Effect of forages in crop rotations on soil carbon levels at the UofA Breton Plots

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Acknowledgements

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• Previous Breton Plots Researchers
Welcome to The Breton Plots:
An Alberta Registered Historic Resource

A Research Site for Several
Medium- & Long-Term Field Experiments
Gray Luvisol

D. Brown Chernozem
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East half Classical = Limed; Classical Rotation Sequence: Wheat- Oats -Barley/Hay-Hay-Hay-Hay
Hendrigan Rotation Sequence: Barley-Barley-Fababeans-Barley-Barley/Hay-Hay-Hay-Hay
CG=Continuous Grain; CF=Continuous Fescue; m=manure

Rates expressed as elemental N-P-K-S (kg/ha)
Perennials in rotations

• Classial Plots: *Alfalfa-Brome*
  – year 4 and 5 of 5-year Wheat-Oats-Barley-Hay-Hay (WOBHH) rotation
  – year 3 Barley under-seeded to Alfalfa-Brome
  – ploughed under after year 5 harvest

• Hendrigan Plots
  – Hendrigan rotation: continuous *creeping red fescue, tall fescue and white “Dutch” clover.*
  – 8-year cereal-cereal-fababeans-cereal-cereal-hay-hay-hay-hay
    • *alfalfa-brome hay*
C sequestration in WOBHH

• NPKS $\rightarrow$ 0.0135 % yr$^{-1}$ $\sim$ 0.28 Mg C ha$^{-1}$ yr$^{-1}$
• NPK $\rightarrow$ 0.0084 % yr$^{-1}$ $\sim$ 0.18 Mg C ha$^{-1}$ yr$^{-1}$

• don’t have reliable estimates for CF, CW, and Agroecological rotation, but we have archived samples from 1980, 2003, 2008, 2013
2013, 2014 Growing Season cumulative $\text{N}_2\text{O}$ emissions

$r = 0.7; P<0.01$
discussion

• source of N$_2$O fluxes include fertilizers, biologically fixed N, previous crop residues

• Farrell et al. (2014)* → more N$_2$O from crop residues than from fertilizer (lab incubation)

• including perennials in rotations (2 – 5 years) increases soil carbon, but requires intermittent disturbance – stimulates nitrification and N$_2$O emissions

discussion cont’d

• may not be the same relationship between total soil carbon and N₂O emissions in “permanent” perennial cover and/or other soil types. If there is a land use change in the future, there is potential for increase N₂O emissions at that time which needs to be included in the C balance

• more efficient nutrient cycling at Breton (Gray Luvisol) compared to Ellerslie (Black Chernozem)
  – twice as much C and N mineralization per total soil C and N in Breton soil compared to Ellerslie in a 10-day incubation (Rutherford and Juma, 1989ab*)
  – “Breton microbes are lean and mean; Ellerslie microbes are fat and lazy” (Tom Goddard)

WOBHH soil C balance

• 0.28 Mg C ha\(^{-1}\) yr\(^{-1}\) = 1.0 Mg CO\(_2\) ha\(^{-1}\) yr\(^{-1}\) (Maybe some methane?)

• 0.003 Mg N\(_2\)O ha\(^{-1}\) yr\(^{-1}\) or 3 kg N\(_2\)O ha\(^{-1}\) yr\(^{-1}\) would offset this sequestration.

• cumulative growing season N\(_2\)O flux in NPKS from WOBHH is 2.5 kg N\(_2\)O ha\(^{-1}\) yr\(^{-1}\)

• more N\(_2\)O is released during freezing and thawing.
Conclusions

• continuous forage had greatest Soil C levels after 30 years

• soil still sequestering C after 80 years of agriculture in some treatments of the Breton Classical plots, but this may be offset by increased N$_2$O emissions.

• N$_2$O fluxes need to be considered in C balance of mixed annual-perennial and permanent perennial systems (cradle to grave)