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Wheat Straw Management and Nitrogen Fertilizer Requirements

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Straw management is an important consideration for conventional tillage crop production systems in Idaho. Most growers using a good crop rotation realize the long term benefits of returning straw residues to the soil. One critical aspect of straw management involves the amount of nitrogen (N) required to compensate for straw immobilization of N. This amount depends on several factors including the amount of straw incorporated, the subsequent crop, the timing of N application and the date that straw residues are incorporated into the soil. Proper straw management and N fertilization practices will minimize the N required.

This publication summarizes several years of research conducted at the USDA-ARS Snake River Soil and Water Conservation Research Laboratory and the University of Idaho Research and Extension Center, both at Kimberly, Idaho, and the USDA-ARS Columbia Plateau Conservation Research Center at Pendleton, Oregon.

Straw Decomposition Rate and N

Straw is decomposed by microbial populations that require N for their metabolism. When N content of residue is low, microbial activity can be limited. The N content of straw residue at harvest is generally too low to support maximum microbial metabolism, growth and activity. For the most rapid decomposition of straw residues, additional N is required. Fortunately, with normal temperatures and adequate moisture, fertile soils in southern Idaho will release N as soil organic matter — crop residues incorporated in earlier years as well as microbial tissues — is decomposed. This N release from soil is available to microbial populations to supplement the low N contents of straw residues.

Straw decomposition rates under field conditions are not appreciably affected by N fertilization, according to USDA-ARS research at Kimberly (2). Decomposition rates can be increased with N under optimum laboratory conditions when N in the straw and soil is low. However, the Kimberly research has shown that straw decomposition rates in the field, even with N added, do not match those in the laboratory. Since straw residues decompose more slowly under field conditions and fertile soils release a certain amount of N naturally, N fertilizer applied with the straw did not appreciably enhance straw decomposition.

Nitrogen Requirement

Microbial use of soil N reduces the amount available for subsequent crops. The soil N used by microbial populations is said to be "immobilized." Because of this microbial N immobilization, additional fertilizer N is recommended for subsequent crops, depending on the amount of straw returned to the soil.

To determine the amount of N needed to compensate for that immobilized by microbes, the amount of straw present must be estimated. Normally, the higher the grain yield, the more straw produced. Unfortunately, the relationship is not always this direct. The straw yield of Nugaines wheat was 36 percent less in the second year of a Kimberly study but grain yield increased 25 percent (3). Straw production is generally higher in winter wheat than spring wheat and higher in early fall-planted wheat than in late fall-planted wheat. A very general rule of thumb is that 75 to 90 pounds of straw are produced for every bushel of wheat harvested under irrigation. Baling straw generally removes only about 50 percent of the straw and chaff produced.

Table 1. Sugarbeet yield, sugar content, sugar yield and N uptake as affected by straw application rate, N rate and timing of application, USDA-ARS, Kimberly, 1970.

N fertilizer		3 tons straw/acre			6 tons straw/acre			
		Yield	Sugar content	Sugar yield	Yield	Sugar content	Sugar yield	N uptake[1]
(lb/acre)		(ton/acre)	(%)	(lb/acre)	(ton/acre)	(%)	(lb/acre)	(lb/acre)
Fall	Spring							
0	0	17.0a[2]	18.1a	6,060a	14.8a	18.8a	5,570a	95a
60	0	21.4b	18.6ab	7,960b	19.2b	18.6a	7,230b	133b
0	60	23.1c	18.8b	8,700c	22.1c	18.7a	8,270c	149c
60	60	25.8d	18.6ab	9,570d	24.0d	18.6a	8,945d	177d
0	120	26.1d	18.8b	9,815d	24.4d	18.9a	9,220d	190e

[1]Means for N uptake are averaged across straw application rates of 0, 3 and 6 tons per acre.

[2]Means within columns followed by the same letter are not significant at the 5 percent level.

Fertilizer N rates for subsequent nonleguminous crops need to be increased if appreciable straw residues are returned to the soil. Add 15 to 20 pounds of extra N per ton of straw returned to the soil. Do not apply more than 50 pounds of N per acre to compensate for straw decomposition since higher rates have seldom been necessary for maximum production.

Nitrogen is not recommended for beans or other legumes following wheat. In one study at Kimberly, pinto bean yields were not significantly increased when 77 pounds N per acre were applied to either Nugaines or Lemhi wheat straw the previous fall.

Timing Nitrogen Application

Although additional fertilizer N will compensate for immobilized N, the timing of the N application will influence its effectiveness for subsequent crops. Research at Kimberly (4) shows 60 pounds N per acre applied in the spring was used more effectively than N incorporated with straw residues in the early fall (Table 1). Sugarbeet yield, sugar yield and N uptake were higher with the spring application.

Fall N fertilization may be justified following wheat if the straw is plowed early in the fall and the N is applied and incorporated late in the fall. Straw immobilization of N is minimized with late fall N applications because cold soil temperatures slow biological activity. Corn silage yield and N recovery at Kimberly were significantly higher with a late fall appplication than when N was plowed down with straw in the early fall (Table 2). Late fall and spring N applications did not differ significantly in silage yield or N recovery. Fall N applications are in some cases cheaper and more convenient. Late fall N may also be more convenient if growers use fall bedding practices.

Table 2. Corn silage yield and N recovery as affected by timing of N application, USDA-ARS, Kimberly, 1985.[1]

Timing of N application	Corn silage yield	N recovery
	(tons/acre)[2]	(lb/acre)
September	16.5a[3]	95a
November	18.7b	111b
May	19.4b	115b

[1]Data provided Jay H. Smith, personal communication.

[2]All means are averaged across straw application rates of 0, 2.2, 4.4 and 6.6 tons/acre and N rates of 0, 134 and 268 lb/acre.

[3]Means within columns followed by the same letter are not significantly different at the 5 percent level.

For late fall N applications, ammonium N (NH_4-N) fertilizers such as anhydrous or aqua ammonia, urea and ammonium sulfate may be more effective than nitrate-N (NO_3-N) fertilizers. The NH_4-N is less mobile than NO_3-N and therefore less susceptible to leaching with winter precipitation. Cool soil temperatures in late fall also should reduce the conversion of NH_4-N to NO_3-N.

Straw Decomposition and Cultural Practices

Many of the benefits from returning straw residues depend on the decomposition of the straw. The greater the decomposition, the greater the benefit to a subsequent crop. Soil microorganisms are responsible for straw decomposition so we need to consider these populations and the factors that influence their effectiveness. Microbial populations generally increase as soils warm in the spring and continue to increase into the summer under irrigated conditions. For the most rapid decomposition, residues should be incorporated when these microbial populations are the most active.

Kimberly research (4) has shown that straw residues incorporated as early as possible are more beneficial for subsequent crops. Plowing straw residues on September 5 resulted in higher sugarbeet sucrose percentage and yield than plowing on November 13 (Table 3).

Many growers beat the straw or lightly till to cover seeds lost at harvest. They then irrigate to germinate

Table 3. Effects of straw plowing date on sugarbeet sucrose percentage and sucrose yield, USDA-ARS, Kimberly, 1970.[1]

Plowing date	Sucrose percent	Sucrose yield
September 5	18.6a[2]	9,792a
November 13	18.2b	9,517b

[1]Data are averaged across N rates of 0, 60 and 120 lb/acre and straw application rates of 0, 6 and 12 tons/acre.

[2]Means within columns followed by the same letter are not significantly different at the 5 percent level.

the seed and to provide better moisture conditions for subsequent tillage operations. Some growers prefer to wait for volunteering wheat to grow as much as possible before plowing, thinking it may serve as a green manure crop. The nitrogen in the volunteered wheat is generally not sufficient to justify delaying the plowing operation nor does it provide much in the way of additional organic matter. The delayed incorporation of residues will delay the decomposition of straw residues that weren't previously covered by soil.

The more straw residues are covered by soil, the more rapidly they decompose. USDA-ARS researchers at Pendleton have examined the decomposition rates of straw incorporated, laying on the soil surface or suspended above the soil (1). Over 20 percent of the wheat straw incorporated into the soil decomposed within 67 days. Straw lying on the surface or suspended above the soil had decomposed less than 5 percent in the same period.

Uniform straw and chaff distribution from the combine at harvest is advantageous in any farming system. Poor residue distribution can affect both nutrient availability and herbicide effectiveness. Unfortunately, standard commercial combines do not distribute straw and chaff uniformly. Pendleton researchers measured straw and chaff distribution from several farmer-operated combines (5). Standard cylinder combines (factory run) had very uneven residue distribution patterns. Residue distribution was over fourfold higher directly behind the combine than near the outer edge of the header. The pattern was similar for standard rotary combines with center exits and no spreading attachments.

By installing commercial chaff and straw spreaders or modifying existing spreading systems, growers can prevent or minimize the problems encountered with poorly distributed straw residues. Relatively low cost commercial modifications are available. For more information on residue distribution, refer to PNW Bulletin 297, *Uniform Combine Residue Distribution for Successful No-till and Minimum Tillage Systems.*

Straw Decomposition and Visual Appearance

Decomposition is generally thought to cause the straw to disappear or at least to darken or discolor. Actually, straw brought to the surface with plowing may have the same color and texture as when it was plowed under. Its appearance is deceiving, however, because research at Kimberly (3) has shown that this straw has lost as much as 44 percent of its original weight. Only the "skeleton" of the original straw remains, and it is quickly broken up with tillage.

Summary

Wheat straw residues require careful management to minimize problems and maximize benefits for subsequent crops. To maximize decomposition, straw should be incorporated into the soil as rapidly as possible to provide maximum time for decomposition and to take advantage of more favorable soil temperatures and more active microbial populations.

Additional N will be necessary to compensate for decomposition of straw low in N. This additional N is more effective if applied in late fall or spring than if incorporated with the straw early in the fall. Fertilizer N applied with the straw does not appreciably increase straw decomposition rates under field conditions.

Apply 15 pounds N per acre per ton of straw when applied in the late fall or early spring and 20 pounds N per acre per ton when applied with the straw at plowdown. Do not apply more than 50 pounds N per acre to compensate for straw immobilization of N.

Straw and chaff spreading attachments or modifications for combines help avoid the agronomic and mechanical problems associated with high concentrations of residue that commonly occur behind combines.

Information for this publication was derived from research at the Snake River Soil and Water Conservation Research Laboratory and the University of Idaho Research and Extension Center, both at Kimberly, Idaho, and the USDA-ARS Columbia Plateau Conservation Research Center, Pendleton, Oregon. This research is discussed in greater detail in the following publications:

1. Douglas, C. L., Jr., R. R. Allmaras, P. E. Rasmussen, R. E. Ramig and N. C. Roager Jr. 1980. Wheat straw composition and placement effects on decomposition in dryland agriculture of the Pacific Northwest. Soil Sci. Soc. Amer. J. 44:833-837.
2. Smith, J. H., and C. L. Douglas. 1971. Wheat straw decomposition in the field. Soil Sci. Soc. Amer. J. 35:269-272.
3. Smith, J. Hamilton, and Clyde Douglas. 1967. Straw decomposition. Univ. of Idaho Current Info. Ser. 57.
4. Smith, J. H., C. L. Douglas and M. J. LeBaron. 1973. Influence of straw application rates, plowing dates and nitrogen applications on yield and chemical composition of sugarbeets. Agron. J. 65:797-800.
5. Veseth, Roger, Carl Engle, James Vomocil and Robert McDole. 1986. Uniform combine residue distribution for successful no-till and minimum tillage systems. Pacific Northwest Extension Publication 297.

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