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

**S. S. Malhi[1], M. Nyborg[2], E. D. Solberg[3], B. McConkey[4], M. Dyck[2], D. Puurveen[2] and D. Leach[1]**

[1]Agriculture and Agri-Food Canada, P.O. Box 1240, Melfort, Saskatchewan, Canada S0E 1A0;
[2]Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada;
[3]Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada;
[4]Agriculture and Agri-Food Canada, Swift Current, Saskatchewan, Canada

## 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 $ha^{-1}$) 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 Black Chernozem (Albic Argicryoll), loam at Ellerslie, 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 $ha^{-1}$) 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 had higher mass of only LFOC and LFON compared to the corresponding $S_{Rem}$ and zero-N control treatments.
- There were strong 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 7.5 cm soil, on average by 0.28 units.
- 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 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 light fraction organic C and N in soil, and generally the differences were more pronounced between the most extreme treatments ($S_{Rem}$0 vs. $S_{Ret}$75).
- 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 Ellerslie (Black Chernozem) Alberta, Canada (experiments established in autumn, 1983)

| Parameter | Correlation coefficients | | | |
|---|---|---|---|---|
| | **TOC** | **TON** | **LFOC** | **LFON** |
| **Relationships among soil organic C or N fractions** | | | | |
| TOC | | 0.952*** | $0.671^{0.07}$ | $0.832^{ns}$ |
| TON | | | 0.751* | $0.662^{0.07}$ |
| LFOC | | | | 0.965*** |
| 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 2009at Ellerslie Black Chernozem), Alberta, Canada (experiments established in autumn, 1983)

| Crop parameter (X) | Soil C or N parameter (Y) | $^{z}$Linear regression (Y = a + bX) | $R^2$ |
|---|---|---|---|
| Crop residue C input | TOC | Y = 87.929 +0.0886X | $0.079^{ns}$ |
| | TON | Y = 7.2739 + 0.0132X | $0.252^{ns}$ |
| | LFOC | Y = 379.17 +63.199X | 0.882* |
| | LFON | Y = -4.169 + 3.9408X | 0.938** |

$^{z}$Y = Soil organic C or N fraction (TOC and TON as Mg C or N $ha^{-1}$; and LFOC, LFON as kg C or N $ha^{-1}$; a = Intercept on Y, origin of the line; b = Regression coefficient of Y on X, slope of line; X = Crop residue C input (Mg $ha^{-1}$).
*, ** 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 $ha^{-1}$)) and organic C or N (TOC, TON, LFOC, LFON) stored in soil sampled in autumn 2009 at Ellerslie Black Chernozem), Alberta, Canada (experiments established in autumn, 1983)

| Amount of N applied (X) | Soil C or N parameter (Y) | $^{z}$Linear regression (Y = a + bX) | $R^2$ |
|---|---|---|---|
| Amount of N applied in $S_{Rem}$ | TOC | Y = 90.22 + 0.0004X | $0.005^{ns}$ |
| | TON | Y = 7.642 + 0.0012X | $0.080^{ns}$ |
| | LFOC | Y = 1929.2 + 9.528X | $0.650^{ns}$ |
| | LFON | Y = 90.385 + 0.765X | 0.884* |
| Amount of N applied in $S_{Ret}$ | TOC | Y = 89.42 + 0.0555X | $0.543^{ns}$ |
| | TON | Y = 7.5163 + 0.006X | $0.717^{ns}$ |
| | LFOC | Y = 2073.5 + 15.27X | 0.985** |
| | LFON | Y = 103.7 + 0.8018X | 0.982** |

$^{z}$Y = Soil organic C or N fraction (TOC and TON as Mg C or N $ha^{-1}$; and LFOC, LFON as kg C or N $ha^{-1}$; 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 $ha^{-1}$).
*, ** and ns refer to significant treatment effects in ANOVA at P ≤ 0.05, P ≤ 0.01 and not significant, respectively.

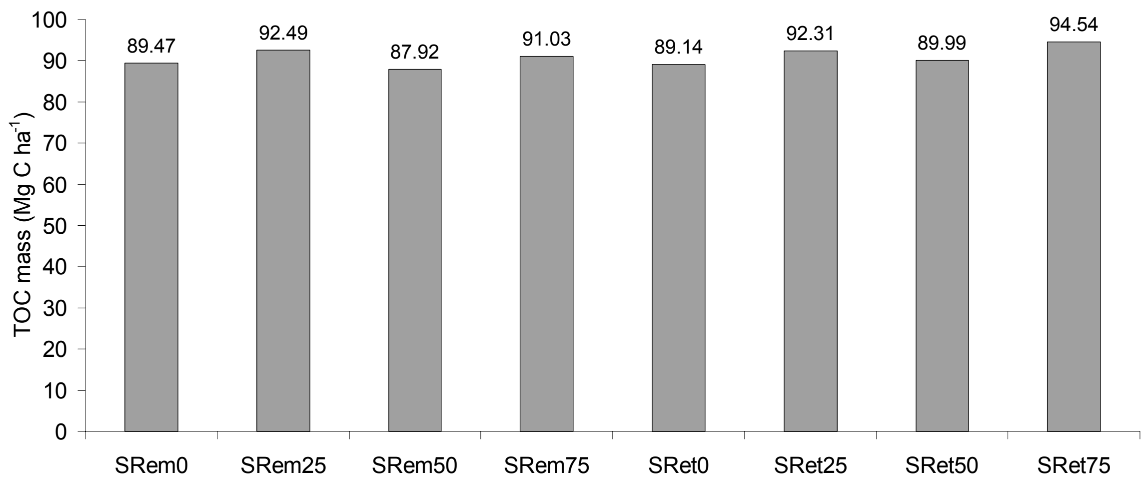


Figure 1. Effect of long-term straw management and N fertilizer rate on mass of total organic C (TOC) in soil (0-15 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 2.082ns).

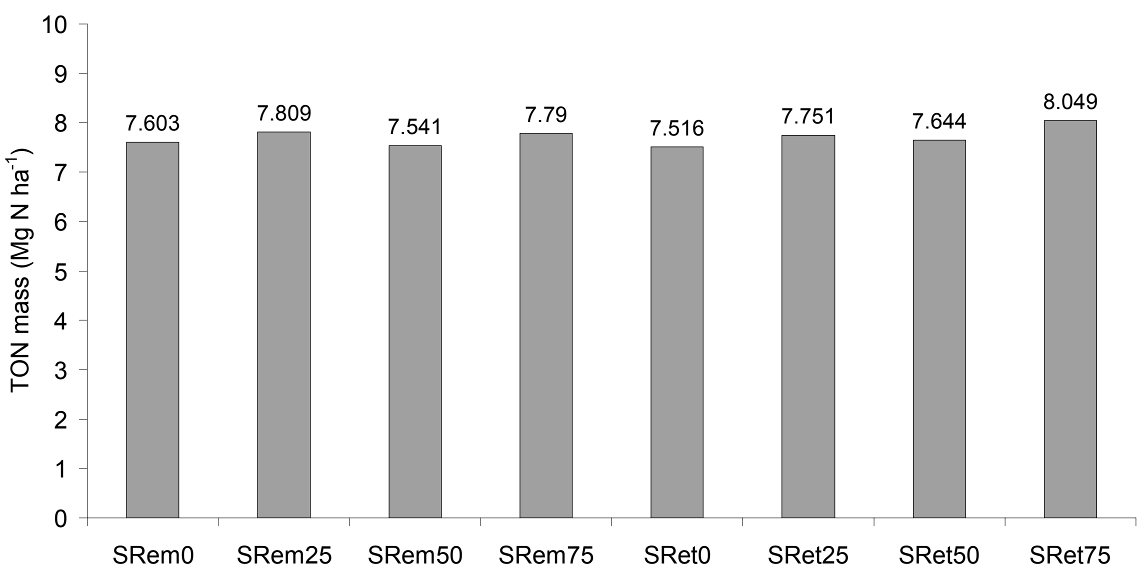


Figure 2. Effect of long-term straw management and N fertilizer rate on mass of total organic N (TON) in soil (0-15 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 1.476ns).

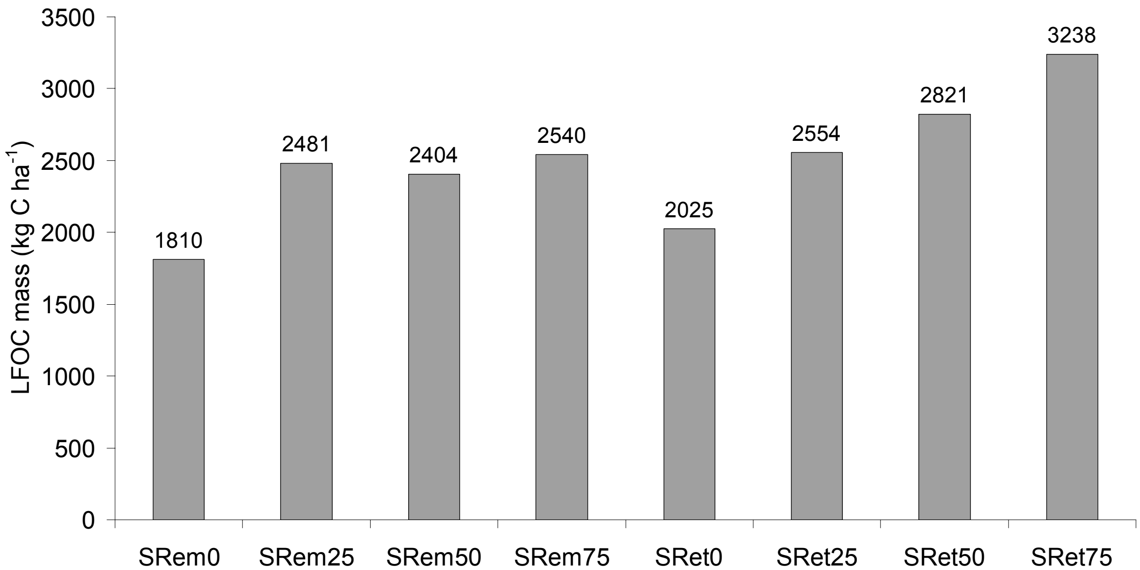


Figure 3. Effect of long-term straw management and N fertilizer rate on mass of light fraction organic C (LFOC) in soil (0-15 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 179.0***).

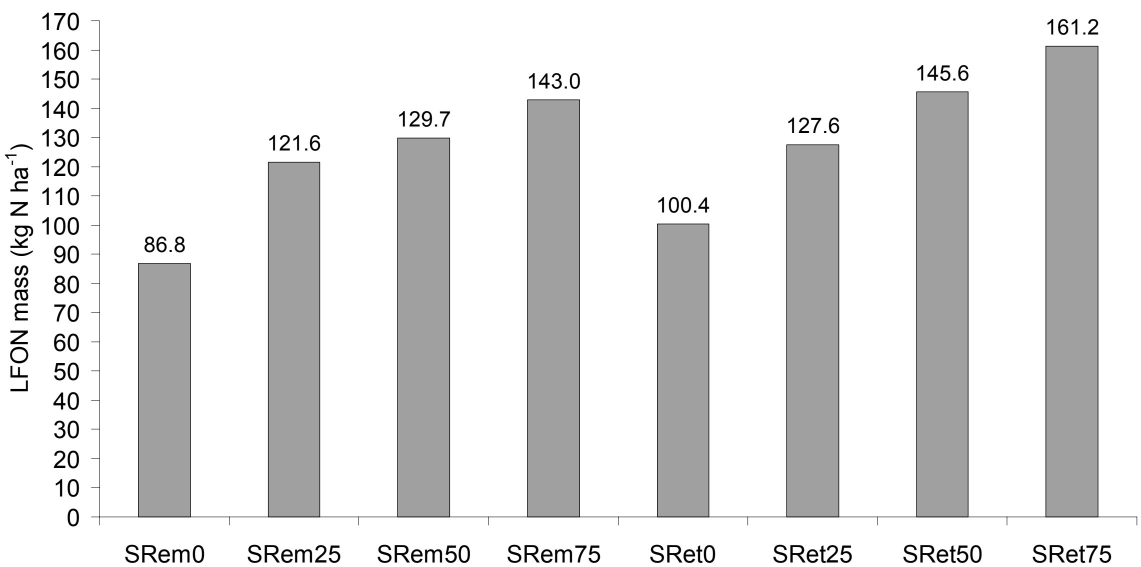


Figure 4. Effect of long-term straw management and N fertilizer rate on mass of light fraction organic N (LFON) in soil (0-15 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 8.67***).

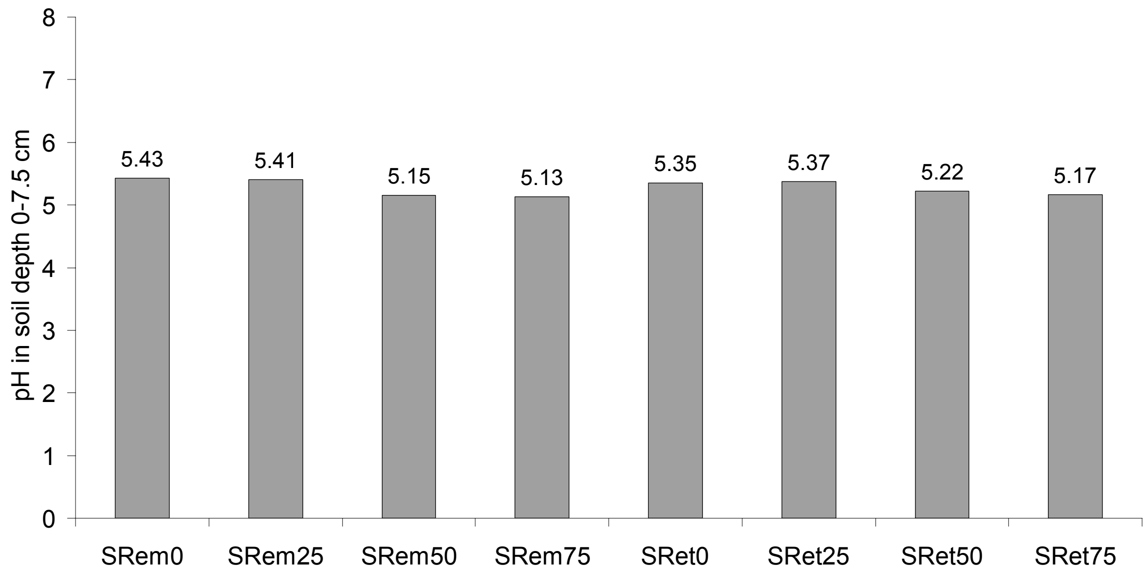


Figure 5. Effect of long-term straw management and N fertilizer rate on pH soil (0-7.5 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 0.056**).

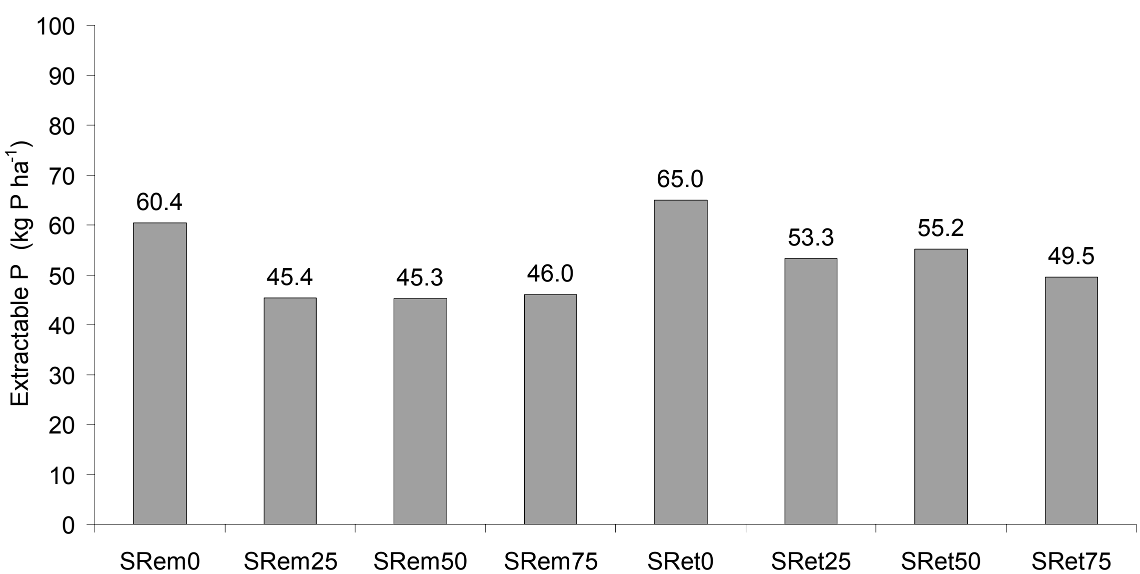


Figure 6. Effect of long-term straw management and N fertilizer rate on extractable P in soil (0-90 cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 6.68ns).

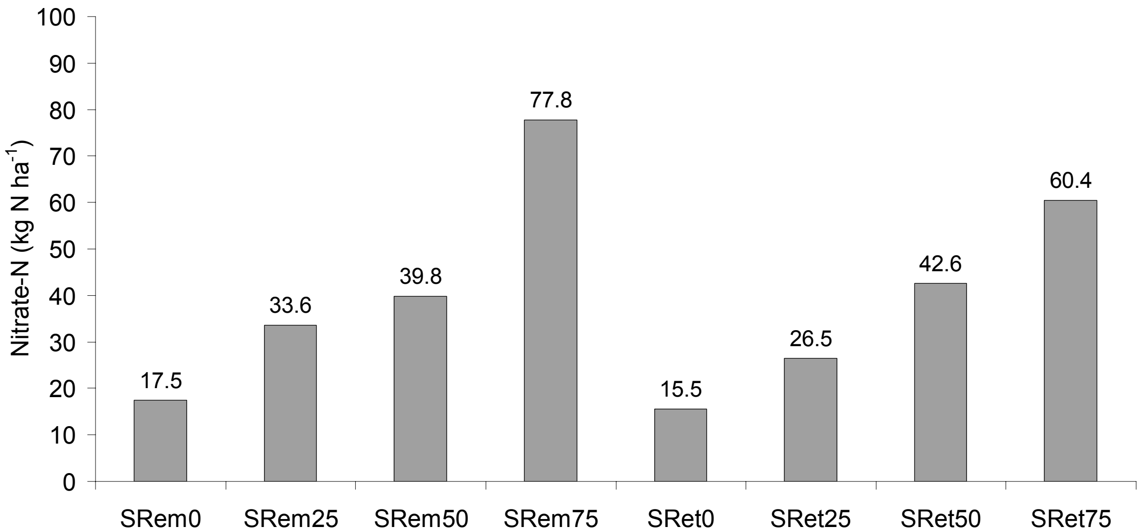


Figure 7. Effect of long-term straw management and N fertilizer rate on nitrate-N in soil (0-90cm) in autumn 2009 at Ellerslie, Alberta, Canada (Black Chernozem soil, experiment established in autumn 1983; SEM = 8.01***).