wheat yields (Table 4).

TABLE 4 - EFFECT OF BURNING ON WHEAT YIELDS IN A CONTINUOUS CROPPING SYSTEM, HAYS, KANSAS, 1945-54. (From R. E. Luebs, 1962, Kansas Agricultural Experiment Station Bulletin 449.)

Residue and Tillage Treatment	Average Yield Bushels Per Acre
Plow	17.5
Burn and plow	18.0
List	15.6
Burn and list	17.6
Disk	19.7
Burn and disk	18.5
Burn and duckfoot	17.0
Burn and chisel	18.4
Average — no burning	17.6
Average — burning	17.9



Stubble burning is a practice not generally recommended. It leaves the soil unprotected from erosion and means a loss of plant nutrients and organic matter.
(Courtesy of USDA-Soil Conservation Service)

Oveson evaluated the effect wheat straw had on soil nitrogen and on the yield of wheat in a wheat-summerfallow system over a 34-year period on a Walla Walla silt loam near Pendleton, Oregon. Table 5 shows that average yield of wheat, where all straw produced was plowed down, was no better than where straw was burned in the fall after harvest and was lower in yield than where straw was burned in the spring. Additions of nitrogen as ammonium sulfate, pea vines or manure increased yields, with the 10-ton manure application giving the best results. Burning of straw after harvest resulted in the greatest loss of nitrogen from the surface foot of soil. Spring burning and plowing under of straw also resulted in significant soil nitrogen losses. When nitrogen fertilizer was added, soil nitrogen losses were greatly reduced, and when 10 tons manure was applied annually with 30 pounds of fertilizer nitrogen, there was a 7.5 percent gain in soil nitrogen.

Figure 1 shows how various treatments in the experiment by Oveson affected yields. The relationship between soil nitrogen levels and yields are clear when data from Table 5 are compared with those shown in Figure 1.

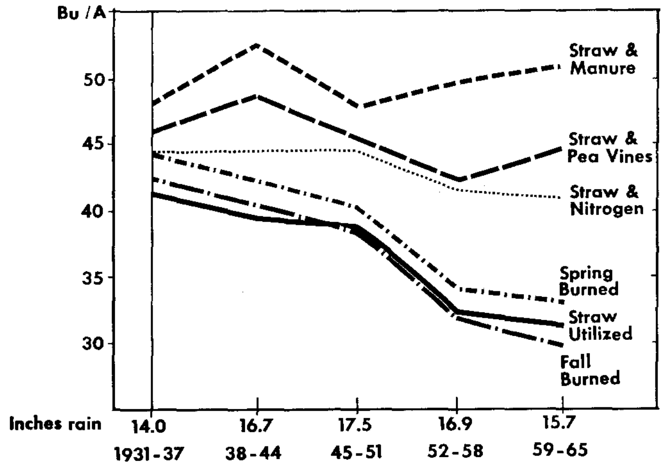


FIG. 1 - SEVEN-YEAR AVERAGE YIELDS OF WINTER WHEAT GROWN ON PLOTS RECEIVING DIFFERENT TREATMENTS OF THE WHEAT STRAW AND OTHER RESIDUES. (From M. M. Oveson, 1966, Agronomy J. 58:444-447.)

Russell (pages 280-285) and Millar (page 101) discuss the effect of various cropping systems and soil amendments on the level of soil organic matter and nitrogen. They indicate that the amount of organic matter and nitrogen will eventually reach an equilibrium level. The equilibrium value reached will depend upon factors such as soil texture, drainage, climatic conditions and the cropping system followed.

Results of a longtime dryland soil study in Kansas as reviewed by Hobbs and Thompson showed that:

1. Nitrogen and organic matter contents of surface soils decreased with continued cultivation.

2. Magnitude of losses from cultivated land was related directly to the quantity of organic matter in the soil originally and to cultivation intensity (Table 6).

TABLE 5 - AVERAGE FIELD PLOT YIELDS, PERCENT NITROGEN IN THE SURFACE FOOT OF SOIL AND LOSS OR GAIN OF NITROGEN IN PERCENT AND POUNDS PER ACRE AFTER 34 YEARS OF CROPPING TO WHEAT AND SUMMERFALLOW ON PLOTS RECEIVING DIFFERENT TREATMENTS OF THE WHEAT, STRAW AND OTHER RESIDUES. (From M. M. Oveson, 1966, Agronomy J. 58:444-447.)

Treatment	Yield Bu/A	% N in Surface Foot of Soil 1931	1964	Loss or Gain of N %	Lb/A
Check, straw returned to soil	36.7	.0970	.0843	-13.1	-423
Straw burned in fall	36.9	.0945	.0788	-16.6	-526
Straw burned in spring	39.4	.0933	.0828	-11.3	-352
Straw returned + 30 lb nitrogen	43.2	.0969	.0879	- 8.3	-268
+ 1 ton dry pea vine	45.3	.0972	.0938	- 3.5	-114
+ 10 tons strawy manure	49.5	.0943	.1014	+ 7.5	+238
LSD $_{(.06)}$ for yield, 1.06 bu					

TABLE 6 - EFFECT OF FORMER CROPPING SYSTEM ON LOSS OR GAINS OF NITROGEN AND ORGANIC CARBON IN SURFACE SOILS AT HAYS, KANSAS. (From Hobbs and Thompson, 1971, Agronomy J. 63 (66-68).

Former Cropping System	Average Soil Content (%) Nitrogen 1958	1966	Ave.	Organic Matter 1956	1966	Ave.
Continuous sorghum and alternate fallow-sorghum	.096	.099	.098	1.55	1.60	1.58
Fallow-wheat-sorghum	.120	.115	.117	2.02	1.86	1.94

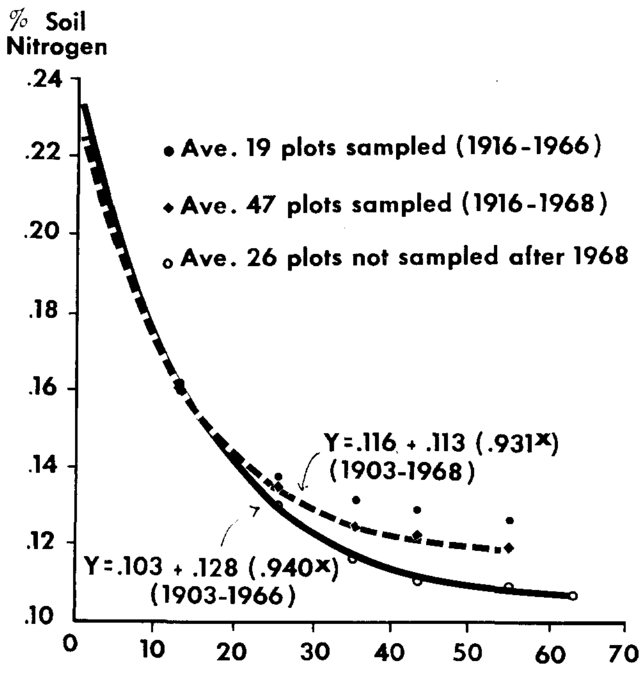


FIG. 2 - RELATION BETWEEN NITROGEN CONTENT OF THE SURFACE SOIL (0 to 18 cm) AND THE DURATION OF LAND CULTIVATION AT HAYS, KANSAS (1903-1966). (From Hobbs and Thompson, 1971, Agronomy J. 63 (66-68.)

3. Organic matter losses followed a curvilinear trend, being large early in the cultivation period and becoming smaller with continued cultivation and approaching an equilibrium-nitrogen content of 0.103 percent (Fig. 2).

Sander, et. al., found that after 25 years of cropping without application of fertilizer, lime or manure and without a legume in rotation on a Sharpsburg silty-loam soil near Lincoln, Nebraska, that the soil nitrogen was in equilibrium with the environment.

From the sampling of research data presented here - it is evident that production potentials of soils are often influenced by organic matter levels in the soil and that the amount of this soil component that can be maintained in the soil depends on several factors. The studies by Oveson and Luebs indicates that burning of crop residues will probably not greatly affect yields of succeeding crops, especially if such a practice is not conducted continuously over a long period of time. However, removal of crop residues, be it by burning or through mechanical means, will reduce organic matter levels at a faster rate. For this reason burning of residue as a crop production practice is usually discouraged by agronomists, however, occasional burning or removal for feed will probably have little noticeable effect on soil productivity or soil organic matter levels.

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