THE INFLUENCE OF NITROGEN ON STRAW DECOMPOSITION IN THE FIELD AND LABORATORY[1/]

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INTRODUCTION

Decomposition of straw and other organic materials in soil is carried out by many living organisms. One pound of a fertile agricultural soil may contain as many as 4.5 billion bacteria, 900 million actinomycetes, 50 million fungi, and 10 million algae. Most of these organisms are beneficial, although a few are pathogenic and cause disease to plants. All of these organisms require certain nutrients and growth factors for their growth and reproduction. For instance the temperature must be in the range of about 50 to 100^{o} F. and moisture in the range of 60 to 80% of field capacity for rapid microbial growth. They must have energy and this is generally obtained from some carbohydrate source such as dead plant material. Most of the organisms require air and several nutrients such as nitrogen, phosphorus, calcium, potassium, sulfur, iron and trace elements as well as carbon, hydrogen and oxygen (1). These nutrients and conditions are generally found in soils in which crops will grow. Occasionally nitrogen may be deficient enough to limit growth of organisms and limit straw decomposition.

It has been traditional to fertilize straw and some other crop residues with nitrogen to increase their rate of decomposition. This recommendation came from some very old laboratory experiments that were conducted on low fertility soils (6, 7), before high rates of N fertilizer were used. More recent work by Krantz and others (3) and by Smith and Douglas (4, 5) suggests that fertilizing the crop and not the crop residue is a desirable practice. Both laboratory and field experiments indicate that in fertile soils straw decomposes as rapidly without nitrogen as it does with added nitrogen. I will report some laboratory and field experiments that show that straw decomposition is not limited by nitrogen deficiency under ordinary field conditions.

Experimental Results

In the fall of 1966 Nugaines wheat was planted on the Idaho Experiment station farm at Kimberly for the purpose of studying nitrogen rates and irrigation treatments. In the spring of 1967 Lemhi wheat was planted at the Snake River Conservation Research Center at Kimberly to study

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the same factors. When these wheat crops were harvested in the fall of 1967 the original plots were divided and half the plot area was treated with 77 lbs. nitrogen per acre sprayed on the straw. The straw was then plowed or rototilled into the soil in early September. Small bags of straw of the same variety that grew on the plots were buried in these plots to study straw decomposition. The straw in the bags that were buried in nitrogen-treated plots were treated with the equivalent of 25 lbs. nitrogen per ton of straw. These bags were buried on September 7 and one set was removed November 15 when the soil temperature had decreased below 40^{o} F. A second set was removed on March 22 when soil temperatures had increased above 40^{o} F. The third set was removed on May 22 and a final set was removed October 3. The amount of decomposition was measured by weighing the straw that remained after these periods of time. The straw was analyzed for nitrogen percentage and some of the samples were analyzed for carbon. Pinto beans were grown on the plots with normal irrigation practices.

Lemhi wheat straw decomposition was not different with 25# of added nitrogen per ton of straw or without added nitrogen (Table 1, first section). Therefore, adding nitrogen did not increase the decomposition rate of Lemhi wheat straw. The next section of Table 1 shows progress of decomposition and nitrogen content of the straw. On September 7 when no nitrogen had been added, the straw contained 5.7 lbs. of nitrogen per ton. By November 15, one ton of straw had immobilized 0.5 lb. nitrogen from the soil, and by March 22 an additional 2.0 lbs. had been immobilized while decomposition had progressed to about 29.6%. By May 22 the nitrogen that had been immobilized during decomposition had been lost and at the end of the experiment on October 3, 2.2 lbs. less nitrogen remained in the straw than was present at the beginning. When 25 lbs. of nitrogen was added per ton of straw, 17.7 lbs. of nitrogen was lost during the first time period. This nitrogen apparently was not tied up in straw decomposition and was leached from the straw into the surrounding soil. The nitrogen content then remained approximately the same until spring. Afterward, as decomposition progressed, 7.3 lbs. more nitrogen was lost from the straw into the surrounding soil. Some of the nitrogen that was lost from the straw during decomposition would presumably be available for use by the plants if it had not been leached or lost by denitrification.

Decomposition of the Nugaines wheat straw was similar to that of the Lemhi except more rapid. Adding nitrogen did not significantly change the decomposition rate of the Nugaines wheat straw. The nitrogen content of the decomposing Nugaines straw was similar to Lemhi, with the Nugaines straw immobilizing 2.5 lbs. of soil nitrogen per ton of straw for a time and then releasing the immobilized nitrogen plus 2.3 lbs. of nitrogen from the straw itself. When 25 lbs. of nitrogen was added per ton of straw, the loss situation during the early period was very similar to that found with Lemhi wheat straw. About 17.5 lbs. of nitrogen per ton of straw was lost during the first ten weeks. The nitrogen content then remained constant until spring and an additional 6.4 lbs. N was lost by October 3.

Table 1. Decomposition of Lemhi Wheat Straw in Portneuf silt loam Soil in the Field

	Decomposition, percent*				
	Sept. 7	Nov. 15	Mar. 22	May 22	Oct. 3
No N added	0	19.6 a	29.6 bc	36.8 c	65.1 d
25#/ton straw	0	24.2 ab	28.7 abc	31.2 bc	61.9 d
Average	0	21.9	29.1	34.0	63.5

Weight of Nitrogen and Straw during Decomposition

No Nitrogen added

Straw lbs.	2000	1608	1408	1264	698
Nitrogen lbs.	5.7	6.2	8.2	5.7	3.5

25 lbs. N added per ton of Straw

Straw lbs.	2000	1516	1426	1376	760
Nitrogen lbs.	30.7	13.0	12.3	9.0	5.2

*Numbers not followed by the same letter or letters are different at the 0.05 significance level.

It has usually been thought that nitrogen would be immobilized and held very tightly by the soil organisms until the nitrogen content in the straw reached about 1.7%. In the cases reported here, considerable nitrogen was lost while the nitrogen content of the straw was much lower than this theoretical value. Some of the nitrogen in straw is water soluble and will leach out with either rain or irrigation water. This seems to take place even though the nitrogen content is lower than the theoretical equilibrium value.

Table 2. Decomposition of Nugaines Wheat Straw in Portneuf silt loam Soil in the Field

	Decomposition, percent*				
	Sept. 7	Nov. 15	Mar. 22	May 22	Oct. 3
No N added	0	23.3 a	30.4 ab	38.8 b	81.0 c
25# N/ton straw	0	27.9 ab	33.6 ab	38.6 b	70.9 c
Average	0	25.6	32.0	38.7	76.0
Weight of Nitrogen and Straw during Decomposition					
No Nitrogen added					
Straw lbs.	2000	1534	1392	1224	380
Nitrogen lbs.	5.4	7.1	7.9	5.7	3.1
25 lbs. N added per ton of Straw					
Straw lbs.	2000	1442	1328	1228	582
Nitrogen lbs.	30.4	12.9	13.0	10.1	6.6

*Numbers not followed by the same letter or letters are different at the 0.05 significance level.

In a laboratory experiment conducted with Nugaines wheat straw in Portneuf silt loam soil the straw was added at the equivalent of 5 or 15 tons per acre. These samples were treated with nitrogen to contain either 0.5% or 1.75% for each of the straw addition rates. Decomposition was measured at intervals and a few of these are reported in Table 3. When five tons of straw per acre was mixed with the soil, the decomposition rate was not accelerated by the addition of nitrogen. In Table 3 differences of less than 0.5 ton of decomposed straw may result from normal variability and have no significant meaning. Differences greater than 0.5 ton represent real differences. When 15 tons of straw was added to the soil the decomposition picture was changed. During the first two weeks, decomposition was not affected by nitrogen content. By the sixth week, the higher nitrogen straw had decomposed more rapidly than the lower nitrogen straw and this continued through the 8- and 11- week sampling periods. These differences are readily explainable. When the equivalent of 5 tons of straw per acre was added to the soil, nitrification supplied enough nitrogen for decomposition to proceed at or near a maximum rate and therefore additional nitrogen in the straw did not accelerate decomposition. When 15 tons of straw was added, nitrification in the soil could not supply enough N to produce maximum decomposition. The additional nitrogen in the straw then accelerated decomposition of the straw. A greater percentage decomposition was found with the 5-ton straw rate compared to the 15-ton rate. This has been observed in laboratory experiments many times. It has been associated with the amount of space that is available for microorganisms (2). It is important to note that even though the percentage decomposition was greater when 5 tons of straw was added, more straw actually decomposed when 15 tons were added.

Table 3. Decomposition of Nugaines Wheat Straw in Portneuf silt loam Soil in the Laboratory

		Time, weeks				
Straw Tons/A	Nitrogen in Straw, %	1	2	6	8	11
		Straw Decomposed - Tons*				
5	0.5	.72	1.50	2.52	2.72	3.00
5	1.75	.70	1.55	2.20	2.35	2.68
15	0.5	.72	1.40	3.12	3.72	4.53
15	1.75	.70	1.35	4.20	5.22	6.33

*The 15 ton straw rate with 1.75% N decomposed significantly (.05) more during the 6-, 8- & 11-week periods than the 15 ton straw rate with 0.5% nitrogen. Decomposition of the 5-ton straw rate was not influenced by nitrogen percentage.

The yield of Lemhi wheat straw on experimental plots at Kimberly during the 1967 growing season, varied from about 6,000 lbs. per acre to about 9,000 lbs. per acre. Nugaines wheat, while being considerably shorter than Lemhi, nevertheless produces much more straw. Our plot yields of Nugaines wheat straw ranged from about 11,000 lbs. per acre to slightly over 15,000 lbs. per acre. During the 1968 growing season, Nugaines wheat straw yields were 2,000 to 3,000 lbs. lower than the previous season and our wheat yields were considerably higher with maximum plot yields of about 130 bushels per acre, compared with slightly over 100 bushels the previous year. Grain:straw ratios are variable and it is difficult to project a straw yield from a yield of grain.

SUMMARY AND CONCLUSIONS:

Under the conditions of the experiments reported in this paper, nitrogen additions are not likely to accelerate straw decomposition unless very large quantities of straw are added to the soil. Under field conditions in fertile soils with normal straw applications it is unlikely that the addition of nitrogen will appreciably accelerate the decomposition of straw. Under conditions of low soil fertility or perhaps sandy soils with large straw applications, the addition of nitrogen may accelerate decomposition. However, such acceleration may be small and probably will not be worth the extra cost.

Some recommendations that can be made for accelerating straw decomposition are: 1. Chop the straw enough to allow complete coverage with soil. 2. Irrigate to provide needed water, as microorganisms do not work in dry soils. 3. Turn under straw immediately after harvest to take advantage of the few weeks the soil is warm enough for rapid decomposition in the fall.

Following these recommendations should generally provide conditions that will facilitate decomposition of straw, should reduce problems that may be associated with tillage when large amounts of straw are applied to soil, and should reduce or eliminate any barriers to water and root growth that may accompany large layers of straw in the soil.

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