The Nutrient Loss with Straw Removal or Burning in Manitoba

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In Manitoba considerable controversy exists over the value and costs of returning crop residue (i.e. straw) 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, thwarts tillage and seeding operations, slows combine capacity, etc. One consequence of straw removal or burning is the loss of plant nutrients.

In the Manitoba Agronomists’ Annual Conference Proceedings, Partridge and Hodgkinson (1977) estimated straw burning produced total loss of nitrogen (N) and sulphur (S) with no loss of phosphorus (P) and potassium (K). Subsequent provincial guidelines have considered this the standard nutrient loss from burning. The following study was performed to evaluate the fertility value of straw and the losses that occur during removal or burning.

Method
Spring wheat, oat and flax straw was collected by Ag rep staff in Selkirk, Starbuck, Killarney and Dauphin in the fall of 2000. An oat sample from Dauphin was not provided. Approximately 1 kg of straw was sampled using a forage analysis probe to provide representative samples. A portion was retained for straw nutrient analysis. The remaining portion was burned on a steel grate to allow retention and collection of the resulting ash. Ash yield from the burn was determined. Samples of straw and ash were submitted to Norwest Labs for analysis of total carbon, nitrogen, phosphorus, potassium, sulphur and other secondary nutrients. No attempt was made to collect or analyse the particulate material that escaped into the air as smoke.

Results were summarized and graphs 1-10 contain the mean analysis of the straw samples and the error bars represent 1 standard deviation.

Results
Much of the straw mass was lost during burning (Figure 1). The amount of straw weight lost through burning varied greatly among sources, damp and combustion was incomplete. Other straw samples were between 4-6% moisture content.

Flax straw burned more completely and only 4% of the mass remained as ash vs. 8% for oats and 13% for wheat.

The nutrient concentration in straw and resulting ash is presented in Figure 2. The amount of carbon (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 nitrogen (N) content of straw generally varied more than other nutrients (Figure 2). Variation in straw nutrient content is expected as it reflects the differing management and fertility regimes the crop is grown under. Nitrogen concentration of the ash is similar in magnitude to the concentration in straw. The phosphorus (P), potassium (K) and sulphur (S) tended to be concentrated 2-10 times more in ash than in the original straw. Flax straw contained substantially less K than cereal straws.

Nutrient loss through burning is illustrated in Figure 3, where the amount of nutrients present in 1 tonne of straw is compared before and after burning. Phosphorus and potassium are reported in fertilizer nutrient equivalent (i.e. P₂O₅ and K₂O, respectively). To convert these values to nutrients/acre, consider that typical straw yields are:
• 1 t cereal straw/acre in SW Manitoba to 1.2 t cereal straw/acre in eastern Manitoba
• ½ t flax straw/acre

Carbon and nitrogen loss due to burning was greater than 90% across all straw types and sources. On average, 24% of the phosphorus, 35% of the potassium and 75% of the sulphur was lost through burning.

Discussion
Where did 24% of the P and 35% of the K go when burnt? 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 may explain the loss, but are less likely. Potassium compounds are known to volatilize with temperatures exceeding 1300°C and it has been hypothesized that these high temperatures may fuse potassium with insoluble compounds such as silicon (Naylor and Schmidt, 1989).

The data was used to estimate the nutrient loss in dollars per acre (Table 1). The considerable variability in $ loss is due to the variability in straw nutrient content, which is largely influenced by the growers fertility management. The nutrients contributing the greatest value to straw are nitrogen and potassium. Potassium content is less commonly valued at it’s replacement fertilizer cost since a major portion of Manitoba soils that produce high straw yields (i.e. heavy clays) already have very high native K levels.

Additional costs to be considered are:
• Straw removal cost of 3 round bales/ac are baling ($10-18/ac) and pickup ($7-11/ac).
Conversely, the cost of retaining those nutrients may be:
• $0-$8/ac depending on the amount of tillage required to breakdown and incorporate straw. Custom rates for extra tillage passes are some $3.25-$5.00 per acre for cultivation and $0.95-$1.15 per acre for harrowing (2001-Farm Machinery Rental and Custom Rate Guide)
• Not all these nutrients in straw are immediately available to succeeding crops. Much of the N, P and S are in the organic fraction and will be released through microbial mineralization. In fact straw with low N content may immobilize soil or fertilizer nitrogen to breakdown before N is released for crop use.

Summary
• The nutrient content (N,P,K,S) of straw varies by crop type and management
• Concentration of nutrients in ash depends upon original straw nutrient content and extent of combustion.
• Burning results in 98-100% loss of N, 70-90% loss of S and 20-40% loss of P and K.
• When fertilizer replacement values are placed on these nutrients, the loss is $11-16/ac when removing wheat straw versus $4-15/ac when burned.

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Figure 1. Mass remaining as ash after straw burning
Figure 2. Nutrient concentration in straw and resulting ashes.
Figure 3. Nutrients remaining from 1 tonne straw.
Table 1. The range of fertility nutrient loss through straw removal.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Assumed Straw yield t/ac</th>
<th>Nutrients value lost per acre</th>
<th>Straw removed **</th>
<th>Straw burned ***</th>
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</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1</td>
<td>$11.15-16.25</td>
<td>$4.10-14.60</td>
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<tr>
<td>Oats</td>
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<td>$6.70-18.65</td>
<td>$3.65-9.70</td>
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<td>Flax</td>
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<td>$4.05-7.35</td>
<td>$3.25-6.95</td>
<td></td>
</tr>
</tbody>
</table>

* based on N= $0.29/lb, P$_2$O$_5$ = $0.27/lb, K$_2$O = $0.14/lb, S = $0.24/lb
** loss of all N, P, K, S.
*** proportional losses of N, P, K and S according to study.
References

Manitoba Agriculture bulletin. Stubble burning can cost you money.

Manitoba Agriculture and Food. 2001 Farm Machinery Rental and Custom Rate Guide.
