Second-Year Decomposition and Nutrient Release Characteristics of Ten Annual Crop Residues in South-Central Saskatchewan, Canada

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INTRODUCTION

- Post-harvest plant residues represent a significant addition of carbon (C) and nutrients to soil; however, limited work has been done to investigate their fate within low disturbance agricultural systems, where these residues are not incorporated into the soil.
- Quantifying these dynamics will improve our understanding of how different crop residues impact C sequestration and nutrient cycling, along with providing data for the development and validation of agroecosystem C and nutrient biogeochemical cycling models.

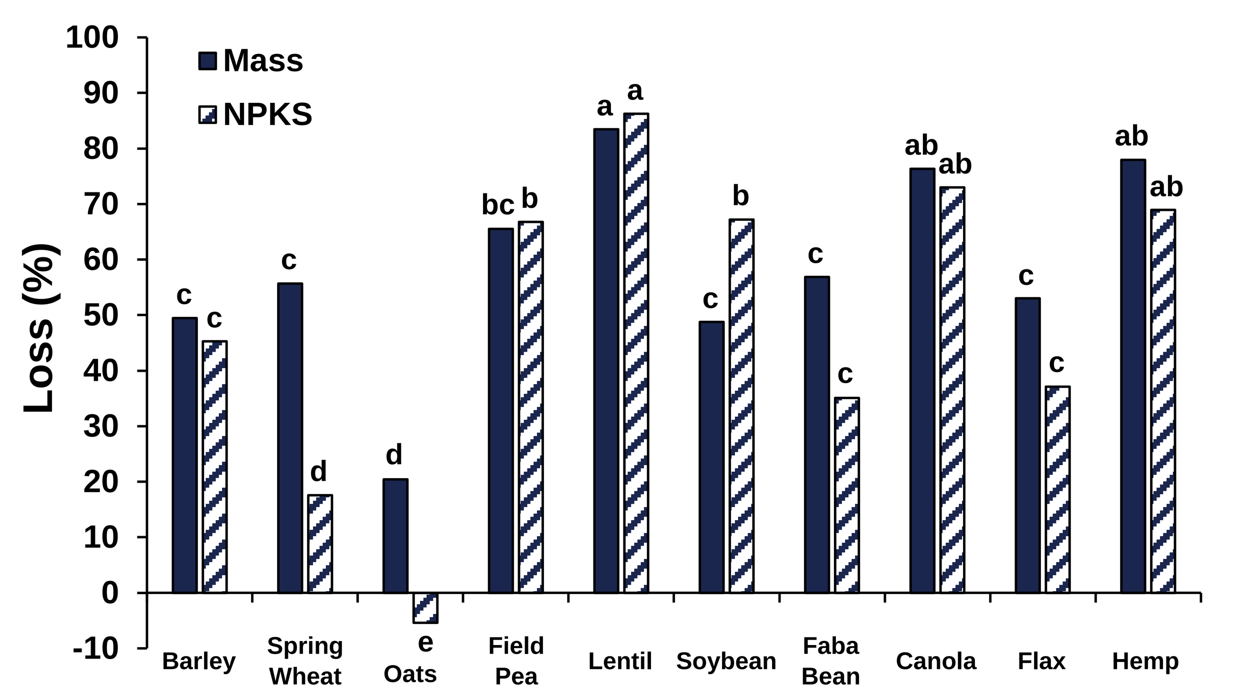
OBJECTIVE

- Quantify the mass loss and changes in nutrient content of decomposing harvest residues from a variety of annual cereal, pulse, and oilseed crops grown in Saskatchewan: barley, wheat, oats, field pea, lentil, soybean, faba bean, canola, flax, and hemp.

MATERIALS & METHODS

- Post-harvest residues were collected in the fall of 2015 from farm fields in Saskatchewan, dried to a constant weight, and a 5-g subsample placed in a polyethylene screen bag (20 × 20 cm; 1 mm mesh) and stapled closed. Additional subsamples of the original residues (i.e., time = 0) were analysed for their nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) contents.
- Prior to snowfall, the litter bags (n = 4) were placed on the soil surface of a farm field in south-central Saskatchewan and arranged in a completely randomized design.
- The soil is an Orthic Brown Chernozem with pH 7.6 and 20 mg/kg extractable NO_3-N, 10 P, 300 K, and 25 S in the 0-15 cm depth.
- Four collection times were chosen: the spring of 2016 (six months) and the fall of 2016 (1 year), 2017 (2 years; reported here), and 2018 (3 years).
- The residual litter was dried to a constant weight, weighed to determine mass loss, and analysed for its N, P, K, and S contents.
- Meteorological data (air temperature, rainfall, relative humidity, wind speed, and snow depth), along with soil temp/moisture (0-60 cm), are being collected using an adjacent MET station.

RESULTS



	Barley	Spring Wheat	Oats	Field Pea	Lentil	Soybean	Faba Bean	Canola	Flax	Hemp
C:N	102	127	113	50	37	39	59	86	102	91
C:P	484	1403	1151	648	396	347	1009	807	1016	897
C:K	247	597	868	450	523	193	1130	507	896	647
C:S	80	216	91	114	143	67	69	128	93	85

Figure 1. Mean (n = 4) initial ratios of total carbon (C) to nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) of post-harvest crop residues, along with their mass and cumulative N, P, K, and S losses after two years, measured using litter bags placed on the soil surface, at a site in south-central Saskatchewan. Means with the same letter are not significantly different (P > 0.05) using LSD.

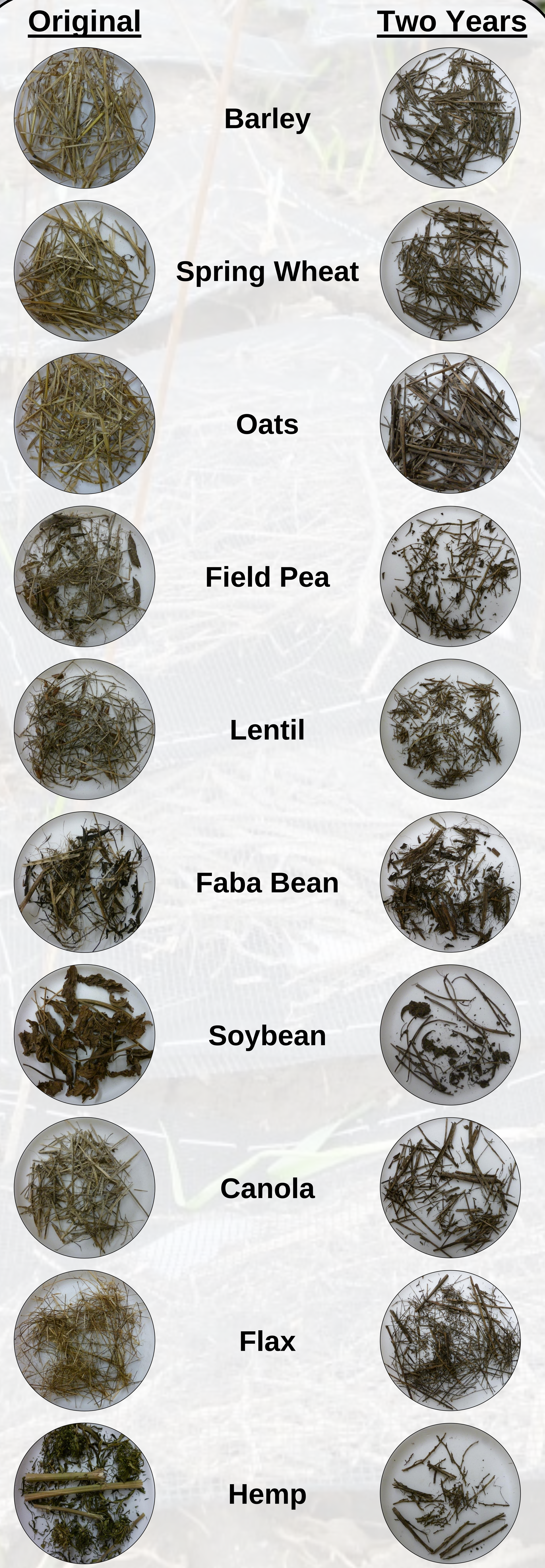


Figure 2. Ten annual crop residues before (left) and after (right) two years of decomposition, measured using litter bags placed on the soil surface.

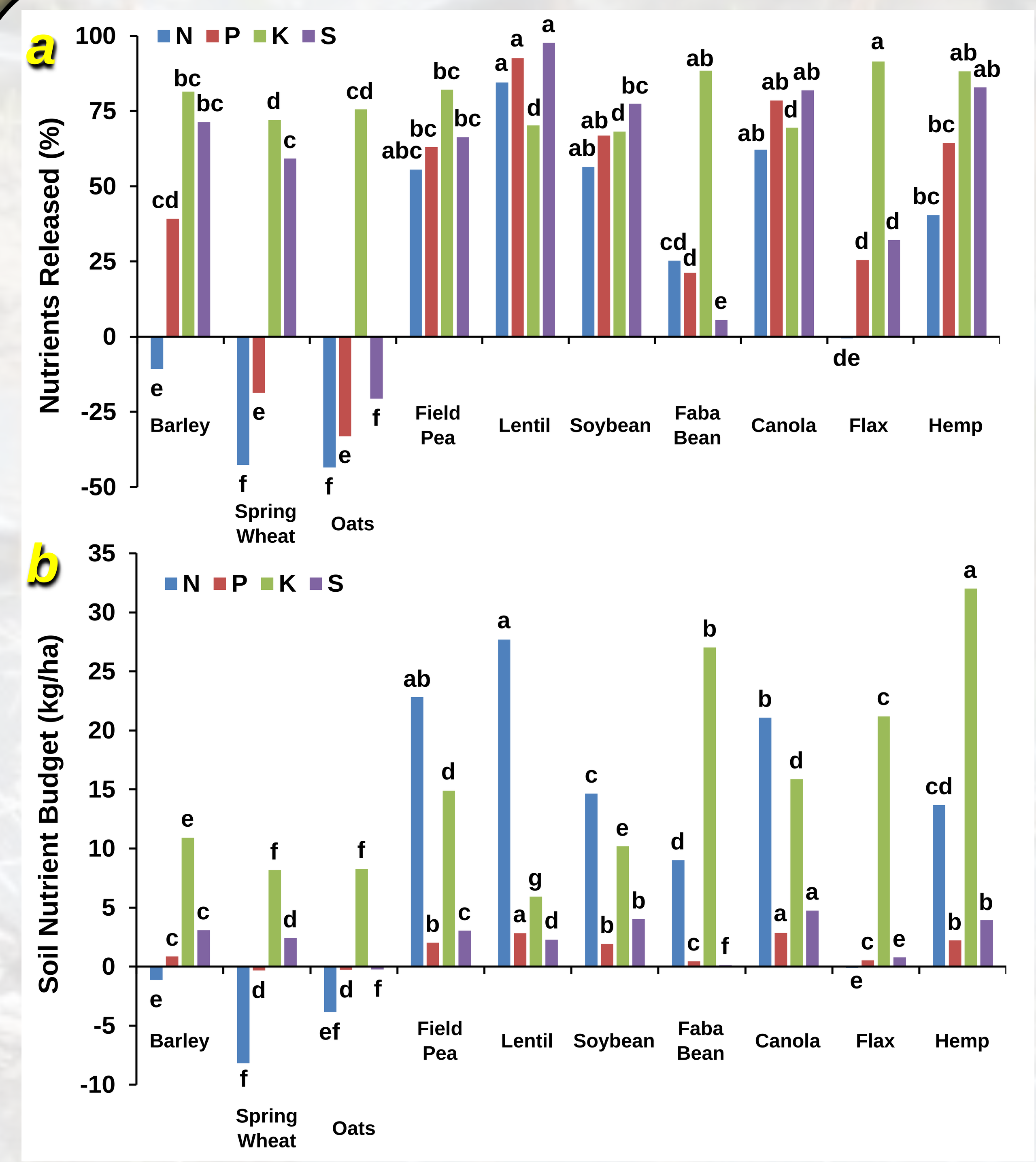


Figure 3. Mean (n = 4) (a) percent change in nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) content of decomposing annual crop residues after two years, measured using litter bags placed on the soil surface, and (b) its predicted effect on soil nutrient availability, estimated by factoring in the initial residue nutrient concentrations, historically reported crop residue biomass, and change in nutrient content. For each nutrient, means with the same letter are not significantly different (P > 0.05) using LSD.

DISCUSSION

- The differences in mass loss (20-83%) and cumulative N, P, K, and S release (-5 to 86%) among the crop residues (Figs. 1 and 2), are attributed to variation in specific surface area and residue quality.
- Average residue N, P, K, and S additions to the soil nutrient pool differed among nutrients (10, 1, 15, and 2 kg/ha, respectively) and crop residue (Fig. 3). Unlike the legume and oilseed crop residues that contributed N via net mineralization (19 and 12 kg N/ha), the cereal crop residues immobilized soil N (-4 kg N/ha). There were no apparent P, K, and S loss trends among residues.
- Generally the cereal residues (especially oats) are decomposing and releasing nutrients slower than other residues, explained by wider C:nutrient ratios (Figs. 1, 2, and 3). Potassium is readily leached from all residues, leading to residue K being the largest contribution to the soil nutrient pool.
- Principal component analysis indicated: i) soil nutrient pool additions were directly related to initial residue nutrient concentrations, and ii) the relationship between mass loss and N, P, and S release (inverse) and K (direct), that reflects the release mechanism of N, P, and S (microbially mediated) vs K (leaching).

CONCLUSION

- Despite similar mass (and C) losses, there were considerable differences in nutrient release among crop residues after two years, with initial residue quality being an important factor controlling decomposition and nutrient release, particularly for N.
- Similar measurements after a third year will provide more insight into longer term residue biomass and nutrient dynamics.

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