

# Long-term Straw Management and N Fertilizer Rate Effects on Soil Organic C and N, and Some Chemical Properties in a Gray Luvisol

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## Introduction

- Due to recent developments in Kyoto protocol, there is a great interest to identify management practices that enhance carbon (C) sequestration in soil.
- Because the amounts of annual inputs and outputs of plant residue C are usually much smaller compared to the amounts of organic C present in the soil, it is difficult to detect changes in organic C in soil, especially in the short duration.
- Long-term studies provide such information to determine the best management practices for sustainable soil quality and productivity.
- Crop residues are a source of soil organic matter, which is the primary source and temporary sink of plant nutrients, and energy source for soil microorganisms.
- Crop residue and fertilizer management practices alter some soil properties, but the magnitude of change depends on soil type and climatic conditions.

## Objective

To determine the effects of 27 years (from 1983 to 2009 growing seasons) of straw management [straw removed ( $S_{Rem}$ ) and straw retained ( $S_{Ret}$ )] and N fertilizer rate (0, 25, 50 and 75 kg N ha<sup>-1</sup>) on soil biochemical [total organic C (TOC) and N (TON), light fraction organic C (LFOC) and N (LFON)], and chemical (pH, extractable P, ammonium-N and nitrate-N) properties under conventional tillage.

## Materials and Methods

- Field experiment with mainly barley (and canola, wheat, triticale, or pea in a few years) was conducted on a Gray Luvisol (Typic Cryoboralf) loam at Breton, Alberta, Canada.
- The treatments included two straw management (straw removed [ $S_{Rem}$ ] and straw retained [ $S_{Ret}$ ]) and four N (0, 25, 50 and 75 kg N ha<sup>-1</sup>) under conventional tillage (tilled twice, once in the autumn and once in the spring, with a chisel cultivator followed by a coil packer) in a RCBD in four replications.
- The crop was harvested every year from 1983 to 2009 for seed and straw yield.
- In autumn 2009, soil samples were taken in eight treatments where N fertilizer urea was broadcast and incorporated into soil in spring just prior to seeding, and then analyzed for various organic C and N fractions.
- The calculated data for each parameter were subjected to analysis of variance (ANOVA). Significant ( $p \leq 0.05$ ) differences between treatments were determined

using least significant difference ( $LSD_{0.05}$ ) test. Correlations between TOC, TON, LFOC and LFON, and linear regressions for relationships between crop residue C input from 1983 to 2009 growing seasons and soil organic C or N (TOC, TON, LFOC, LFON) stored in soil were calculated using the linear (REG) procedure.

### **Summary**

- $S_{Ret}$  and N fertilizer treatments usually had higher mass of TOC, TON, LFOC and LFON in soil.
- There were highly significant correlations among most soil organic C or N fractions. Linear regressions between crop residue C input and soil organic C or N were significant in most cases.
- There was no effect of residue management on soil pH, but application of N fertilizer reduced pH significantly in the top 15 cm soil.
- Extractable P in the 0-15 cm soil layer tended to be higher with  $S_{Ret}$  than  $S_{Rem}$  in many cases, but it decreased significantly with N application.
- Residual nitrate-N (though quite low) increased with application of N and also indicated some downward movement in the soil profile up to 90 cm depth.
- There was generally no effect of any treatment on ammonium-N in soil.

### **Conclusions**

- Straw retention and N application improved both total and light fraction organic C and N in soil, and generally the differences were more pronounced for light fraction organic C and N, and between the most extreme treatments ( $S_{Rem0}$  vs.  $S_{Ret75}$ ).
- Retention of straw tended to increase extractable P in the surface soil, but application of N fertilizer reduced it. Application of N fertilizer reduced pH in the surface soil, and showed accumulation and downward leaching of nitrate-N in the soil profile.

### **Acknowledgements**

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**Table 1.** Relationships among soil organic C or N fractions (TOC, TON, LFOC, LFON), or between crop residue C input from 1983 to 2009 growing seasons and organic C or N stored in soil sampled in autumn 2009 at Breton (Gray Luvisol), Alberta, Canada (experiments established in autumn, 1983)

Parameter	Correlation coefficients			
	TOC	TON	LFOC	LFON
<b>Relationships among soil organic C or N fractions</b>				
TOC		0.960***	0.855**	0.843**
TON			0.792*	0.773*
LFOC				0.993***
LFON				

**Table 2.** Linear regressions for relationships between crop residue C input from 1983 to 2009 growing seasons and organic C or N (TOC, TON, LFOC, LFON) stored in soil sampled in autumn 2009 at Breton (Gray Luvisol), Alberta, Canada (experiments established in autumn, 1983)

Crop parameter (X)	Soil C or N parameter (Y)	<sup>2</sup> Linear regression (Y = a + bX)	R <sup>2</sup>
Crop residue C input	TOC	Y = 14.20 + 0.3627X	0.954**
	TON	Y = 1.418 + 0.0279X	0.892*
	LFOC	Y = 303.55 + 33.94X	0.997**
	LFON	Y = 8.708 + 1.3484X	0.994**

<sup>2</sup>Y = Soil organic C or N fraction (TOC and TON as Mg C or N ha<sup>-1</sup>; and LFOC, LFON as kg C or N ha<sup>-1</sup>; a = Intercept on Y, origin of the line; b = Regression coefficient of Y on X, slope of line; X = Crop residue C input (Mg ha<sup>-1</sup>).

\*, \*\* and ns refer to significant treatment effects in ANOVA at P ≤ 0.05, P ≤ 0.01 and not significant, respectively.

**Table 3.** Linear regressions for relationships between the amount of N applied in various treatments from 1983 to 2009 (0, 675, 1350 and 2025 kg N ha<sup>-1</sup>) and organic C or N (TOC, TON, LFOC, LFON) stored in soil sampled in autumn 2009 at Breton (Gray Luvisol), Alberta, Canada (experiments established in autumn, 1983)

Amount of N applied (X)	Soil C or N parameter (Y)	<sup>2</sup> Linear regression (Y = a + bX)	R <sup>2</sup>
Amount of N applied in	TOC	Y = 18.99 + 0.1172X	0.997**
	TON	Y = 1.856 + 0.0081X	0.882*
	LFOC	Y = 879.5 + 6.3922X	0.713 <sup>ns</sup>
	LFON	Y = 31.76 + 0.2302X	0.680 <sup>ns</sup>
Amount of N applied in	TOC	Y = 20.71 + 0.1041X	0.934**
	TON	Y = 1.8474 + 0.009X	0.914*
	LFOC	Y = 802.66 + 13.88X	0.985**
	LFON	Y = 28.41 + 0.5741X	0.997**

<sup>2</sup>Y = Soil organic C or N fraction (TOC and TON as Mg C or N ha<sup>-1</sup>; and LFOC, LFON as kg C or N ha<sup>-1</sup>; a = Intercept on Y, origin of the line; b = Regression coefficient of Y on X, slope of line; X = Amount of N applied in various treatments from 1983 to 2009 (kg ha<sup>-1</sup>).

\*, \*\* and ns refer to significant treatment effects in ANOVA at P ≤ 0.05, P ≤ 0.01 and not significant, respectively.

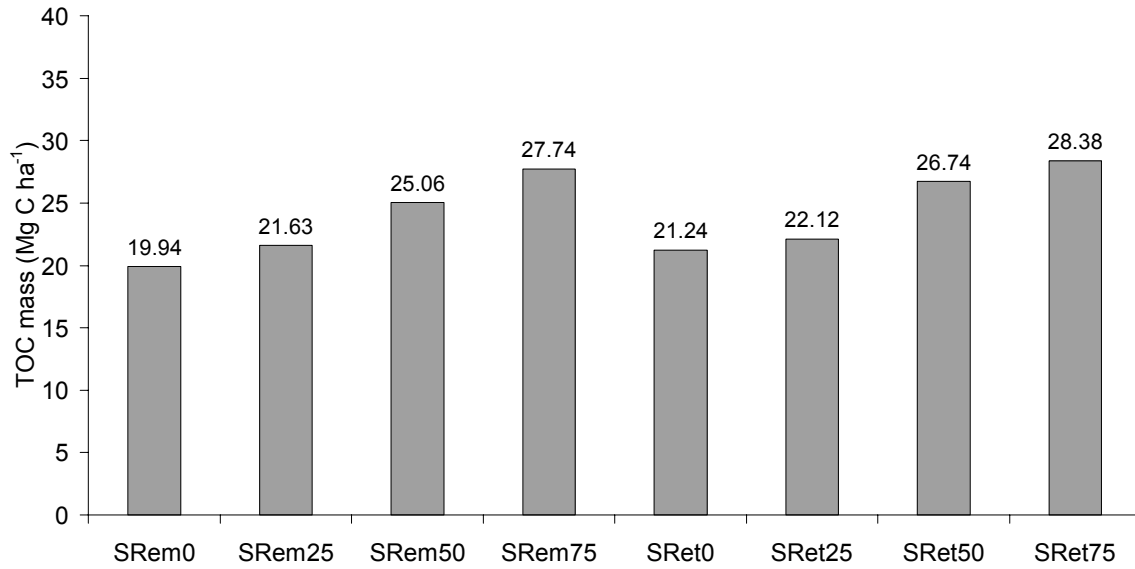


Figure 1. Effect of long-term straw management and N fertilizer rate on mass of total organic C (TOC) in soil (0-15 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 1.159\*\*\*).

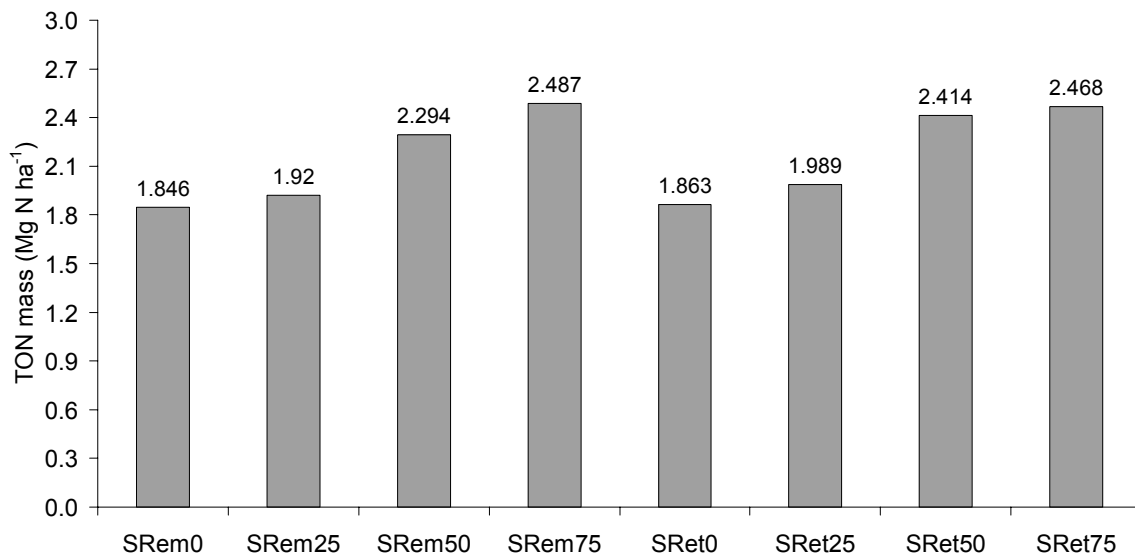


Figure 2. Effect of long-term straw management and N fertilizer rate on mass of total organic N (TON) in soil (0-15 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 0.1105\*\*\*).

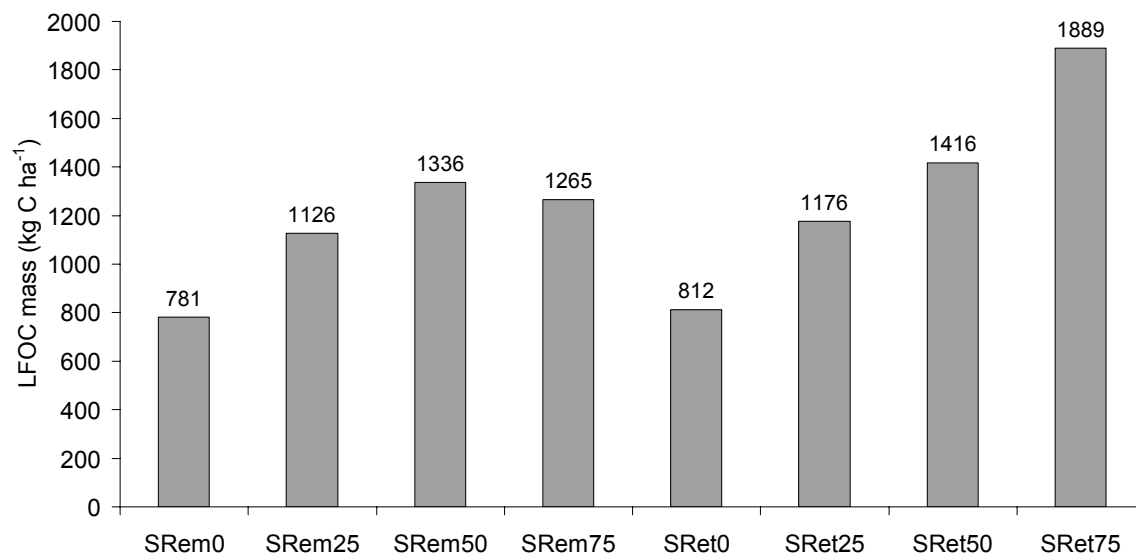


Figure 3. Effect of long-term straw management and N fertilizer rate on mass of light fraction organic C (LFOC) in soil (0-15 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 122.8\*\*\*).

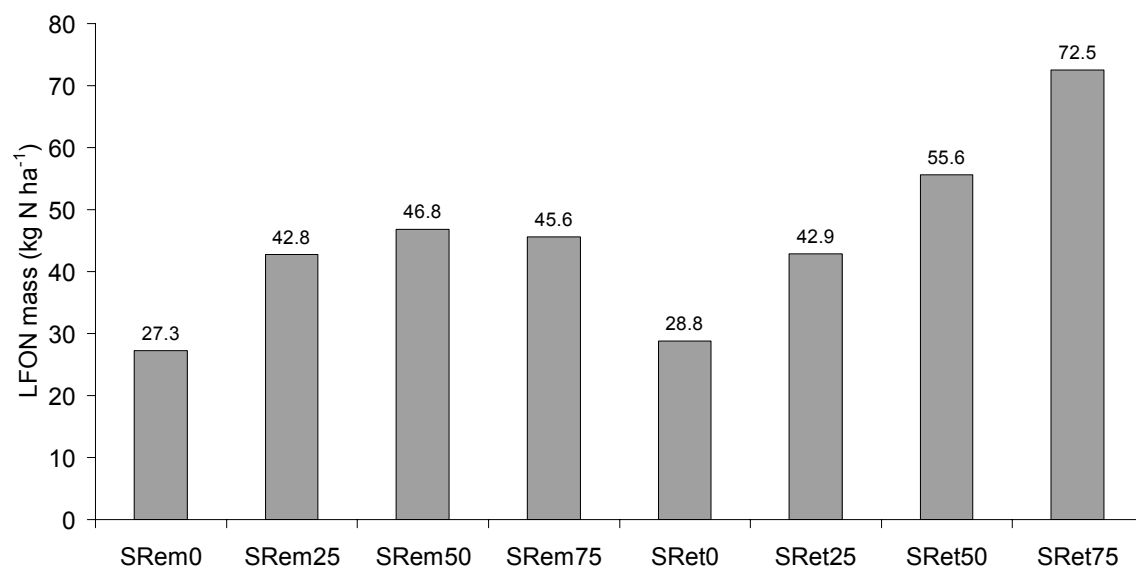


Figure 4. Effect of long-term straw management and N fertilizer rate on mass of light fraction organic N (LFON) in soil (0-15 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 4.11\*\*\*).

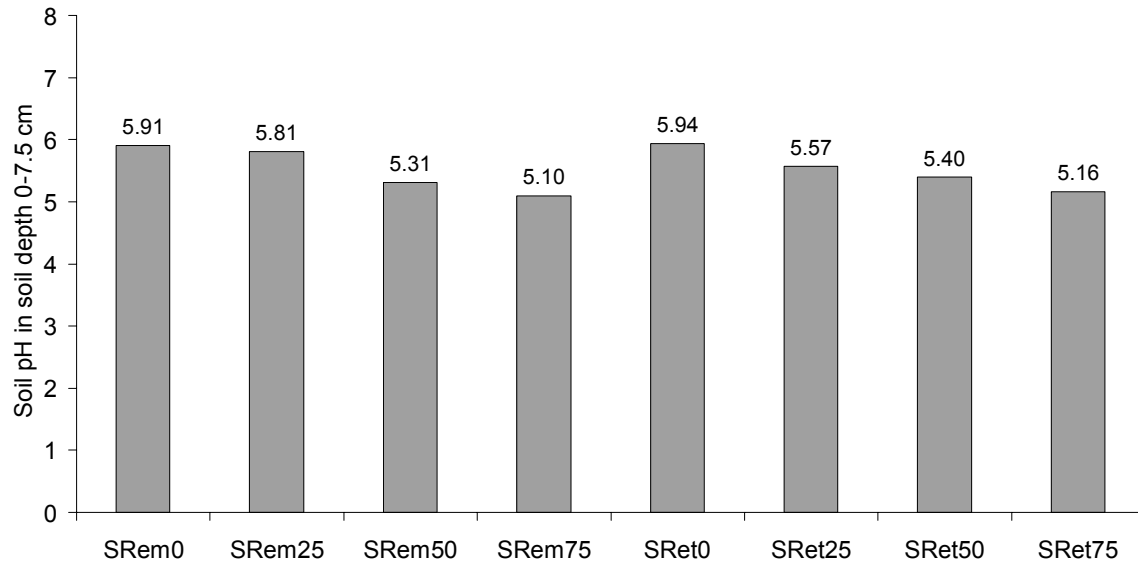


Figure 5. Effect of long-term straw management and N fertilizer rate on pH in soil (0-7.5 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 0.103\*\*\*).

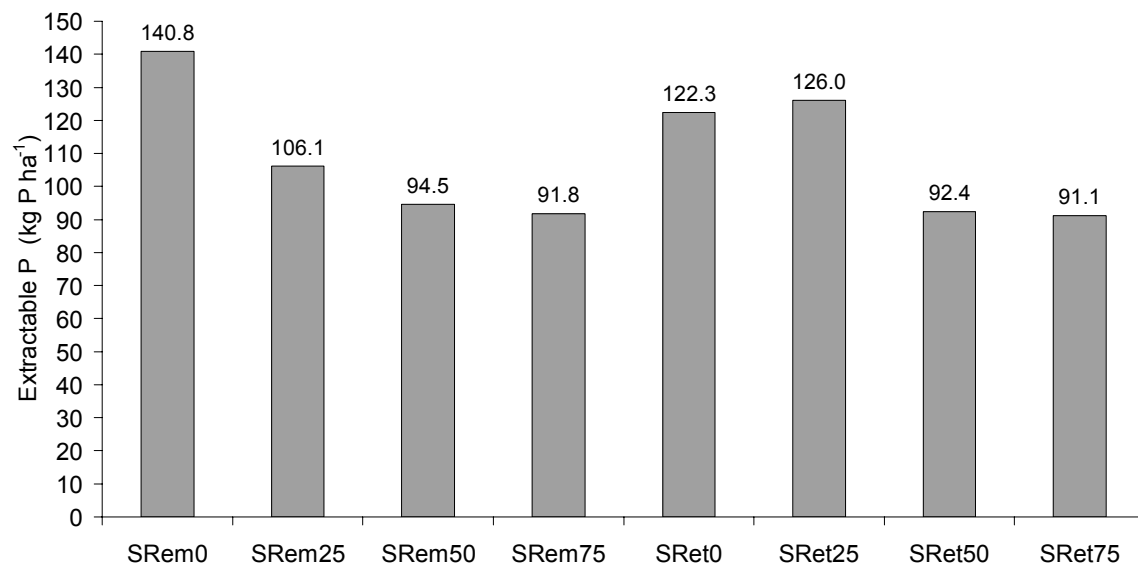


Figure 6. Effect of long-term straw management and N fertilizer rate on extractable P in soil (0-90 cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 12.01\*).

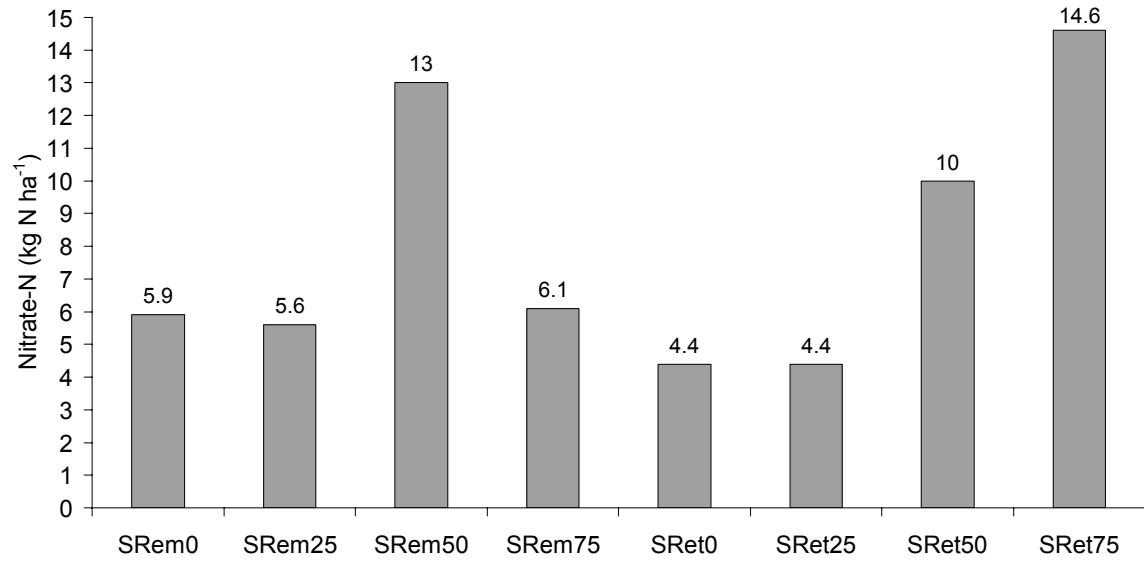


Figure 7. Effect of long-term straw management and N fertilizer rate on nitrate-N in soil (0-90cm) in autumn 2009 at Breton, Alberta, Canada (Gray Luvisol soil, experiment established in autumn 1983 ; SEM = 1.63\*\*\*).