# Release and Retention of N and P During Crop Decomposition

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## Abstract

Understanding the release and retention of nutrients from decomposing crop residue is critical to gain insight of nutrient cycling for sustained crop production. Using the mesh bag technique, we compared the mass loss and mineralization of N and P from straw and root residues of pea, canola and wheat in the 10 months following crop harvest. Wheat straw decomposed more slowly than either pea or canola mostly because of low N content, and released no measurable amount of N. By spring, pea straw had lost 25% of its N (7 kg N/ha) and canola straw 18% (2.5 kg N/ha). However, between spring and summer, these straw residues immobilized 1.5 to 2 kg N of soil N per ha. Wheat root lost more mass at the end of the study period than pea or canola root: Net mineralization of root residue N was 1 to 1.5 kg/ha. Residues of all test crops released P into the soil, however, the total amount from root and straw was less than 1 kg P/ha.

## Introduction

Canola and pea crop residues generally contain higher N and P concentrations than cereal crop residues. However, there is little field data comparing and quantifying the release of these nutrients from decomposing straw and root residues. This type of data has implications for nutrient cycling, and is important for deciding the end use of residues, especially straw for which an alternate use may exist other than return to land. Canola, field pea and wheat are important crops in the Canadian prairie. We conducted this study to quantify the release and/or retention of N and P from straw and root residues of those crops in the following growing season.

## Materials and Methods

The experiment was conducted on an Albright Series, a Dark Grey Solod with a clay loam texture, from 1997 through 1999. The experiment was a no-till study comparing three crop rotations ( pea-wheat-wheat, canola-wheat-wheat, and fallow-wheat-wheat) with continuous wheat culture. The fallow-wheat-wheat rotation was omitted from the present study. At crop maturity in 1997, the moisture content and dry matter of above-ground crop residue and root (to 12 cm depth) of canola, field pea and wheat were determined, and subsamples returned, in mesh bags, to plots they originated from. Straw residues recovered after threshing for grain were left on the soil surface as this was a no-till study, while intact root samples were buried vertically to 15 cm depth. Samplings to determine mass and nutrient loses were done 2 to 4 times in the fall and another 2 to 4 times in the following growing season. The plots were seeded to wheat in the spring, and each plot split into two, with one half receiving N fertilizer and the other half none. Remaining sample bags were removed prior to, and replaced in plots, after seeding operations in spring. There were four replications of each treatment. At each sampling, retrieved residues in bags were washed to remove soil, dried at 60$^{o}$C and weighed to determine mass loss. Residue samples were ground, subjected to Kjeldahl digestion, and N and P in the digest determined by colorimetry. The study was repeated in 1998/99. The data presented are the averages of the two years and two N rates (0 and 60 kg N/ha).

**Results and Discussion**

Straw residues had lower concentrations of N and P than root residues, however, lignin content was higher in root than straw (Table 1). N concentration in root and straw residues decreased in the order: pea>canola>wheat. P concentration in root was in the order: pea> canola>wheat, however, in straw the concentration decreased in the order: canola>pea>wheat. The amount of roots recovered from pea appears to be low. Jensen (1989) recovered the equivalent of 200 kg pea roots/ha by excavation (to an unspecified depth). Canola straw production for the two years of the study were below normal for the area.

**Table 1.** Dry Matter (DM) and Chemical Composition of Pea, Canola and Wheat Straw and Root at Maturity[a].

| Crop Species | Straw | | | | Root | | | |
|---|---|---|---|---|---|---|---|---|
| | DM | N | P | Lignin | DM | N | P | Lignin |
| Pea | 5085 | 7.13 | 0.72 | 115 | 152 | 20.42 | 1.51 | 155 |
| Canola | 2890 | 6.31 | 1.00 | 135 | 467 | 8.64 | 1.27 | 165 |
| Wheat | 4490 | 4.56 | 0.57 | 103 | 575 | 7.49 | 0.68 | 160 |

[a] Units are kg/ha for DM and mg/g for chemical constituents.

**Table 2.** Percent of Dry Matter of Straw and Root Residues of 3 Crop Species Remaining in November, and April and July of the Following Year.

| Crop Species | Straw | | | Root | | |
|---|---|---|---|---|---|---|
| | November | April | July | November | April | July |
| Pea | 82.5 | 78.5 | 75.0 | 78.5 | 82.0 | 71.0 |
| Canola | 86.0 | 83.0 | 75.5 | 93.5 | 86.5 | 73.0 |
| Wheat | 92.5 | 91.5 | 87.5 | 87.5 | 88.0 | 57.5 |

The residues lost 7 to 21% of initial dry matter between placement in the field in September and onset of winter in November (Table 2). There was no measurable mass loss over winter except, possibly, for canola root. Wheat showed the least straw mass loss and the most root mass loss in 10 months of field decomposition. Mass loss from placement through spring was greatest for pea residues, but its rate of mass loss decreased in the summer. Pea and canola lost similar proportions of mass by the summer. The decomposition rate of litter is initially influenced by its nutrient content, especially N, and during later stages by the lignin content (Pandey and Singh 1982; Janzen and Kucey 1988). Christensen (1986) showed that a barley straw of 4.1 mg N/g neither gained nor lost measurable amounts of N in 15 months of field incubation, while samples with 5.7 mg N/g or more showed loss of N throughout the incubation cycle. Wheat straw decomposition in our study was limited by a low N concentration (4.56 mg N/g).

Results for N and P remaining in residues, expressed on the basis of kg/ha, are presented for placement in the fall (i.e.,initial content) and for sampling in April (before seeding of the sequent wheat crop) and July only (Table 3). Pea returns twice as much N in straw as canola, with wheat occupying an intermediate position. This is mostly due to the low productivity of canola at this site as we have recorded a return of over 40 kg N/ha with canola straw in another study. Pea straw released 25% and pea root 60% of its N by spring. Wheat straw was not a source of N. Both pea and canola straw immobilized N (net) between spring and summer. Most of the immobilization occurred during the 1998 growing season. Differences in the amount of N returned in root residues were small in spite of the big differences in N concentrations. Decaying roots of all crop species returned and released small amounts of N to the soil (Table 3), although the cumulative amount released from annual cropping will not be biologically insignificant. The amount of mineral N in the surface soil (0 to 10 cm depth) in the spring was 22, 17 and 10 kg N/ha in plots where pea, canola and wheat, respectively, were grown the previous year. This trend in soil N was similar to that of N released from crop residues between fall and spring (Table 3).

**Table 3.** Recovery of N in Decomposing Straw and Root of 3 Crop Species (kg/ha).

| Residue Type: | | Time of Sampling | |
|---|---|---|---|
| *Straw* | Fall | April | July |
| Pea | 28.5 | 21.5 | 23 |
| Canola | 14 | 11.5 | 13.5 |
| Wheat | 18 | 17.5 | 18 |
| *Root* | | | |
| Pea | 2.6 | 1.1 | 1.2 |
| Canola | 3.3 | 1.0 | 2.4 |
| Wheat | 4.1 | 3.0 | 2.5 |

Straw and root residues of all 3 crop species were sources of P. However, together straw and root released no more than 1 kg P/ha in the 10 months of decomposition in this study. Differences in P mineralization between crops were minor.

**Table 4.** Recovery of P in Decomposing Straw and Root of 3 Crop Species (kg/ha).

| Residue Type: | Time of Sampling | | |
|---|---|---|---|
| *Straw* | Fall | April | July |
| Pea | 2.8 | 2.1 | 2.3 |
| Canola | 2.3 | 2.2 | 1.6 |
| Wheat | 2.5 | 2.3 | 1.9 |
| *Root* | | | |
| Pea | 0.19 | 0.09 | 0.06 |
| Canola | 0.52 | 0.35 | 0.25 |
| Wheat | 0.38 | 0.3 | 0.2 |

This study showed that root residues of all 3 crops acted sources of N and P for the soil. We only measured root mass and decomposition in the surface soil layer (to 12 cm). In addition, we made no special effort to recover fine roots during excavation. Since estimates of root mass in the top 10 to 20 cm of soil range from 80 to 97% of that of the root system (Xu and Juma 1992; Armstrong et al. 1994), our estimates of nutrient releases from roots should be considered a minimum amount. As well, roots turn over and recycle significant amounts of nutrients during crop growth. Rhizodeposition of N into soil by crop plant has been estimated to range from 22 to 46% of total below-ground, plant-derived N for pea (Sawatsky and Soper 1991), and from 18 to 33 % of assimilated N for wheat (Janzen 1990).

Whether N is mineralized from crop residues or not is determined mainly by its initial N content. Wheat straw with its low N concentration showed no tendency to release N. Both pea and canola straw showed net N mineralization, however, there was a tendency for those straws to immobilize N in some years as the indigenous soil matter was mineralized in the summer. This study showed that little, if any, wheat straw N is involved in soil N cycling in the short term, in contrast to pea or canola straw N which is mineralized and turned over rather rapidly in the soil. Approximately 25% of pea straw N and 18% of canola straw N was released at planting of the subsequent crop. There is considerable interest in exporting cereal straw for the fibre manufacturing industry. This study indicates that in a crop rotation of cereals, pea and canola, cereal straw may be exported for cash income provided that the cost of nutrient replacement, and loading and baling are less than the revenue received.

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