IMPROVING ORGANIC C AND N IN A SULPHUR-DEFICIENT SOIL WITH S FERTILIZATION

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Abstract
A field experiment was conducted over nine years (1999 to 2007 growing seasons) in northeastern Saskatchewan on a S-deficient Gray Luvisol (Typic Haplocryalf) soil to determine the relative effectiveness of N alone versus combined annual application of N (120 kg N ha^{-1}) and S (15 kg S ha^{-1}) fertilizers to wheat-canola rotation on storage of total organic C [TOC and N (TON), and light fraction organic C (LFOC) and N (LFON)] in soil. Compared to N alone, annual applications of S fertilizer in spring in a combination with N resulted in an increase of TOC (by 2.18 Mg C ha^{-1}), TON (by 0.138 Mg N ha^{-1}), LFOC (by 1018 kg C ha^{-1}) and LFON (by 42 kg N ha^{-1}) mass in soil. The relative increases in organic C or N due to S fertilizer application were much higher for light organic fractions (36.9% for LFOC and 27.5% for LFON) than for total organic fractions (9.2% for TOC and 7.3% for TON). The findings suggest the importance of balanced/combined application of N and S fertilizers to crops in storing more organic C and N in S-deficient soil, but further research is needed on a number of S-deficient sites.

Rationale and Objective
Sustainability of agricultural production is linked to soil quality, which in turn is influenced by soil organic matter (SOM) or carbon (SOC). Fertilization is one of the major and direct agronomic practices that can increase SOC by alleviating nutrient deficiencies in crops. In most long-term experiments, application of fertilizer nutrients was limited to nitrogen (N), N and phosphorus (P) and/or N, P and potassium (K). Long-term combined annual applications of N and sulphur (S) fertilizers to native grass forage grown on S-deficient soil in northern Saskatchewan substantially increased forage yield and SOC compared to N alone (zero-S control treatment). However, the information is lacking on the effects of S fertilization to annual crops on soil organic C and N, especially in the Parkland region, where many Gray and Dark Gray soils are deficient in available S for optimum crop yield, especially for *Brassica* oilseeds. The objective of this study was to determine the relative effectiveness of N alone versus combined annual applications of N (120 kg N ha^{-1}) and S (15 S ha^{-1}) fertilizers to wheat-canola rotation on storage of total organic C [TOC and N (TON), and light fraction organic C (LFOC) and N (LFON)] in the surface soil on a S-deficient Gray Luvisol in northeastern Saskatchewan.

Materials and Methods
A field experiment in wheat-canola rotation was conducted over nine years (1999 to 2007) on a S-deficient Gray Luvisol (Typic Haplocryalf) loam soil (1.8 mg SO4-S kg^{-1}) at Porcupine Plain, Saskatchewan. There were 9 treatments, arranged in a RCBD on 1.8 m x 7.5 m plots in four replications. In this report we used only two treatments: 1. Zero-S control and 2. Spring-applied S. The S fertilizer (ammonium sulphate) was applied at 15 kg S ha^{-1}, surface-broadcast and incorporated into soil annually in spring. In spring, all plots (including control) received blanket annual applications of 120 kg N ha^{-1} (as ammonium nitrate), 30 kg P ha^{-1} (as triple super phosphate) and 20 kg K ha^{-1} (as KCl – muriate of potash), surface-broadcast and incorporated into soil to a depth of 8 cm prior to seeding. Each plot was harvested for seed and straw yield.

After nine growing seasons, soil samples were obtained from the 0-15 cm depth in October 2007. Data were collected/calculated on total organic C (TOC), total organic N (TON), light fraction organic matter (LFOM), light fraction organic C (LFOC) and light fraction organic N (LFON) mass in soil.

Summary of Results (Figures 1 to 6)

The mass of TOC, TON, LFOC and LFON in the 0-15 cm soil layer was greater when N and S fertilizers were applied together compared to N fertilizer alone. Compared to N alone, application of S in a combination with N increased TOC by 2.18 Mg C ha^{-1} (9.2%), TON by 0.138 Mg N ha^{-1} (7.3%), LFOC by 1018 kg C ha^{-1} (36.9%) and LFON by 42 kg N ha^{-1} (27.5%) in soil. The mass of TOC, TON, LFOC or LFON in soil were closely associated with cumulative amounts of crop residue C or N inputs.

Conclusions

Compared to N alone, annual applications of S fertilizer in a combination with N to wheat-canola rotation increased storage of TOC, TON, LFOC and LFON in our extremely S-deficient soil, especially for canola, by returning more crop residue C and N. Our findings demonstrate the importance of balanced/combined application of N and S fertilizers to crops in storing more organic C and N in soils, lacking in these nutrients.

Acknowledgements

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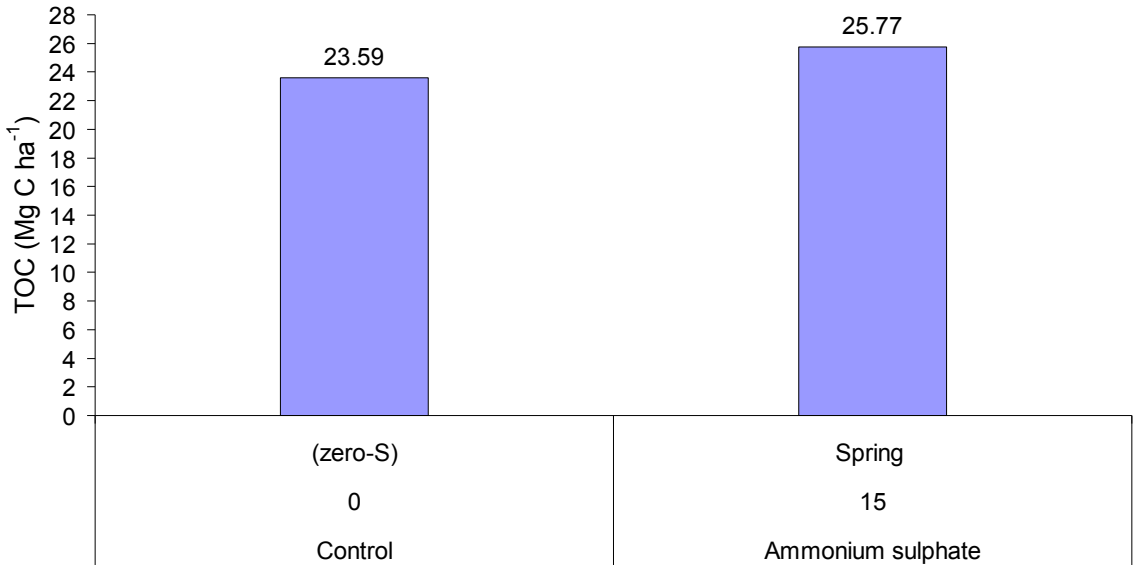

Figure 1. Mass of total organic C (TOC) in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 1.668).

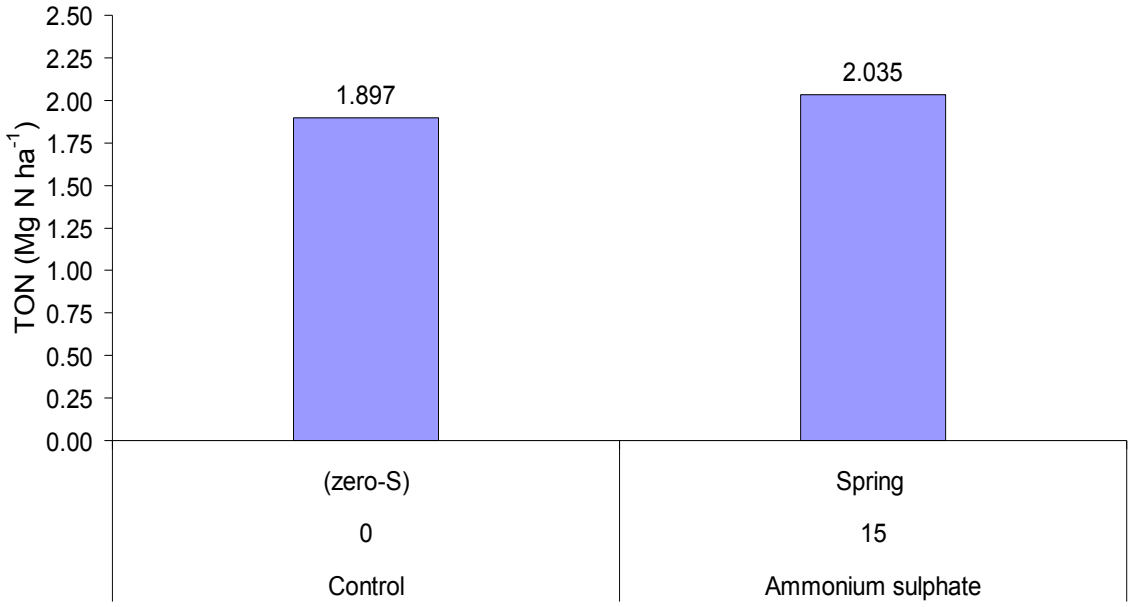

Figure 2. Mass of total organic N (TON) in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 0.0831).

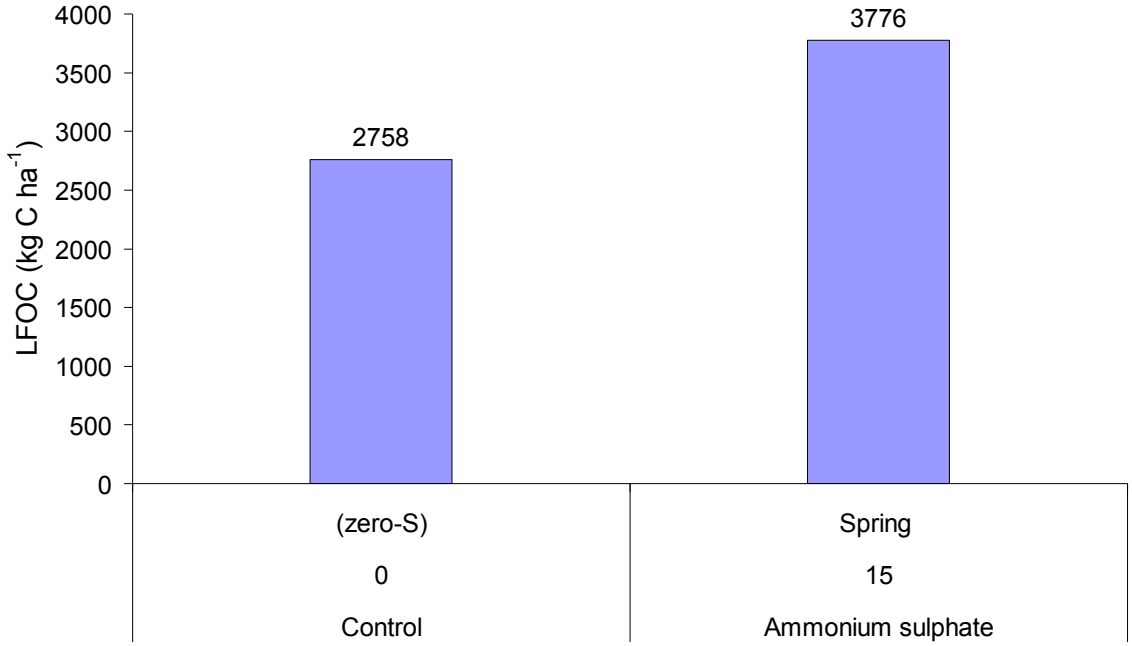

Figure 3. Mass of light fraction organic C (LFOC), in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 536.4).

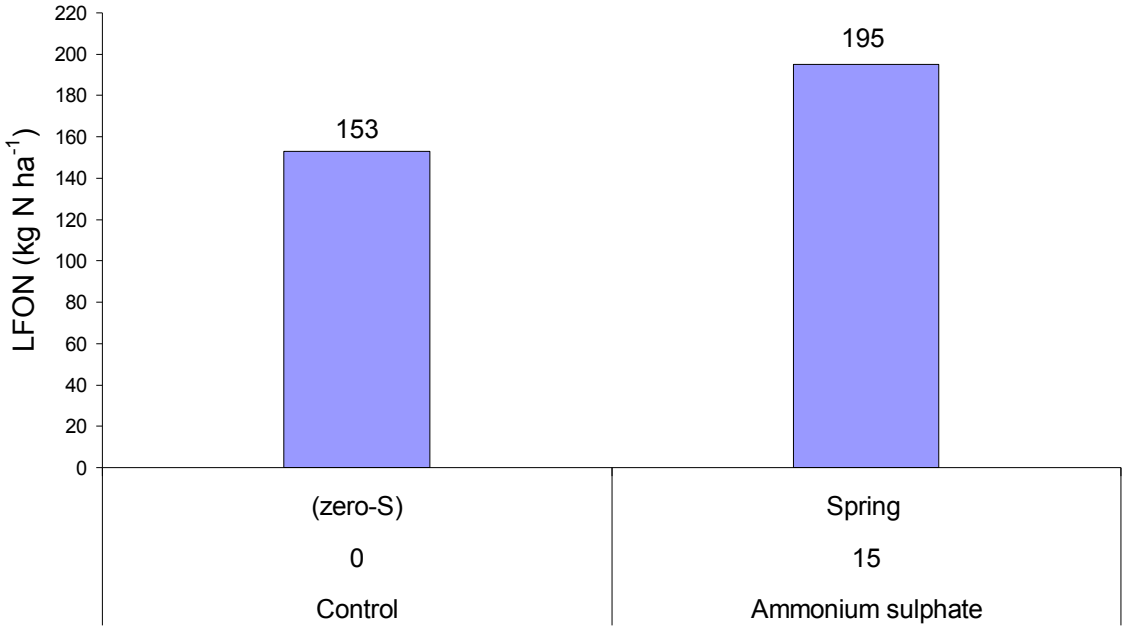

Figure 4. Mass of light fraction organic N (LFON), in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 25.2)..

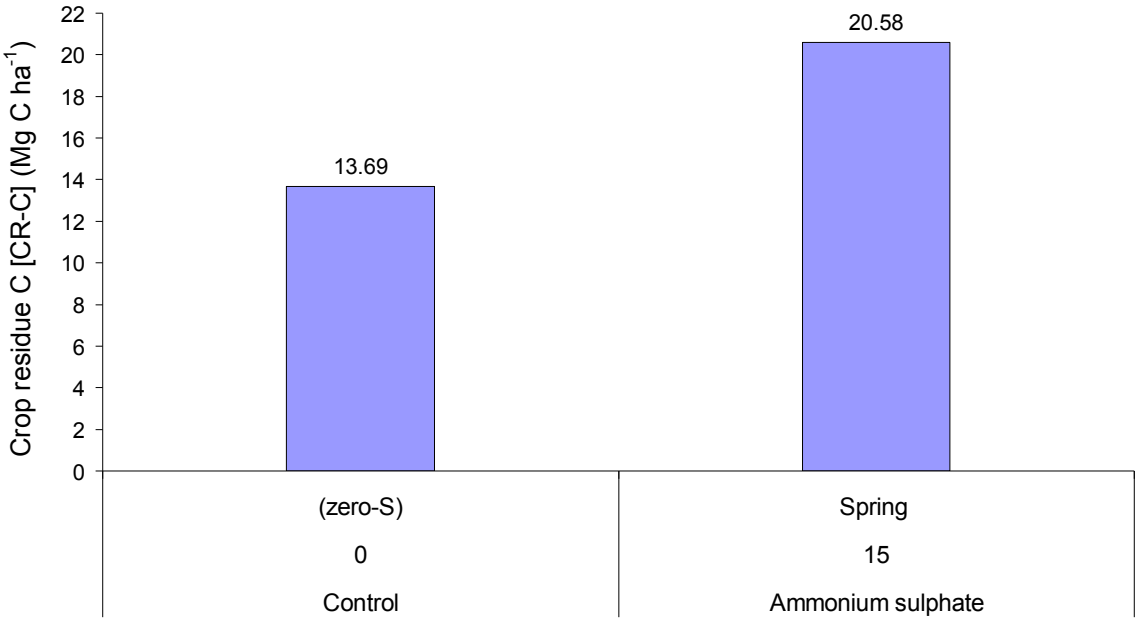

Figure 5. Cumulative inputs of crop residue C (CR-C), in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 0.550).

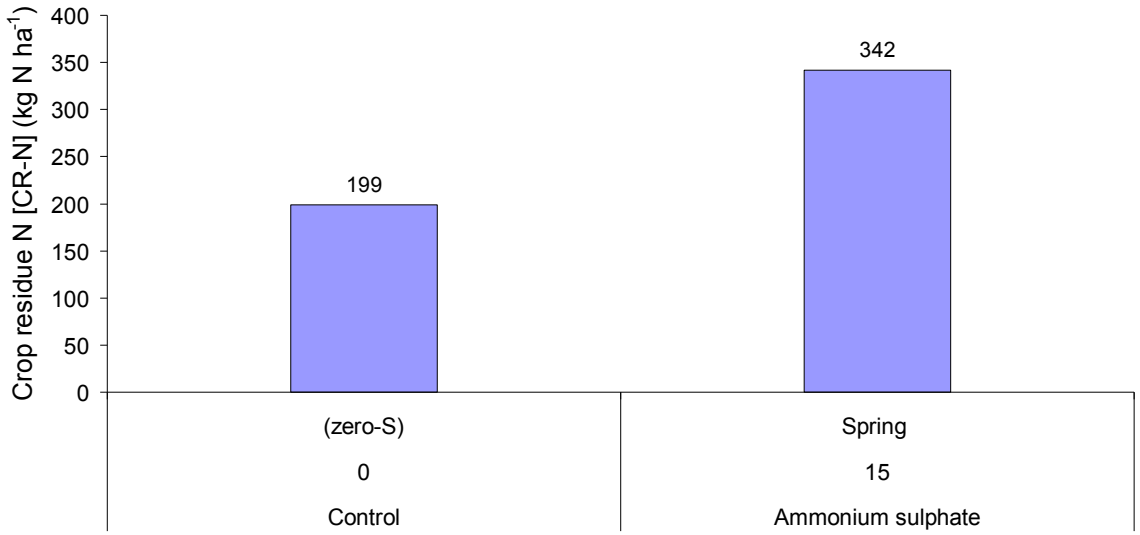

Figure 6. Cumulative inputs of crop residue N (CR-N), in 0-15 cm soil, in autumn 2007 after nine annual applications (1999 to 2007) at Porcupine Plain in northeastern Saskatchewan (SEM = 14.7).