Non-bloat legumes alter pasture soil greenhouse gas fluxes, nutrient cycling rates, & microbial community structure

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Introduction
- Pasture grazing systems act as both sources and sinks of greenhouse gases (GHGs), including methane (CH₄) and nitrous oxide (N₂O).
- Cattle producers use non-bloat legumes to increase cattle protein uptake, decrease enteric CH₄ emissions, and revitalize pasture productivity.
- Introducing non-bloat legumes to grass systems can shift soil microbial communities with unknown effects on nutrient cycling and GHG fluxes.

Objective
- Determine how the introduction of two non-bloat legumes affects soil microbial community structure, nutrient cycling, and GHG fluxes in a grass pasture.

Materials & Methods
- Midslope positions (n = 3 per paddock) were sampled in 2017 & 2018.
- GHG fluxes were sampled from sealed chambers.
- Three soil cores were sampled at 0-10 cm depth for (D) microbial phospholipid fatty acid (PLFA) composition and (E) enzyme activity.

Site Location & Plot Layout
Termuende Research Ranch
Lanigan, SK, CAN

Climate: Annual Averages
Temp. 1.7°C
Min. Temp. -23.1°C
Max. Temp. 24.8°C
Precipitation
2017 372 mm
2018 272 mm
2018 263 mm

Seasonal Pasture Conditions Outweighed Legume Influences on Soil Microbes

Figure 1: Non-metric multidimensional scaling (NMDS) plot of Bray-Curtis PLFA data constructed using R package Vegan. Ellipses are yearly 95% confidence intervals.
- Microbial community composition shifted from June (yellow) to September (blue) (Fig. 1).
- Legume microbial communities shifted from control communities mid-summer (Fig. 1: red) and after precipitation (Fig. 1: 2017 red and blue).
- Increased soil nitrate (NO₃⁻) and lower dissolved organic carbon (DOC) under legume pastures gave rise to distinct communities and higher N₂O fluxes in 2017 (Fig. 2A).

Figure 2: Distance-based redundancy analysis (dbRDA) and PerMANOVA models of factors contributing to observed microbial community structure. Models constructed using R package Vegan. *P = 0.001, n = 135 for each dbRDA and PerMANOVA model. Pie slices are proportional to variance explained by each factor.
- More variable precipitation in 2017 resulted in a larger influence of moisture and NO₀ on microbial community structure (Fig. 2B).
- Lower moisture variability and minimal pasture plant productivity in 2018 resulted in a much larger influence of plant production on community structure (Fig. 2D).

Non-bloat legumes had a small but significant effect on microbial community structure.

Cicer Milkvetch Decreases AMF Abundance, Increases N₂O Emissions

Figure 3: Structural equation model (SEM) of 2017 pasture effects on N₂O emissions. Constructed using R package lavaan. *P = 0.233, RMSEA = 0.037, SRMR = 0.057.
- Structural equation modelling (SEM) revealed forage legumes increase soil nitrate levels relative to the control (Fig. 3).
- Moisture had a strong positive influence on N₂O emissions, soil N levels, and microbial community structure.
- Ammonium production was lower in cicer milkvetch pastures, partially due to decreased soil organic N cycling by N-acetyl glucosaminidase.
- Cicer milkvetch lowered arbuscular mycorrhizal fungi (AMF) abundance.
- Higher AMF abundance was associated with lower N₂O emissions.

Cicer milkvetch pastures increased soil NO₃⁻ content and decreased AMF abundance, increasing the magnitude of N₂O fluxes. The presence of AMF can decrease N₂O emissions through competition for soil N⁶.

Conclusions
- The small, significant effect of forage legumes on soil microbial community composition was outweighed by declining pasture plant productivity, variable moisture, and seasonal changes in pasture conditions.
- The potential for increased N₂O emissions in productive cicer milkvetch pastures must be weighed against the expected benefits of reduced enteric cattle CH₄ emissions.

Acknowledgements: Funding for this research is provided by the Canadian Agricultural Partnership’s (CAP) Agricultural Greenhouse Gases Program (AGGP).