Up in Smoke— Nutrient Loss with Straw Burning

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Burning spring wheat, oat, and flax straw resulted in 98 to 100% loss of nitrogen (N), 70 to 90% loss of sulfur (S), and 20 to 40% loss of phosphorus (P) and potassium (K).

In the province of Manitoba in western Canada there is considerable controversy regarding the value and costs of returning straw from crops to the soil. In much of Manitoba, ample growing season moisture produces high straw yields. This straw is sometimes burned in the fall when it cannot be marketed for fibre, or when it impairs tillage and seeding operations the next spring. The most obvious consequence of straw removal or burning is the loss of plant nutrients.

Past work on straw management in this region has estimated that straw burning produced total loss of N and S, with no loss of P and K. As a result, subsequent guidelines have considered this the standard nutrient loss from burning. In an attempt to clarify this estimate, a study was carried out to evaluate the fertility value of straw and the losses that occur during removal or burning.

Spring wheat, oat, and flax straw samples were collected in three regions of Manitoba with a portion retained for straw nutrient analysis and the remaining portion burned on a steel grate to allow retention and collection of the resulting ash.

Straw rows burning at night to control spread of fire.

Ash weight from the burn was determined, and the resulting straw and ash samples were submitted for analysis of total carbon (C), N, P, K, and S.

Straw samples were between 4 to 6% moisture content and much of the straw mass was lost during burning. The amount of straw weight lost through burning varied greatly among sources, with flax burning more completely and only 4% of the mass remained as ash versus 8% for oats and 13% for wheat.

The nutrient concentration in straw and resulting ash is presented in **Table 1**. The amount of C in straw varied little within straw types. The amount of C remaining in the ash varied more as a result of the degree of combustion (where less combustion, more C remained). The N content of straw generally varied more than other nutrients. Variation in straw nutrient content is expected as it reflects the

Caution When Soil Sampling Burned Fields

Burning crop residue to improve equipment operation is a common practice on no-till fields in parts of the northern Great Plains. However, one must be careful when soil sampling fields where crop residue has been burned in the windrows. An agronomist working in northeast Saskatchewan reported that a composite soil sample from a burned field gave a false reading on soil test K. While the field composite reading was 223 parts per million (ppm) K, further sampling found that 25% of the field where the windrows were burned was 325 ppm, while the remaining 75% of the field was 114 ppm. So, be cautious of misleading results when sampling burned fields.

Table 1. Nutrient content (%) in harvested straw and ash from spring wheat, oats, and flax.

Nutrient	Material	Spring wheat	Oats	Flax
Carbon	Straw	41(1.02)[1]	42 (0.15)	46 (0.26)
	Ash	24 (15.4)	19 (9.8)	39 (12)
Nitrogen	Straw	0.97 (0.31)	0.64 (0.38)	0.86 (0.18)
	Ash	1.09 (0.67)	0.48 (0.23)	1.40 (0.47)
Phosphorus	Straw	0.14 (0.05)	0.08 (0.04)	0.07 (0.03)
	Ash	0.97 (0.5)	0.76 (0.26)	1.30 (0.90)
Potassium	Straw	1.44 (0.77)	2.34 (0.97)	0.24 (0.05)
	Ash	9.82 (6.76)	19.40 (10.5)	3.73 (1.24)
Sulfur	Straw	0.11 (0.05)	0.22 (0.28)	0.06 (0.006)
	Ash	0.30 (0.25)	1.28 (2.02)	0.20 (0.09)

[1]Value in brackets represents 1 standard deviation of the mean.

differing management and fertility regimes the crop is grown under. Nitrogen concentration of the ash is similar in magnitude to the concentration in straw. Unlike N, the P, K, and S tended to be concentrated 2 to10 times more in ash than in the original straw. This concentration of nutrients indicates increased retention in the ash left after the burning was carried out.

Nutrient loss through burning is illustrated in **Table 2**, where the amount of nutrients present in one ton of straw is compared before and after burning. Carbon and N loss due to burning was greater than 90% across all straw types and sources. On average, 98 to 100% of the N, 24% of the P, 35% of the K, and 75% of the S was lost through burning.

While the loss of N and S with burning agrees with previous assumptions, the primary question asked from these results was: Where did 24% of the P and 35% of the K go? It is likely that most of the loss was smoke or particulate matter that drifted away from the fire, since no attempt was made to collect or retain it. There is some possibility that this particulate matter may settle down over the field being burned – but this will depend on wind and other smoke dispersion factors. Other factors like high temperature volatilization of K may explain the loss, but are less likely.

Determining the economic impact of burning straw may be as difficult as when straw is baled. A complete job of burning converts the vast majority of all above-ground straw and chaff to ash, while baling removes only a portion of the straw, and usually no chaff. However, the usual objective is to burn only that excess straw that is dropped in the swath, leaving stubble intact between swaths. Such burning practices can also influence nutrient distribution in a field, especially when straw is burned in rows dropped behind a combine. The result is nutrients concentrated along this row position in the field. Soil sampling should avoid any cores from these ash rows. The variability in straw nutrient content observed in this study supports the argument that straw nutrient content is largely influenced by the grower's fertility management. BC

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Table 2. Nutrient content (lb) in one ton of harvested straw and ash from spring wheat, oats, and flax.

Nutrient	Material	Spring wheat	Oats	Flax
Carbon	Straw	826 (23)	832 (3.4)	910 (5.8)
	Ash	77 (100)	31 (22)	28 (12.3)
Nitrogen	Straw	22 (14.9)	10 (5.04)	28 (10.3)
	Ash	0.4 (0.22)	0.1 (0.07)	0.05 (0.03)
Phosphorus[2]	Straw	2.7 (1.02)	1.5 (0.77)	1.4 (0.74)
	Ash	2.4 (1.50)	1.3 (0.50)	0.9 (0.77)
Potassium[2]	Straw	29 (17)	47 (21)	4.7 (1.12)
	Ash	24 (16)	30 (17)	2.6 (1.03)
Sulfur	Straw	2.2 (1.06)	4.4 (6.11)	1.1 (0.13)
	Ash	0.7 (0.51)	2.2 (3.76)	0.14 (0.03)

[1]Value in brackets represents 1 standard deviation of the mean.
[2]Convert P and K values to P_2O_5 and K_2O equivalent by multiplying values by 2.29 and 1.2, respectively.