Nitrogen and Carbon Mineralization From Canola, Pea, and Wheat Residues with Differing Nitrogen Content and Carbohydrate Composition

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1. Introduction

- The inland Pacific Northwest is one of the few wheat belts in the world that does not commonly have oilseeds in rotation.
- Current high global prices have stimulated the demand for a local canola industry. However, agronomic knowledge is still lacking in our region.
- Conflicting studies indicate that net N mineralization can either increase or decrease when following canola relative to cereal crops (Engstrom, 2010; Soon and Arshad, 2002).
- Understanding decomposition and N mineralization is critical for residue and fertility management within a crop rotation that includes canola under zero-tillage.
- **Interactions between N fertility and biochemistry in the decomposition and N release/retention of various crops requires further study, ultimately to determine whether more or less fertilizer N is needed following canola.**

2. Materials and methods

Residue Characterization

a. **NMR and elemental analysis**
- Bruker DRX 400 ^{15}N CP/MAS solid state NMR
  - 25,000 scans
- Varian Vx 400 1H NMR
  - 10:1 (w/v) D_2O extraction, 30 min sonication
  - 256 scans
- Residue TC/TN and NH_4^+/NO_3^- and Dissolved organic C and N (<.45μ)

b. **Proximate fiber analysis**
- ANKOM 200 sequential fiber digestion (www.ankom.com)
  - Neutral detergent fiber (NDF)
  - Acid detergent fiber (ADF)
  - Acid detergent lignin (ADL)
- Fractionation: Step-wise mass and TC/TN determination
  - **Mostly soluble mass, C, and N = Total - NDF**
  - **Mostly hemicellulose mass, C, and N = NDF - ADF**
  - **Mostly cellulose mass, C, and N = ADF-ADL**
  - **Mostly lignin mass, C, and N = ADL**

Experiments

c. **Residue decomposition**
- 1.5 g of residue incubated in 15 g of acid-washed and heat sterilized quartz sand
- 2.5 ml of microbial solution (1:10 (w/v) extraction of agriculturally important Palouse, Ritzville, Ralston, Prosser, and Broadax soils
- 2.5 ml of Hoagland solution containing 250 ppm N
- Destructive sampling for mass loss (weight difference) at 0, 1, 2, 4, 6, 8, 12, 16 weeks
- TC/TN determination of residues at 16 weeks to calculate C and N loss
  - **Projected 16 wk net N mineralization = (ΔC*(1 g N/25 g C)) – ΔN**

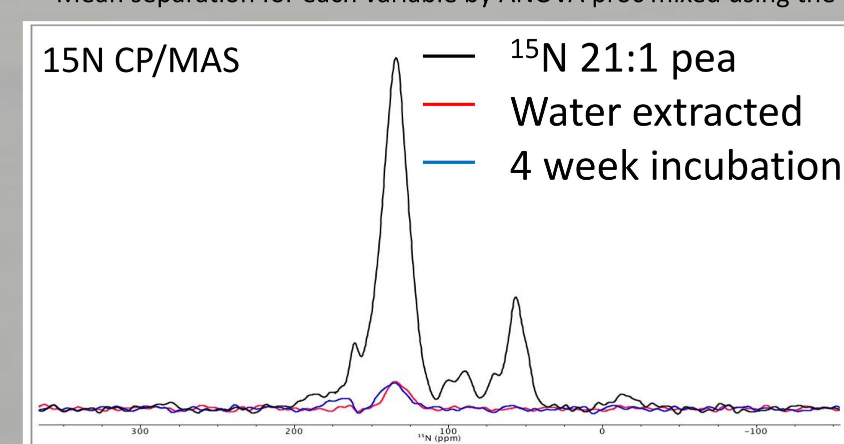
d. **Weekly CO_2 evolution rates**
- 4 g/kg of residue in a Palouse silt loam previously cropped in canola
- GRACEnet protocol for gas sampling at 0, 2, 4, and 6 hour deployments following capping samples within Mason jars fitted with septa
- Weekly sampling from rates at 1, 2, 3, 4, and 6 weeks
- CO_2 measured with a GC-2014 Shimadzu GC

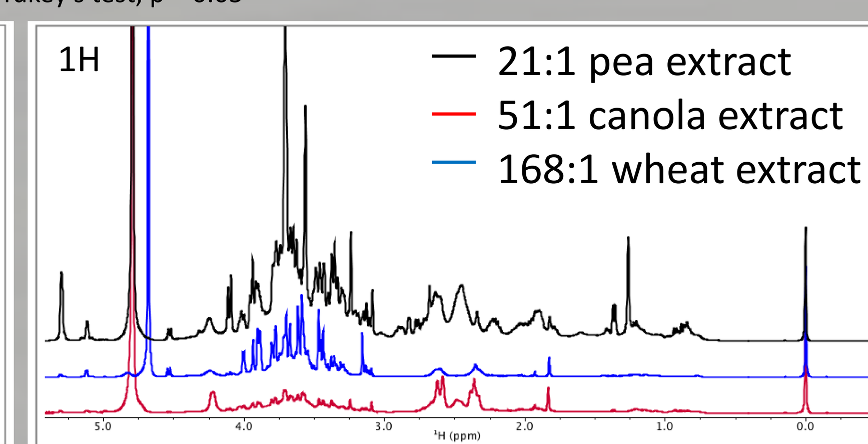
e. **Net N-mineralization**
- Destructive sampling for NH_4^+-N and NO_3^--N in a Palouse soil amended with 4 g/kg of residue at 0, 1, 2, 4, 6, 8, 12, and 16 weeks.
- **Net N mineralization relative = net change in inorganic N of treated soils – net change in inorganic N of non-treated control soil at week 16 and summed over all weeks**

3a. Results: Residue characterization

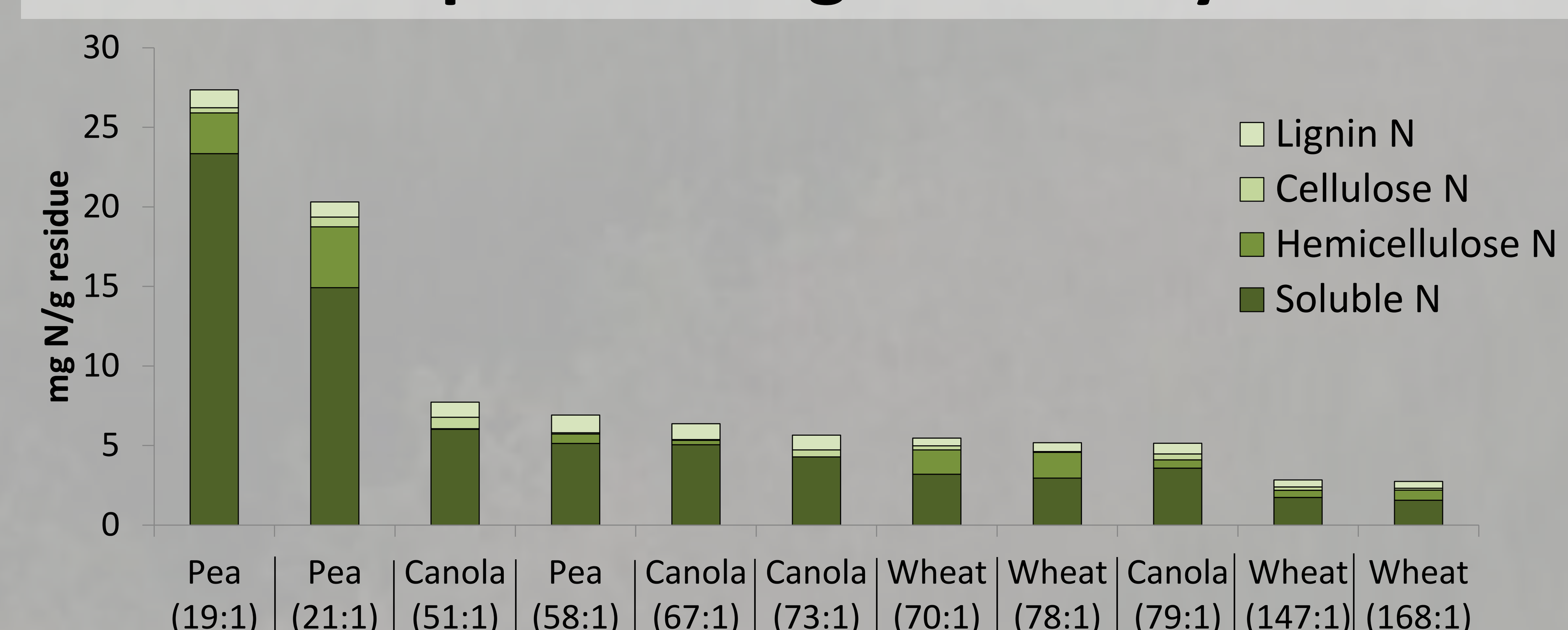
	Pea (21:1)	Canola (51:1)	Pea (58:1)	Canola (73:1)	Wheat (70:1)	Wheat (78:1)	Canola (79:1)	Wheat (147:1)	Wheat (168:1)
	g/100 g residue (%)								
NDF	47.1e*	67.3b	61.3cd	65.5bc	73.9a	72.1a	66.0bc	74.0a	78.2a
ADF	36.2e	52.5b	48.2cbd	51.1b	45.3d	49.1cbd	51.4b	46.4cd	50.7bc
ADL	7.2a	12.8a	10.6a	10.4a	11.4a	9.5a	14.0a	8.4a	9.8a
TC	42.7a	39.2a	40.3a	40.4a	38.5a	40.2a	40.7a	41.6a	46.0a
TN	2.03a	0.77b	0.69bc	0.55bc	0.55bc	0.52cd	0.51cd	0.28d	0.27d
DOC	11.7a	4.4c	9.0b	3.7c	4.3c	4.6c	3.8c	4.0c	3.3c
DON	0.448a	0.179b	0.183b	0.073bc	0.088bc	0.093bc	0.076bc	0.040c	0.030c
TIN	0.048b	0.157a	0.024bc	0.015c	0.018c	0.027bc	0.013c	0.011c	0.006c

*Mean separation for each variable by ANOVA proc mixed using the Tukey's test, p = 0.05



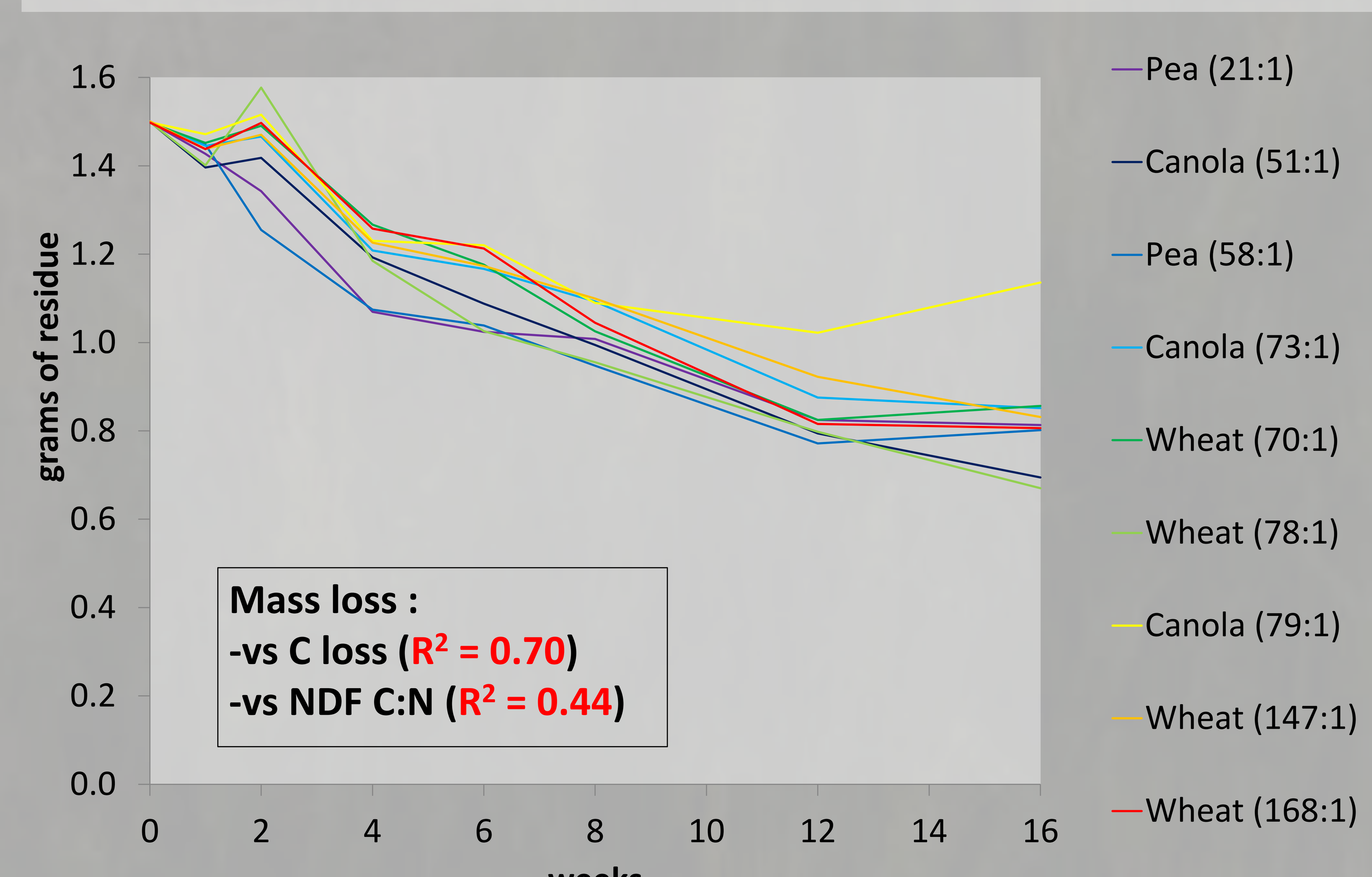


3b. N partitioning in carbohydrates



	Pea (19:1)	Pea (21:1)	Canola (51:1)	Pea (58:1)	Canola (67:1)	Canola (73:1)	Wheat (70:1)	Wheat (78:1)	Canola (79:1)	Wheat (147:1)	Wheat (168:1)
TN (%)	2.74	2.03	0.77	0.69	0.64	0.55	0.55	0.52	0.51	0.28	0.27
TC (%)	51.5	42.7	39.2	40.3	42.6	40.4	38.5	40.2	40.7	41.6	46.0

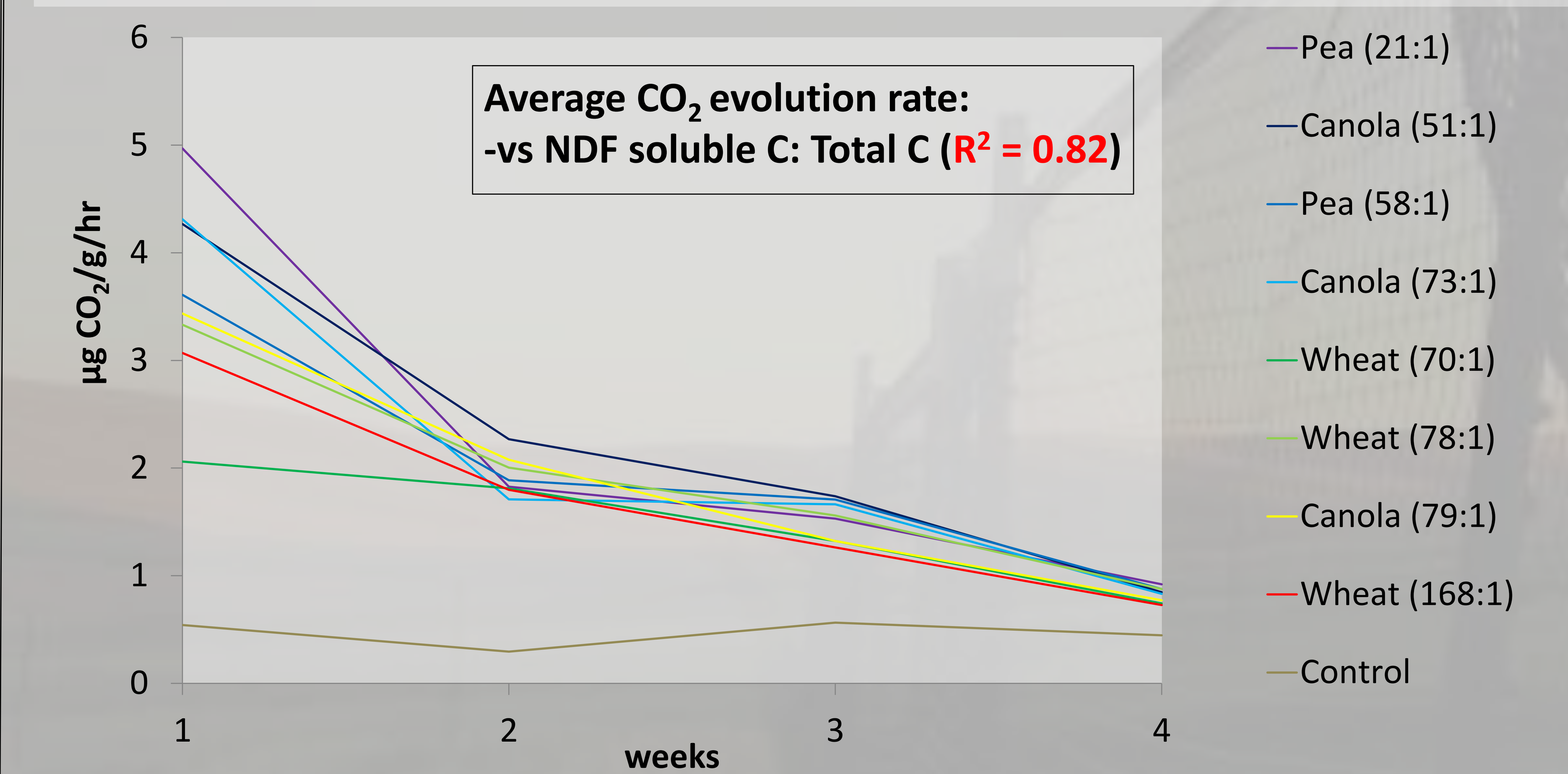
3c. Mass loss of decomposing residue



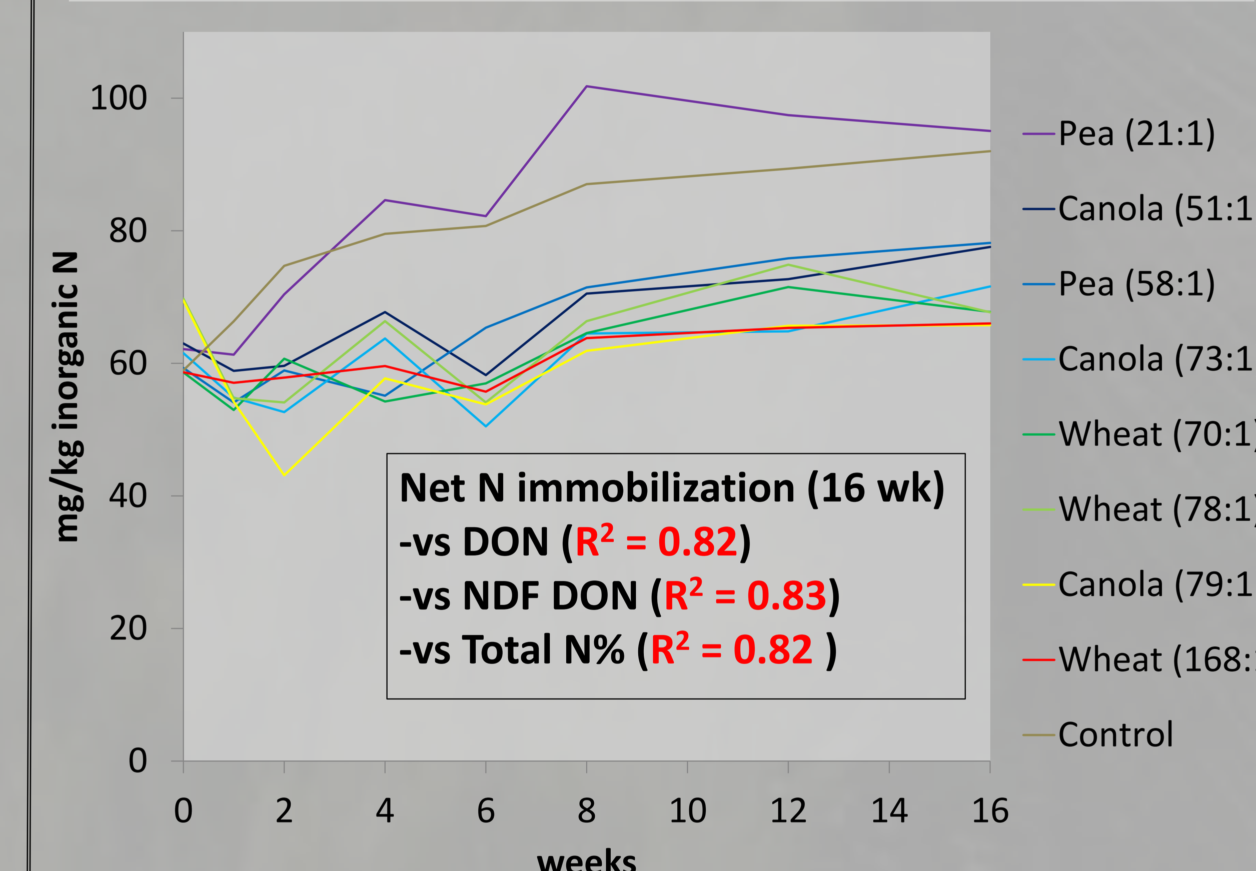
	mg N lost	mg C lost
Pea (21:1)	21.1a*	298a*
Canola (51:1)	5.7b	278ab
Pea (58:1)	2.4cd	217ab
Canola (73:1)	5.3bc	176ab
Wheat (70:1)	5.4bc	231ab
Wheat (78:1)	5.2bc	347a
Canola (79:1)	4.8bcd	67.2b
Wheat (147:1)	1.8d	278ab
Wheat (168:1)	2.5cd	356a

*ANOVA proc mixed Tukey's test, p = 0.05

3d. Weekly CO_2 evolution rates



3e. N mineralization dynamics



	Net N mineralization		
	Total	wk 16	Projected
	mg N/kg		
Pea (21:1)	-0.13a*	3.0a*	43.8
Canola (51:1)	-18.5a	-14.5ab	-8.4
Pea (58:1)	-14.2a	-13.8ab	-10.5
Canola (73:1)	-23.0a	-20.4b	-14.2
Wheat (70:1)	-23.9a	-24.3b	-14.4
Wheat (78:1)	-35.1a	-24.3b	-8.7
Canola (79:1)	-36.8a	-26.3b	-12.0
Wheat (168:1)	-25.7a	-26.0b	-21.6

*ANOVA proc mixed Tukey's test, p = 0.05

4. Discussion and conclusion

- Pea and canola residue had a higher proportion of soluble components (3a). Most residue N was easily soluble and not bound up in structural carbohydrates (3b), particularly for pea and canola (NMR spectra). DON and NDF soluble N was strongly related to the total N content of the residues (R^2 = 0.97 and 0.99).
- Over a 16 week incubation, mass and C losses were mostly similar among the residues (3c), despite differences in biochemistry.
- Within the first 4 weeks, the average CO_2 mineralization rate was strongly correlated to the readily available fraction of C that was NDF soluble (3d).
- N dynamics were largely explained by differences in TN, DON, and NDF soluble N. More net N immobilization was measured (3e) than predicted based on C and N loss in the idealized decomposition study, most likely due to the effects of soil organic matter.
- **Residues with C:N ratios above 25:1 did not differ in their net N immobilization potential, suggesting similarities in quality. However, further research needs to consider the interactive effects of residue quantity and quality on N cycling .**

5. Acknowledgements

- Engstrom, L. 2010. Nitrogen dynamics in crop sequences with winter oilseed rape and winter wheat. PhD dissertation. Swedish University of Agricultural Sciences.
- Soon, Y.K. and Arshad, M.A. 2002. Comparison of the decomposition and N and P mineralization of canola, pea, and wheat residues. Biology and Fertility of Soils. 36: 10-17.

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