

## Decomposition of Crop Residue in the Landscape

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### Abstract

Decomposition of spring wheat (*Triticum aestivum* L.), flax (*Linum usitatissimum* L.) and pea (*Pisum sativum* L.) residue placed at the soil surface, was measured at four slope positions: upper, upper-middle, lower-middle and lower, in the landscape. Slope position did not significantly affect decomposition or microbial populations in crop residue placed at the surface under a cereal leaf canopy. Decomposition of pea residue was significantly higher than for wheat and flax, due to differences in carbon to nitrogen ratios. Over-winter loss of crop residue varied considerably between crops. Microbial populations in residue were highest in pea residue compared to wheat and flax, and were independent of slope position. Microbial populations in the soil were affected by slope position but not residue. The most active phase of residue decomposition occurred from late, spring to early summer, and was correlated with high yeast populations.

### INTRODUCTION

Residue management is a primary concern of producers who direct seed annual crops in the Parkland. Surface-placed residues affect emergence, germination, soil cover, nutrient availability, soil structure, soil temperature, water infiltration and evaporation, pest populations, and microbial activity (Douglas *et al.* 1980; Stroo *et al.* 1989; Collins *et al.* 1990). The goal of effective residue management in conservation tillage systems is to maintain sufficient crop residues at or near the soil surface to minimize erosion, yet not in excessive amounts that impede planting operations or subsequent crop seedling emergence and establishment.

Residue decomposition proceeds at a rate determined by the most limiting environmental, soil, residue, or management factor (Parr and Papendick 1978; Tanaka 1986). Microbial degradation is mainly responsible for crop residue decomposition (Parr and Papendick 1978; Douglas and Rickman 1992), although physical breakdown, removal by wind or water, or use by soil fauna also can significantly affect residue loss (Stott *et al.* 1990). Environmental factors are temperature and precipitation (Parr and Papendick 1978). Soil factors include available nutrients, pH, and aeration (Smith and Douglas 1968; Tanaka 1986). Residue factors include N content (C/N ratio), chemical composition, size, age, and species or cultivar type (Smith and Douglas 1968, 1971; Parr and Papendick 1978; Douglas *et al.* 1980; Smith and Peckenpaugh 1986; Collins *et al.* 1990). Janzen and Kucey (1988) concluded that the rates of decomposition of cereal, oilseed, and pulse crop residues were primarily influenced by their N content.

Generally, residues with low N content or high C/N ratios have slower decomposition rates (Parr and Papendick 1978).

The relationship between decomposition of wheat, barley, canola, flax and alfalfa with carbon to nitrogen ratio of crop residue, and degree days (DD) (heat units) has been reported previously (Moulin and Beckie 1993, Moulin and Beckie 1994, Moulin et al 1995). Under fallow conditions, decomposition simulated with an exponential equation (Douglas and Rickman 1992) was correlated with rates measured in the field.

A study was initiated to determine if decomposition of crop residues at the surface varied with landscape position. Slope position is not a factor in the Douglas Rickman equation. The study was also designed to determine rates of decomposition under cereal crops.

The objectives of this study are three fold:

1. To measure decomposition of flax, pea and wheat residue at the surface under cereal crops over the growing season for several landscape positions.
2. To measure changes in microbial populations in crop residue and soil at the surface under cereal crops over the growing season for several landscape positions.
3. To compare decomposition rates measured in the landscape with those simulated by the Douglas Rickman equation.

## **MATERIALS AND METHODS**

A crop residue decomposition study was initiated in 1993 on 3 ha of a moderately sloping (7%) Orthic Black Chernozem (Melfort silty clay, clay loam surface texture) in the R.M. of Star City, Saskatchewan. The experimental design is a split-split-strip plot design. Each of three replicates (3) and plot cover the full length of the slope with the strip-plot factor (slope position) running perpendicular to the slope. The main plot factor is tillage (conventional and zero); the split-plot factor is crop. the three crop rotations are: (1) flax-wheat-canola-wheat (2) pea-wheat-canola-wheat; and (3) pea-wheat-pea-wheat. Fertilizer N rate (0, 50, 100, and 150 kg/ha) comprised the split-split-plot factor in sequence year 2. No N fertilizer was applied in sequence year 3. The four slope positions are upper; upper middle; lower middle; and (4) lower.

In fall 1993 and 1994, 25 g of unweathered pea, wheat or flax residue in nylon mesh bags (35 cm \* 18 cm) were placed into unfertilized zero tillage wheat stubble at 4 slope positions. All treatments were replicated 3 times with sufficient residue bags for microbial and mass loss. Bags were located between rows seeded after seeding to avoid disturbance. Residue bags and the top 5 cm of underlying soil were first collected in May 1995, 7 months after residue placement, and thereafter at 2-month intervals in early summer, late summer and fall for microbiological analyses. Residue bags were collected in 1994 and 1995 at

monthly intervals to determine decomposition. The residue bags were placed on the soil surface in the cereal plots of the zero rate fertilizer treatments

Microbial analyses included respiration, and counts of viable bacteria, actinomycetes, yeasts and filamentous fungi according to methods described by Biederbeck et al. (1995). Microbial respiration ( $\text{CO}_2\text{-C}$ ) was measured *in vitro* with 0.21 g of pea or flax residue and 0.59 g of wheat straw on sterile, saturated sand in Biometer flasks with KOH during 21 days at 21 °C. Serial 10-fold dilutions were made with the suspension and 0.1 ml of the appropriate dilutions were inoculated by aseptically spreading onto plates with selective agar media for incubation and subsequent counting of colonies of these microbial communities:

- Bacteria and Actinomycetes on soil extract agar after 14 days at 21 °C.
- Yeasts and Filamentous fungi on rose bengal streptomycin agar after 7 days at 21 °C.

Residues measured for mass loss were sieved (1 mm) to remove loose soil, oven dried at 60 °C, and weighed. The residue was ground to pass through a 1-mm sieve, and a subsample was ashed at 500 °C in a muffle furnace over night to determine the soil content within the residue. Residue weights were expressed on an ash-free, dry matter basis. Values for surface and buried residue at each sampling date are means of the three replicate bags per treatment.

The residue decomposition model is described in detail by Douglas and Rickman (1992). Four equations are used in the model to estimate decomposition of crop residues based on CDD calculated from daily mean air temperature. Each is based on the general equation:

$$R_r = I_r \exp(-f_N f_W k \text{CDD})$$

where  $R_r$  = the residue remaining,  $I_r$  = the initial residue,  $f_N$  is an N coefficient based on initial residue N content,  $f_W$  is a water coefficient based on a combination of residue and field management, and  $k$  is a general decomposition coefficient. Water coefficients are 1.0 (buried residue in fallow), 0.8 (buried residue in crop), 0.3 (surface residue in fallow) and 0.2 (surface residue in crop).

## RESULTS AND DISCUSSION

### Residue Decomposition

Flax, pea and wheat residue decomposed at different rates in the following order (decreasing rate of decomposition): peas > flax ≥ wheat (Figure 1). These rates were attributed to the initial carbon to nitrogen ratios of the residue (Table 1). Flax residue decomposed in the field at similar rates to wheat in 1994, but

higher in 1995. Observed rates of decomposition were higher than those calculated with the Douglas Rickman model (Figure 1). These data are in contrast to those reported by Moulin and Beckie (1993, 1994) who found lower rates of decomposition, for flax than cereals in fallow. Higher rates of decomposition are attributed to decomposition in the humid microenvironment of the cereal crop canopy, and to carbon to nitrogen ratios which were similar for flax and wheat, and lower for all three crop residues compared to earlier studies. Carbon to nitrogen ratios in previous studies were much higher, at 85.0 for wheat and 128.0 for flax. Decomposition rates shown (Figure 1) do not account for over-winter loss. Pea residue decomposed at a rate similar to that calculated by the Douglas Rickman equation.

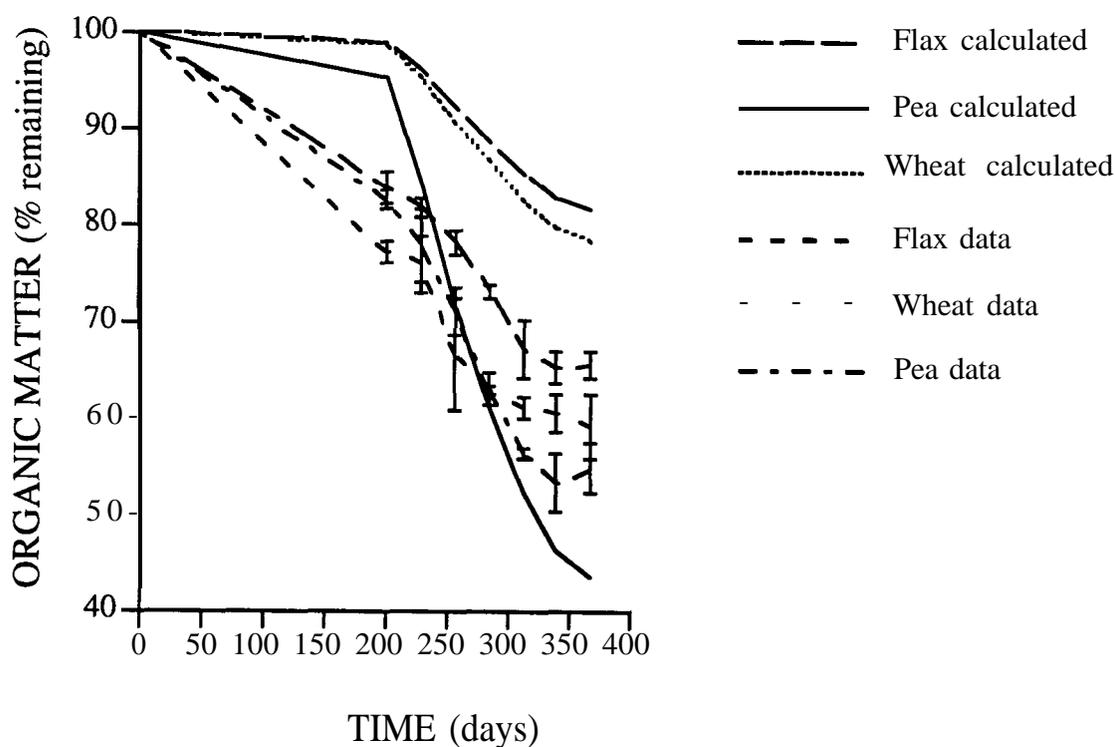
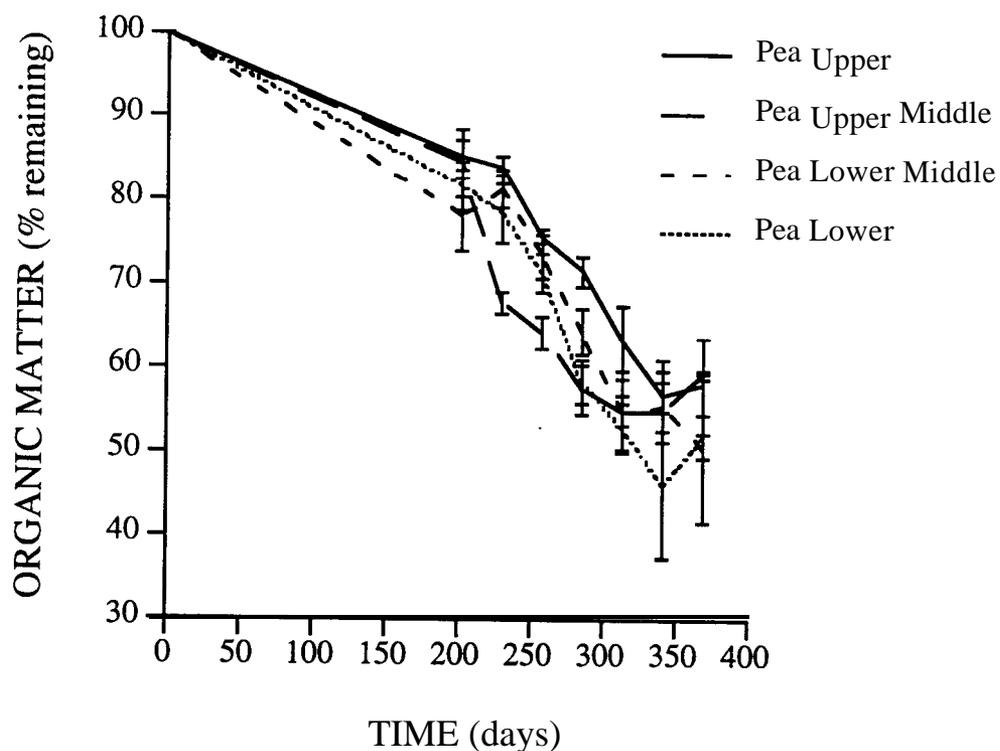


Figure 1 Calculated and actual decomposition of flax, pea and wheat residue at the surface in 1995. Standard errors of the mean are reported for data averaged across four slope positions :

Table 1. Initial composition of residue.

|      | Wheat | Flax | Pea  |
|------|-------|------|------|
| N(%) | 1.0   | 0.8  | 2.9  |
| C(%) | 45.1  | 47.3 | 44.2 |
| C/N  | 45.1  | 59.1 | 15.2 |

Decomposition rates were similar at all slope positions for flax, pea (Figure 2), and wheat in both 1994 and 1995. This was attributed to levels of microorganisms in crop residue which were not significantly different between slope positions.

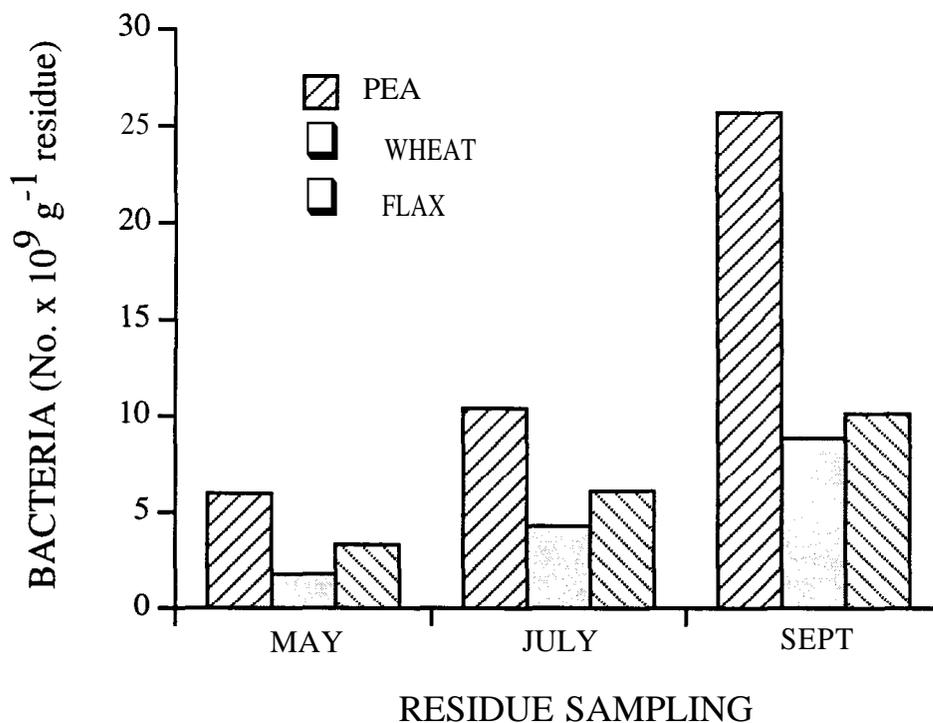


*Figure 2* Decomposition of pea residue at the surface in barley crop located at upper, upper-middle, lower-middle and lower slope positions in 1995.

### Microbial populations

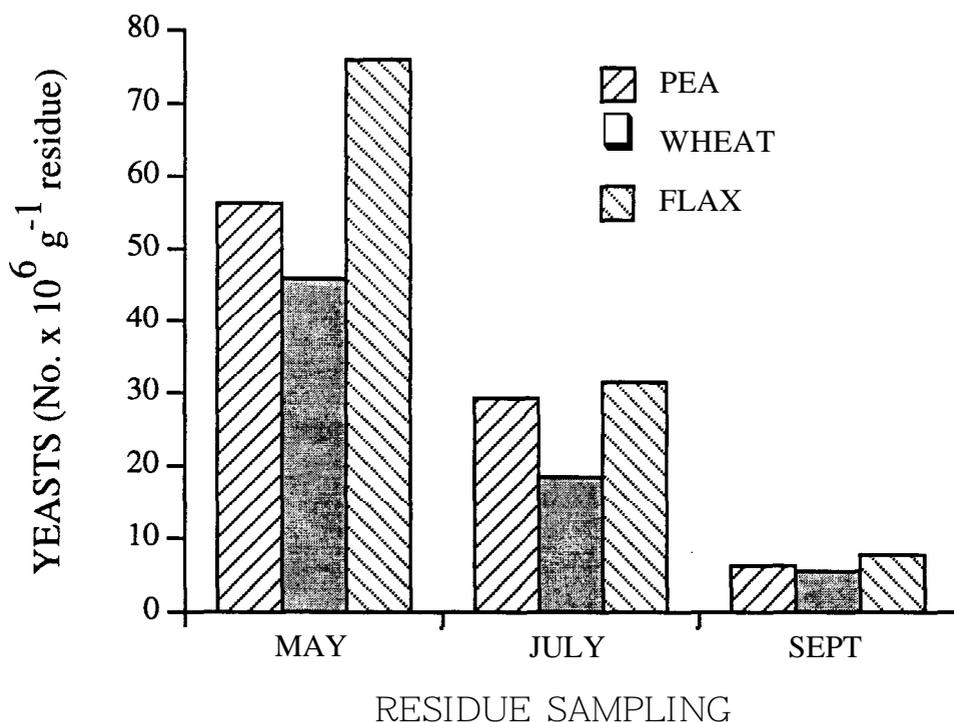
Microbial populations on residues were not affected by slope position but were greatly influenced by crop type; hence counts on residue were averaged for all slopes for statistical analyses. However, microbes in the soil were affected by slope but not by residue type.

Bacterial populations were very high on all 3 residues (Figure 3) . They increased from May to September and then declined in October as more readily decomposable residue fractions were depleted. Pea residues supported significantly greater numbers of bacteria and actinomycetes than did wheat. Numbers on flax were intermediate. Counts of actinomycetes were very small compared to bacteria, but as they declined less with season there was narrowing of the average bacteria/actinomycete ratio from 24 in May to 19 in July and to 5 in September.



**Figure 3.** Bacteria (No. x 10<sup>9</sup> g<sup>-1</sup> residue) for pea wheat and flax residue in 1995

During the most active phase of residue decomposition, in late spring and early summer, yeasts (Figure 4) were more numerous than filamentous fungi, while the reverse is always the norm in surface soils. Yeast populations were always greatest on flax, smallest on wheat and intermediate on pea residue. Residue colonization by filamentous fungi showed the opposite trend. Yeast populations decreased extensively on all residues, from spring to fall while numbers of filamentous fungi steadily increased indicating different abilities for substrate utilization. Therefore, the average yeasts/filamentous fungi ratio narrowed from 7.1 in May to 1.9 in July and to 0.2 in September.



**Figure 4** Yeasts (No. x 10<sup>9</sup> g<sup>-1</sup> residue) for pea wheat and flax residue in 1995

Under laboratory conditions, microbial respiration and breakdown of residues was also greatly affected by crop type and ranged, initially from a low 80 mg CO<sub>2</sub>-C/g wheat to 315 mg CO<sub>2</sub>-C/g and a high of 372 mg CO<sub>2</sub>-C/g pea residue during 21 days of incubation (Figure 5). Respiration rates on pea and flax residues decreased by about one third from May to September but remained constant for wheat.

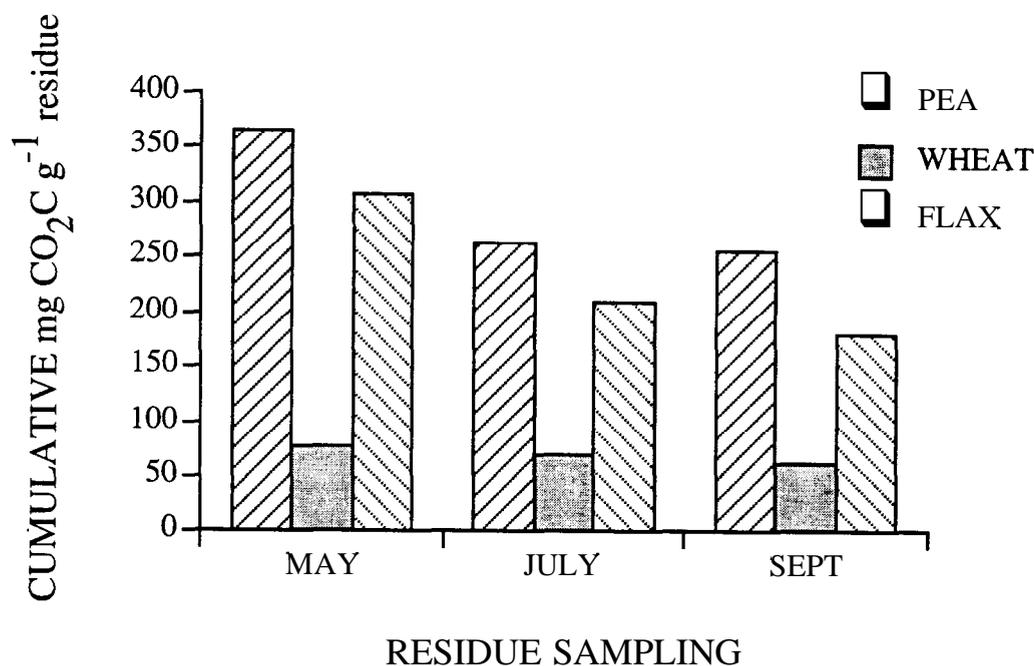


Figure 5 Microbial respiration (mg CO<sub>2</sub>C g<sup>-1</sup> residue) in 1995

## CONCLUSIONS

High rates of decomposition of pea residues relative to those of spring wheat, and flax are due to the high nitrogen content. The Douglas/Rickman model may require modification in order to simulate decomposition of crop residues in cereal canopies but appears appropriate for estimating decomposition across the landscape. Overwinter loss also appears to be a factor which affects crop residue.

Microbial communities of plant residues are greatly influenced by crop type and differ in quantity and structure from the communities in the soil below. The ecology of microbes colonizing residues is very dynamic. Relationships change extensively with progressive decomposition as shown by the drastic narrowing of the bacteria/actinomycetes and also the yeasts/filamentous fungi ratios from spring to fall. The greater number of yeasts living on flax and the much higher rate of *in vitro* microbial respiration (index of ease of decomposition) by this oilseed residue, relative to wheat straw, requires further study.

## ACKNOWLEDGMENTS

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