Comparing Constant and Variable Rate Applications of Solid Cattle Manure on Greenhouse Gas Emissions From Dark Brown Chernozems

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INTRODUCTION

- Field application of solid cattle manure (SCM) is an alternative, low-cost nitrogen (N) source to conventional synthetic fertilizers.
- Gaseous losses of manure-N (e.g., NH_3, N_2O, NO, and N_2), occurring via volatilization and denitrification, are well documented. However, the effect of precision applications, including variable rate application, of livestock manure on gaseous N emissions at a landscape-scale has received less attention.

OBJECTIVE

- Compare the nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) fluxes from watershed basins within the same field, with and without the addition of fresh feedlot SCM applied at either constant blanket or variable landscape adjusted rates.

MATERIALS & METHODS

- The field site is located at the Beef Cattle Research and Teaching Unit (U of S Livestock Forage Center of Excellence) near Clavet, SK. The loam field soils (Bradwell Association) primarily consist of Orthic Dark Brown Chernozems, with Eluviated Dark Brown Chernozems in shallow depressional areas: E.C. 0.2 dS/m, pH 6.7, and 3.0% soil organic carbon (average site values).
- In the spring of 2019, three field treatment zones were established: i) non-manured, ii) SCM applied at a constant rate (45 T/ha = 270 kg N/ha), and iii) SCM applied at a variable rate (135-404 kg N/ha) based on historical crop productivity from Echelon^{TM} NDVI imagery and with increased rates in low productivity areas and decreased rates in high productivity areas. Watershed basins were avoided.
- Prior to seeding silage barley (cv. Ranger; *Hordeum vulgare*) each year, all treatment zones received fertilizer N (80 kg N/ha), to prevent N-deficiency.
- Gas sampling locations were established in two basins (0.3-0.6 ha) within each treatment zone and classified using their catchment area (m^2): small (<500), medium (500-1000), and large (>1000). Gas samples were manually collected (at minimum weekly) in 2019 and 2020, using non-steady state vented chambers, from prior to seeding until the soil froze. The gas sample N_2O, CO_2, and CH_4 concentrations were used to estimate cumulative seasonal fluxes.

RESULTS & DISCUSSION

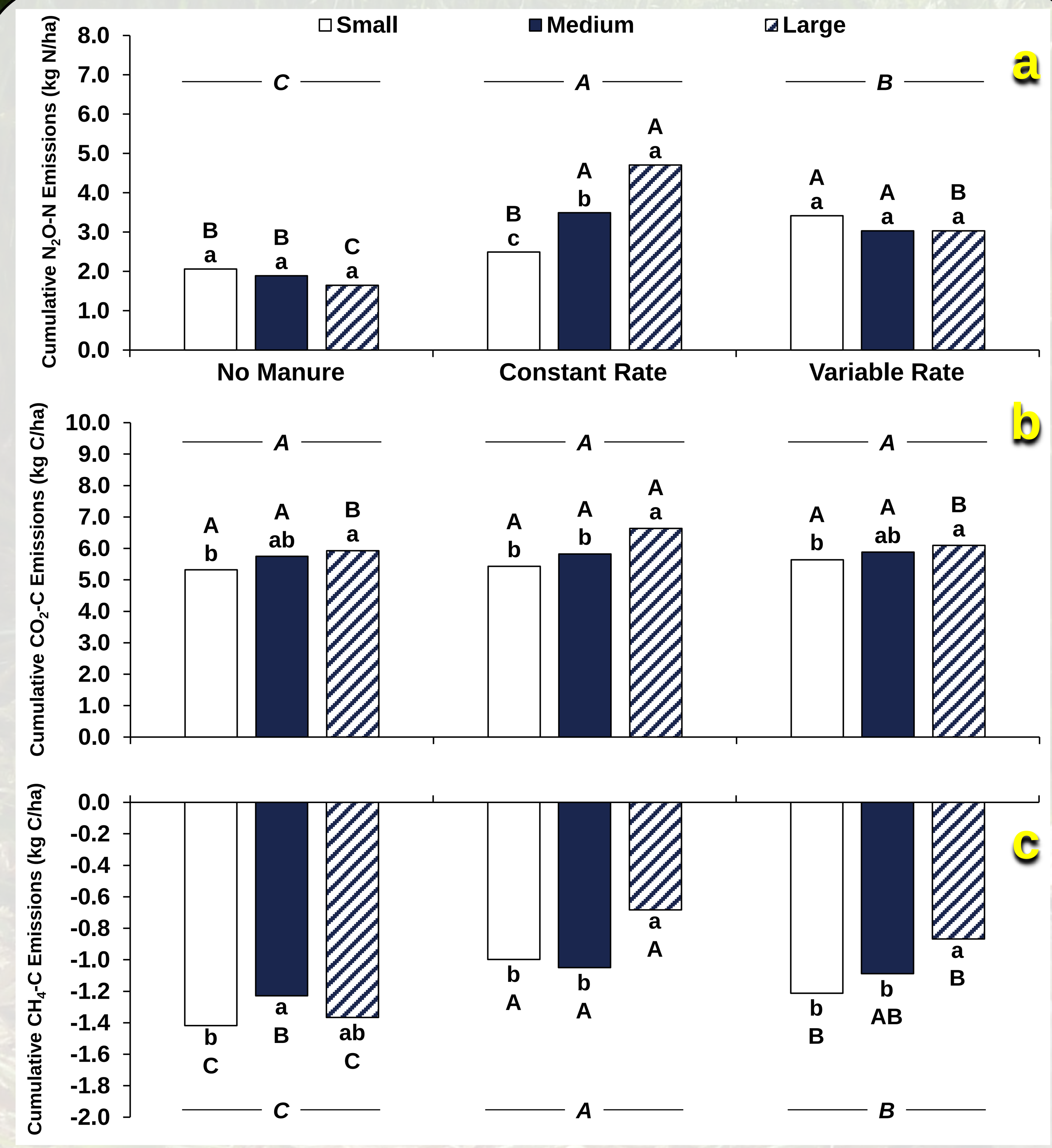

Figure 1. Mean (n=9-55) estimated cumulative N_2O (a), CO_2 (b), and CH_4 (c) emissions from soil, during the 2019 and 2020 sampling seasons, within watershed basins with and without the addition of fresh feedlot solid cattle manure applied at either constant or variable rates. Notes: i) within each N-treatment, bars with the same lower-case letter are not different, ii) among each catchment area size class, bars with the same upper-case letter are not different, iii) grouped treatments with the same italicized upper-case letter are not different, and iv) all statistical differences (P >0.10) were determined using LSD.

- The Constant Rate manure treatment had greater two-year cumulative N_2O emissions than both the Variable Rate manure (13%) and non-manured (68%) treatments (Fig 1a). This may reflect denitrification differences, as depressions received more manure with the Constant Rate treatment.
- Cumulative, two-year CO_2 emissions were the same among treatments (Fig 1b). There was a trend for higher emissions in the manured treatments.
- The Constant Rate manure treatment reduced the soil CH_4 sink strength compared to both the Variable Rate manure (18%) and non-manured (31%) treatments (Fig 1c) and is consistent with the known shift in autotrophic methanotrophy to nitrification activity under increased soil NO_3^- availability.
- Overall, the low elevation/large catchments had greater N_2O (18%) and CO_2 emissions (13%), along with being weaker (20%) CH_4 sinks compared to the higher elevation/smaller catchments. This reflects the greater soil moisture and organic matter content of these depressional soils.
- Temporal variations in both N_2O emission and CH_4 consumption were associated with soil anaerobisis, following triggering events of spring snow melt and growing season precipitation. Conversely, CO_2 emissions were primarily controlled by soil temperature, with the greatest emissions occurring during June and July (data not shown).

CONCLUSION

- The non-manured watershed basins had low cumulative N_2O and CO_2 emissions, and were strong CH_4 sinks compared to manured basins. As well, basins receiving the Variable Rate manure application had lower N_2O emissions than those receiving the Constant Rate manure application. Low elevation, large catchments contribute proportionally more to cumulative emissions.
- Future work includes estimating the GHG intensities within each basin and their relationship with barley fertilizer N use efficiency.

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