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INFLUENCE OF RESIDUAL NITROGEN ON WHEAT STRAW DECOMPOSITION IN THE FIELD[1]

J. H. SMITH AND C. L. DOUGLAS

Snake River Conservation Research Center

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Plant material decomposition appears to be mainly controlled by the C/N ratio of the plant material under soil moisture, temperature, and aeration conditions that support plant growth in the field. Harmsen and VanSchreven (4) reported, "Numerous earlier papers were devoted to the study of this problem.... Fairly close agreement was obtained by all these investigators as to the N content limits of the added material, below which no N mineralization may be expected. This is 1.5 to 2.0 per cent of the dry matter, corresponding to a C/N ratio of 20 to 25." Similar values were also reported by Broadbent (2) from laboratory studies; and Allison (1), in a recent review, cited several reports that are in general agreement.

In contrast to many laboratory plant material decomposition experiments, only a few experiments have been conducted in the field. In one of these Parker (7) compared the decomposition of surface-applied and buried cornstalks. He found that the N content of the surface-applied cornstalks did not change; however, the C/N ratios narrowed from 57 to 30. The buried cornstalks decomposed 65 per cent in 140 days and the C/N ratio narrowed from 57 to 22. Narrowing of the C/N ratio resulted from C loss rather than from N increase in the cornstalk residue. At the narrower C/N ratios, N was lost from the residue.

In a field experiment at Rothamsted Experimental Station, Jenkinson (5) measured the decomposition of ryegrass labeled with C-14. He reported losses of about 66 per cent of the ryegrass through decomposition in six months and 80 per cent after four years.

Field studies on the decomposition of wheat straw were set up to compare with the results of the decomposition of other plant materials already reported. The objectives of this study were to determine the decomposition rate of straw from three wheat varieties buried in the field and to observe the influence of N fertilizer applied for the previous crop on decomposition rate, N content, and C/N ratios of the straw.

[1] Contribution from the Northwest Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA; Idaho Agricultural Experiment Station cooperating.

MATERIALS AND METHODS

Field plots arranged in a 3^3 factorial design with three replications were fertilized with 0, 89, or 268 kg. N/ha. and with 0, 58, or 116 kg. P/ha. Lemhi, Idaed, and University of Idaho experimental variety 59-10320 soft white spring wheats (*Triticum aestivum*) were grown to maturity and harvested. Part of the straw was removed, and the remainder was disced back into the soil of the plot on which it grew. Composited samples of each wheat straw variety were coarsely ground, mixed, and 25-g. subsamples were sewed into close-mesh glasscloth bags. Three bags containing the same variety of straw that grew on the plot were buried 15 cm. deep in each plot on June 10 and a crop of Pinto beans (*Phaseolus vulgaris*) was grown. Average monthly soil temperatures for June through September, obtained from the U. S. Weather Bureau, Environmental Sciences Service Administration, Kimberly, Idaho are given in Table 1. Soil moisture was maintained at what appeared to be optimum for the beans by surface irrigation.

One bag of straw was removed from each plot after periods of 1, 2, and 3 months. Adhering soil was removed, the bags were dried at 60 C, and weight loss was determined. The straw samples were removed from the bags, and the straw was ground and analyzed for total N by a Kjeldahl method (3) and for total C by dry combustion at 900 C. Calculations were made for N percentage, N weight, C percentage, and C/N ratio for each sample.

TABLE 1

Soil temperatures at Kimberly, Idaho from June through September 1966

	Soil Temperature, C							
	June		July		August		Sept.	
	10 cm.	20 cm.	10 cm.	20 cm.	10 cm.	20 cm.	10 cm.	20 cm.
Maximum	22.2	20.5	25.5	23.9	23.9	23.9	21.6	20.5
Minimum	14.4	15.0	16.1	17.2	16.6	17.8	14.4	15.0
Mean	18.9	17.7	22.5	21.2	21.2	20.5	18.5	18.0

RESULTS AND DISCUSSION

The effects of previous fertilization with N, straw variety, and time on straw decomposition are tabulated in Table 2. Fertilization with P had no influence on any of the factors studied in this experiment. Decomposition of Lemhi and 59-10320 wheat straws was not increased by N addition. The 89 kg. N rate appeared to increase the decomposition rate of Lemhi but it did not carry through to the three-month sampling. The Idaed straw decomposed slightly faster with N addition than without it, but the percentage increase was relatively small. Decomposition rates were different for the three straw varieties and increased in the order Lemhi < Idaed < 59-10320. Of course, decomposition progressed with time and the differences between month intervals were significant. Nitrogen is usually thought to increase straw decomposition in soil; however, in this experiment an increase was observed in only one of three cases. This should be expected when small straw applications are made and nitrification can supply adequate N for normal decomposition.

The N content of the decomposing straw increased with each increment of fertilizer except in Lemhi at one month, and in variety 59-10320 for months two and three (Table 3). The N content increased significantly for each monthly sampling in almost every case. The three straw varieties differed in N percentage and the N content increased in the order Lemhi < Idaed < 59-10320. Both the starting and ending N percentages were too low for net N mineralization. Additional C would have to be lost until the N increased to about 1.75 per cent before N would be available to growing crops.

The N gain or loss in the samples during decomposition tells a more revealing story about N immobilization than do the percentage figures (Table 4). The Lemhi straw decomposing in plots receiving no N lost N from the straw each month. At the 89 kg. N treatment, N increased the first and third months. At the 268 kg. N treatment, increasing gains in N were ob-

TABLE 2

Decomposition of three wheat straw varieties buried in glass-cloth bags in the field*

Variety	Nitrogen fertilizer *kg./ha.*	Time, *months* 1	2	3
		Decomposition, *percentage*		
Lemhi	0	17.95 b	27.39 d	40.90 h
	89	17.23 b	29.95 e	40.60 h
	268	17.25 b	27.66 d	40.47 h
Idaed	0	14.56 a	27.12 d	39.00 h
	89	17.98 b	30.29 e	47.58 j
	268	19.28 b	83.41 f	44.44 i
59-10320	0	23.50 c	39.23 h	51.65 k
	89	22.83 c	34.29 f	45.20 i
	268	23.69 c	36.99 g	49.82 k

Numbers not followed by the same letter are different at the .05 probability level (6).
* Original weight 25 g.

TABLE 3

Nitrogen percentages in wheat straw samples decomposing in glass-cloth bags in the field

Variety	Nitrogen fertilizer *kg./ha.*	Time, *months* 0	1	2	3
		Nitrogen, *percentage*			
Lemhi	0	.362 a	.416 b	.467 de	.586 h
	89	.362 a	.463 d	.522 f	.648 j
	268	.362 a	.441 c	.547 g	.725 n
Idaed	0	.410 b	.425 bc	.514 f	.641 j
	89	.410 b	.482 e	.557 g	.751 o
	268	.410 b	.600 i	.687 l	.783 p
59-10320	0	.441 c	.600 i	.708 m	.909 q
	89	.441 c	.639 j	.645 j	.792 p
	268	.441 c	.670 k	.750 o	.964 r

Numbers not followed by the same letter or letters are different at the .05 probability level (6).

TABLE 4

Nitrogen gain or loss in wheat straw samples decomposing in glass-cloth bags in the field*

Variety	Nitrogen fertilizer kg./ha.	Original N content of straws- mg	Time, months 1	2	3
			mg N-loss or gain		
Lemhi	0	90.5 b	−5.3 a	−5.8 a	−3.7 a
	89	90.5 b	+5.2 d	+0.2 b	+5.2 d
	268	90.5 b	+0.7 bc	+7.7 e	+16.2 g
Idaed	0	102.5 f	−11.8 b	−9.0 c	−5.6 de
	89	102.5 f	−4.6 de	−6.4 de	−5.7 de
	268	102.5 f	+17.4 k	+10.4 i	+2.8 g
59-10320	0	110.2 h	+4.3 i	0.0 h	−1.4 h
	89	110.2 h	+13.6 l	+4.4 g	−3.9 g
	268	110.2 h	+17.2 m	+7.4 j	+10.3 k

* Original weight 25 g.

Numbers not followed by the same letter or letters are different at the .05 probability level (6).

A carryover of fertilizer N or mineralization from organic sources built up by heavy fertilization for maximum crop yields will minimize the effect of N content on decomposition of straw or other plant residues applied to soil.

The C percentages of the straw samples are given in Table 5. The analysis of variance showed a significant "f" for nitrogen and the Duncan Multiple Range test showed some significant differences, but no systematic patterns were evident. The average C percentage for all samples was 41.2 per cent.

In most cases, the C/N ratios narrowed significantly with the addition of each increment of N to the Lemhi and Idaed straw samples (Table 6). N addition did not narrow the C/N

TABLE 5

Carbon percentages in wheat straw samples decomposing in glass-cloth bags in the field

Variety	Nitrogen fertilizer kg./ha.	Time, months 0	1	2	3
		Carbon, percentage			
Lemhi	0	41.3	42.6 jk	42.7 k	41.3 defgh
	89		41.9 ghijk	41.9 ghijk	40.0 ab
	268		42.0 hijk	42.1 hijk	41.6 fghij
Idaed	0	41.0	40.9 cdef	42.3 ijk	41.4 efgh
	89		40.2 abc	41.3 defgh	39.8 a
	268		40.4 abc	42.3 ijk	42.1 hijk
59-10320	0	41.0	40.6 abcd	40.0 ab	41.8 ghij
	89		40.2 abc	39.9 ab	41.6 fghij
	268		40.7 bcde	40.5 abc	41.1 cdefg

Numbers not followed by the same letter or letters are different at the .05 probability level (6).

served the second and third months. The Idaed straw lost N all three months for the 0 and 89 kg. N treatments. The straw increased in N at the 268 kg. N treatment, but the increases for the second and third months were less than for the first month. Straw variety 59-10320 decreased in N significantly the third month for the 89 kg. N treatment and either showed no significant change or increased in N for all other samplings with a general trend downward as N increases with time. These results indicate appreciable losses in N from the straw samples incubated in soil without N fertilizer, or in some cases with the lower N rate and appreciable gains in N in the straw where a heavy application of N was made for the preceding crop.

TABLE 6

Carbon/Nitrogen ratios of wheat straw samples decomposing in glass-cloth bags in the field

Variety	Nitrogen fertilizer kg./ha.	Time, months 0	1	2	3
		C/N ratios			
Lemhi	0	114	103.3 o	92.9 n	72.0 hi
	89		91.8 mn	82.3 kl	63.1 def
	268		96.2 n	78.4 jk	58.8 bcd
Idaed	0	100	96.8 n	82.5 kl	65.1 efg
	89		87.0 lm	76.3 ij	54.6 b
	268		69.9 gh	63.0 def	56.8 bc
59-10320	0	93	68.8 fgh	57.9 bcd	46.6 a
	89		64.5 efg	62.4 cde	54.4 b
	268		62.8 cdef	55.1 b	43.3 a

Numbers not followed by the same letter or letters are different at the .05 probability level (6).

ratios of the 59-10320 straw samples. The C/N ratios of the straw varieties decreased in the order Lemhi > Idaed > 59-10320, and as would be expected, they decreased markedly with time.

Some interesting interactions were observed between straw varieties and N fertilization and between straw varieties and time. The C/N ratios of the Lemhi wheat straw narrowed sharply with the first N increment but only slightly more with the second increment. The C/N ratios of the Idaed wheat straw narrowed at a more nearly uniform rate with each increment of N while there was no narrowing in C/N ratio with the first N increment in 59-10320 and only slight narrowing with the second. The narrowing during the second month from the C/N ratios found at the end of the first month on the average were 12.9, 12.6, and 19.6 per cent for Lemhi, Idaed, and 59-10320 respectively. The next month the C/N ratios narrowed 23.5, 20.4, and 21.6 per cent respectively from the values found at the end of the first month. The C/N ratios were widely different between the three straw varieties at the beginning of the decomposition experiments but their rates of change were almost uniform. The changes in C/N ratio were almost entirely the result of C loss from the straw samples. After 3 months decomposition the C/N ratios were still wide and must be narrowed considerably before N could be mineralized.

The appearance of the straw samples did not change noticeably during decomposition for 1, 2 or 3 months in the field plots. The straw was bright and clean without the browning that is often associated with decomposition. The average of the numbers in Table 2 showed 44 per cent of the straw decomposed in 3 months. The greatest decomposition was 51.6 per cent of one sample of variety 59-10320.

The question occasionally arises as to why straw that is plowed into the soil lies there for a long time without decomposing. The answer appears to be that the straw does decompose, to a great extent, but does not change appearance enough to indicate that decomposition has taken place. The bright straw that is plowed up after many months is just a "skeleton" of the original straw. Even though the appearance has not changed materially, from 60 to 90 per cent of the straw may have decomposed.

SUMMARY

Straw samples from three spring wheat varieties were buried in fiberglass cloth bags in field plots that had been fertilized with 0, 89, or 268 kg. N/ha. for a wheat crop grown the previous year. The bags were removed at monthly intervals and analyzed for weight loss, N, and C percentages. Straw decomposition during three months in the field was not materially influenced by the residual N. The straw N percentage increased with each increment of N fertilizer. Nitrogen percentage also increased with time. The weight of N in the straw samples increased with increments of applied N but were variable with decomposition time. The C percentage remained almost constant, but the C/N ratio narrowed with increasing N and with loss of C. The color and texture of the buried straw samples did not change noticeably in visual appearance with time in the soil, but an average of 44 per cent weight loss was observed in three months.

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