Methane recovery and agronomic values of anaerobically digested solid beef cattle manure

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Presented at the 2017 Manure Management Update at Lethbridge College

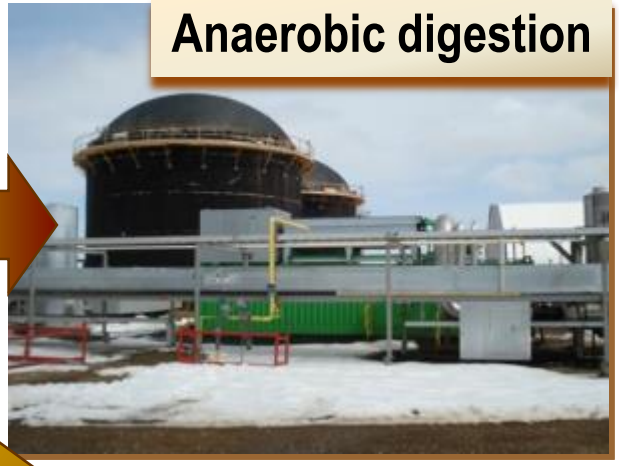
Cattle Production in Alberta

- Large confined operations produce a lot of manure
  - Applied to a relatively small land area
  - Nutrient loading creates large nutrient imbalances
- Alberta has 5.1 M cattle (42% of the national herd)
  - County of Lethbridge licensed feedlot capacity: ~900,000 head
  - Several feedlots >25,000 head
- Manure contains a lot of carbon, which may be converted to biogas (methane)
- Manure is not effectively used as fertilizer
- Poor manure management is an environmental issue

Manure Management Options

Manure in feedlot pen

Anaerobic digestion



Land application

Stockpiling

Composting

Anaerobic Digestion as a Manure Management Option

- Anaerobic digestion is environmentally attractive
- Anaerobically digested manure, or “digestate,” is one of the final co-products of the biogas energy industry
- Digestates are typically good nutrient sources

The Knowledge Gap…

- Most research has been conducted on digestates from liquid swine manure and liquid dairy cattle manure
- Limited research conducted on solid manure
- Liquid and solid manure have different chemical and physical properties, so digestates from solid manure likely have different agronomic values than digestates from liquid manures

Objective

- To determine potential methane recovery and the agronomic values of anaerobically digested beef cattle manure
  - Barley forage yield
  - Forage barley N and P uptake
  - Apparent N and P recovery
  - Residual nitrate and soil test P levels

Methane Recovery from Beef Cattle Manure

- Measured by methane potential batch test for 40 days
- Methane recovery was:
  - 0.350 m^3 kg^{-1} based on dry matter mass
  - 0.055 m^3 kg^{-1} based on wet mass

Biogas plant Vegreville, AB

Field Studies

Biogas plant location: Vegreville

Experimental sites: St. Albert and Lethbridge

Experimental periods: Four and five years

Experimental designs: Four amendments
Two rates

Treatment list:

(1) Control (non-amended soil)

(2) Undigested manure

(3) Anaerobically digested manure (digestate)

(4) Separated solids of the digested manure

(5) Pelletized separated solids (St. Albert only)

Materials and Methods

Materials:

- Undigested cattle manure (33 to 50% solid)
- Digestate (4 to 9% solid)
- Separated solids (24 to 44% solid)
- Pellets (65 to 80% solid)

Cattle manure Separated solids Pellets

Materials and Methods

- Two rates (Assumed 50% total N available):
  - 1 × local recommended rate
  - 2 × local recommended rate
- Surface applied, double disk with minimal soil disturbance
- Seeded on same day or one day after amendment application

Amendment Application

Amendment Properties

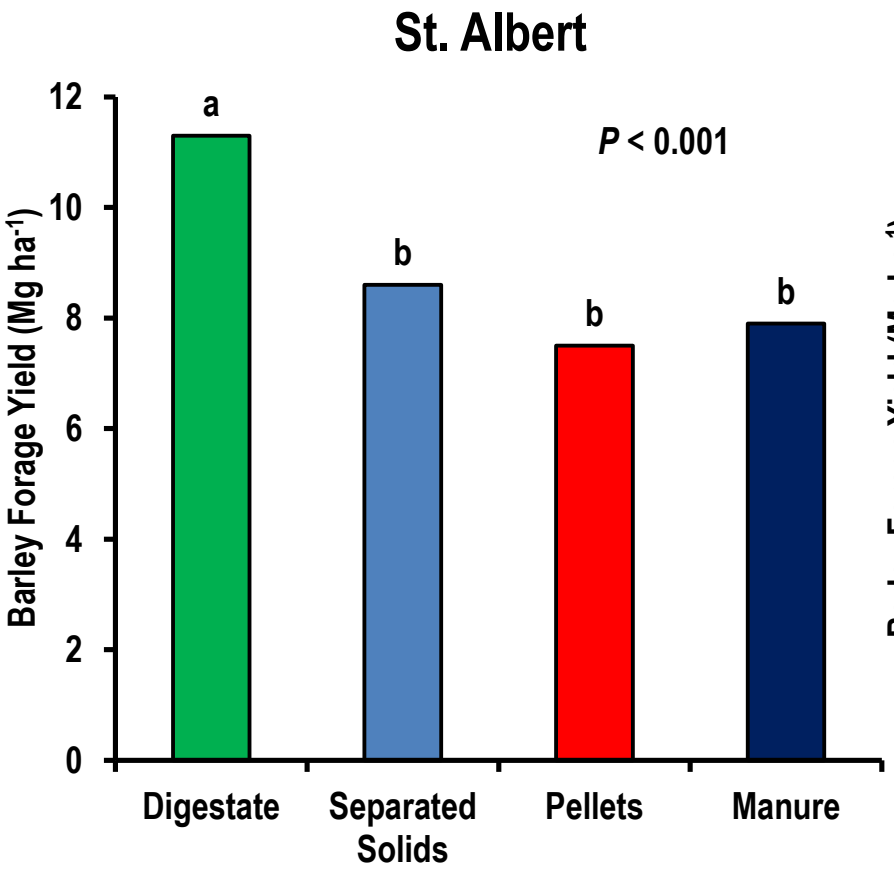
Amendment†	WC§	pH	Total C	Total N	Org-N	Total P	NH_4-N	NO_3-N	C/Org-N	N/P	NH_4-N/Total N
	kg kg^{-1}		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	mg kg^{-1}			
Digestate	0.94 ± 0.01	8.1 ± 0.2	347 ± 25	70 ± 6	29 ± 4	9 ± 1	39 ± 6	21 ± 8	12 ± 1	8 ± 1	0.55 ± 0.05
Separated Solids	0.75 ± 0.01	8.5 ± 0.1	397 ± 37	17 ± 1	13 ± 1	5 ± 1	4 ± 1	14 ± 10	31 ± 4	3 ± 0	0.20 ± 0.07
Pellets	0.44 ± 0.08	8.3 ± 0.2	362 ± 32	18 ± 1	17 ± 1	5 ± 1	1 ± 0	1 ± 0	21 ± 2	4 ± 0	0.03 ± 0.01
Manure	0.62 ± 0.02	7.6 ± 0.4	388 ± 17	24 ± 2	20 ± 2	6 ± 1	4 ± 1	5 ± 1	20 ± 3	4 ± 0	0.17 ± 0.04

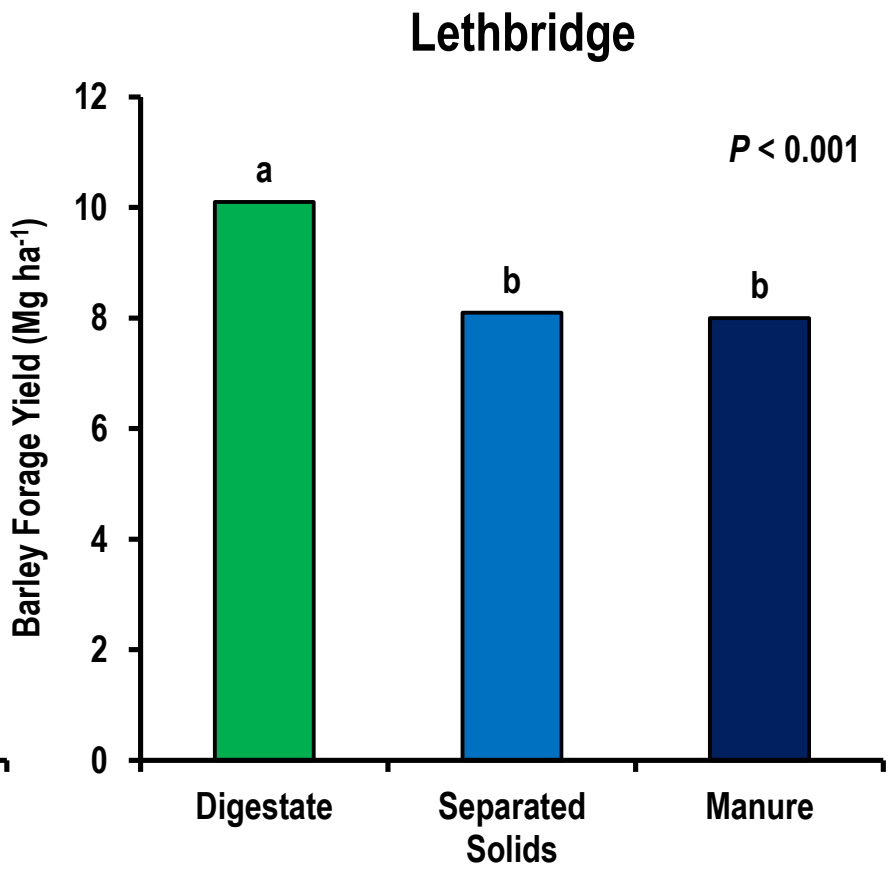
Values are means ± standard error

†All amendment properties are expressed on a dry mass basis

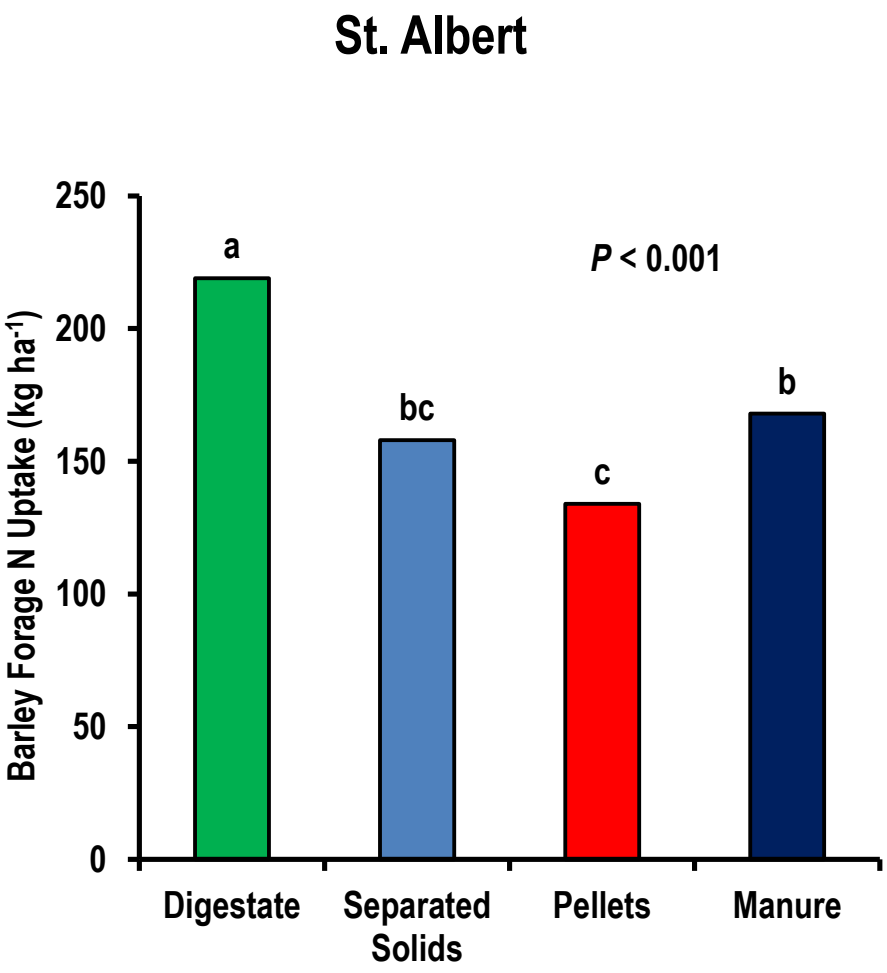
§WC is water content on a wet weight basis

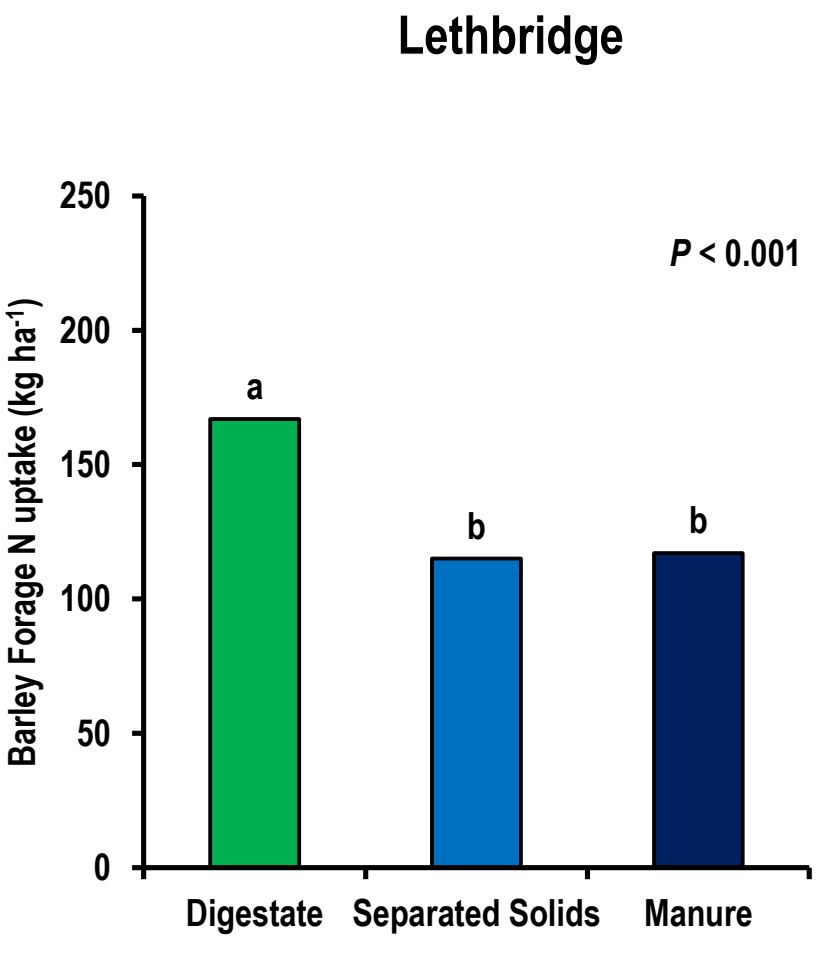
Results: Barley Forage Yield



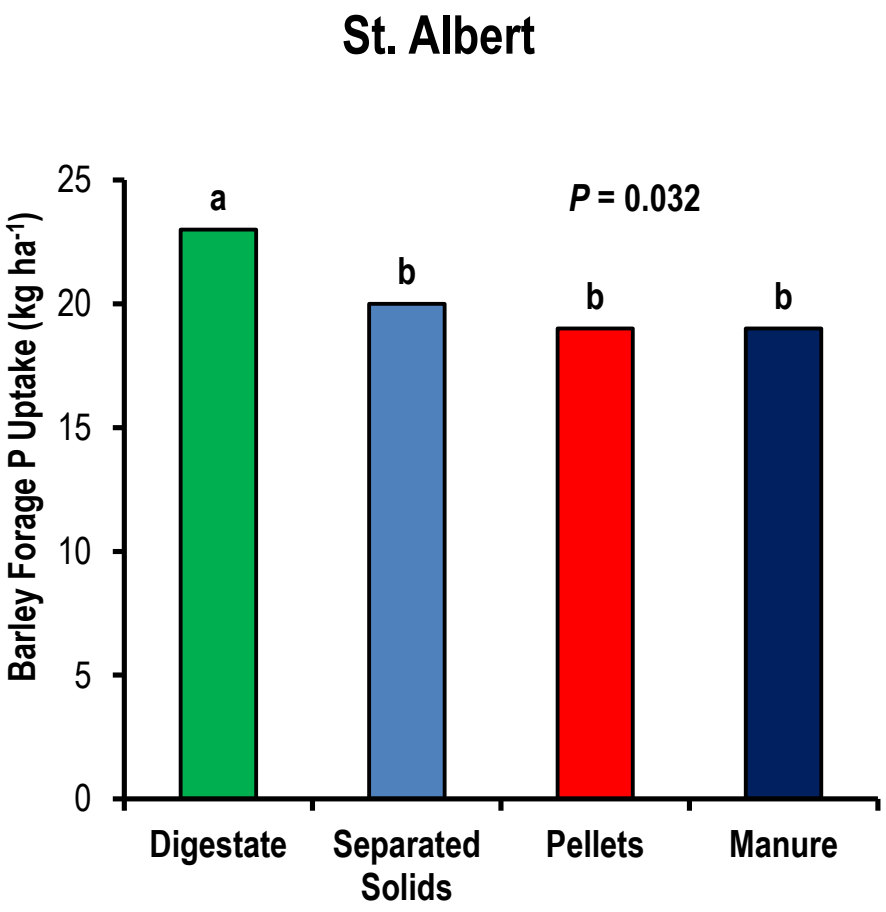


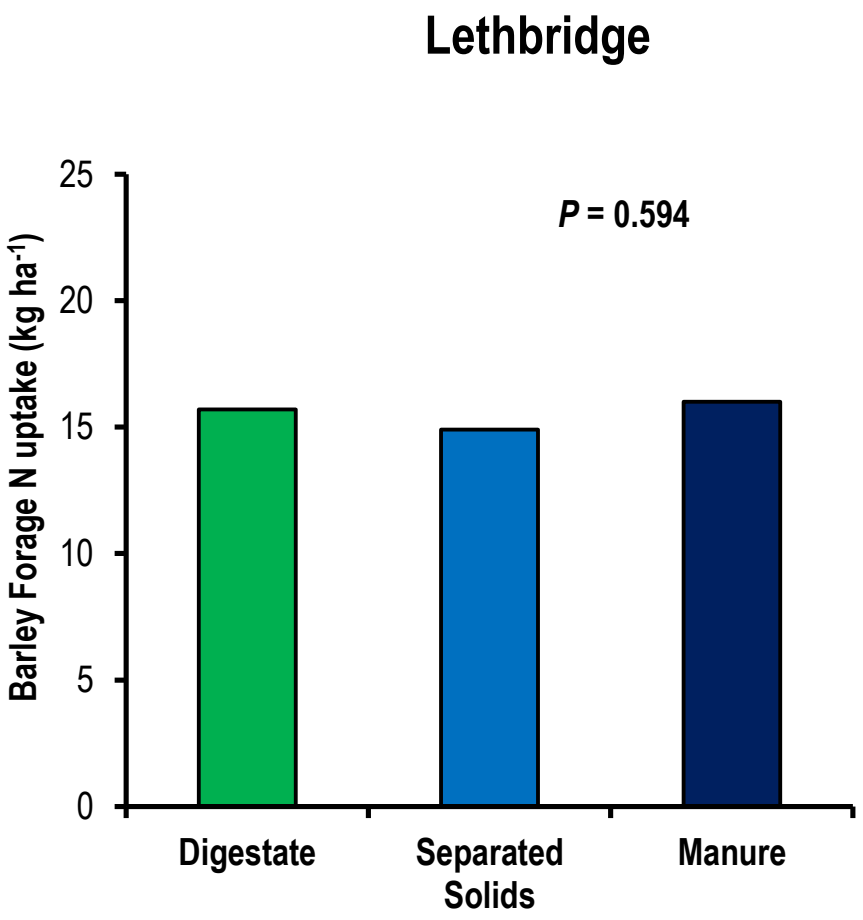
Results: Barley Forage N Uptake



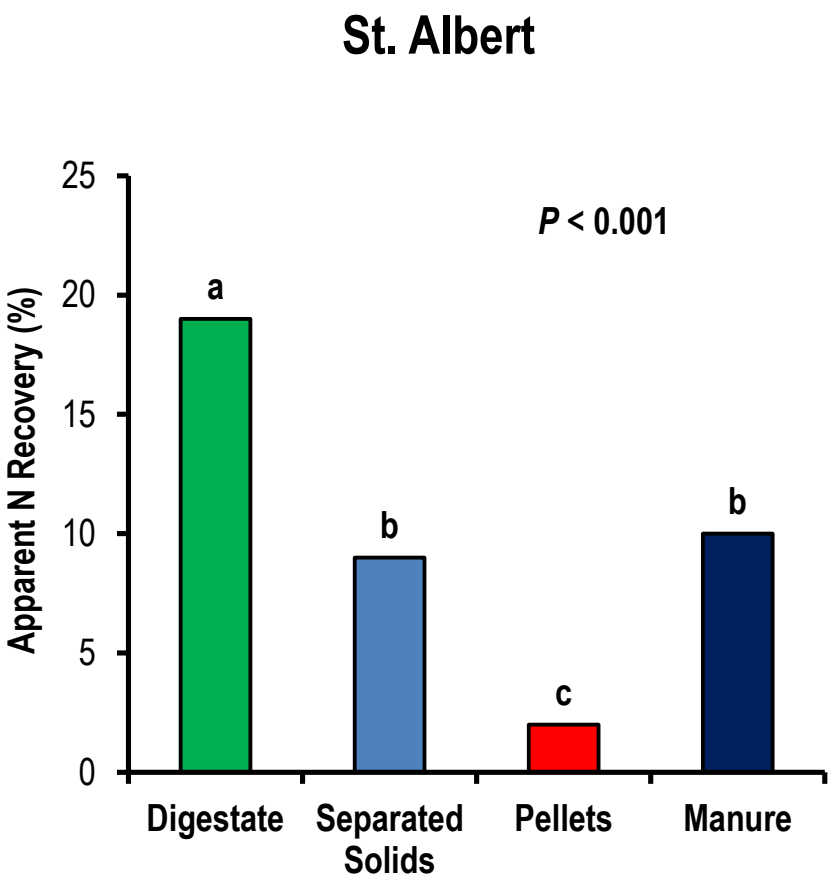


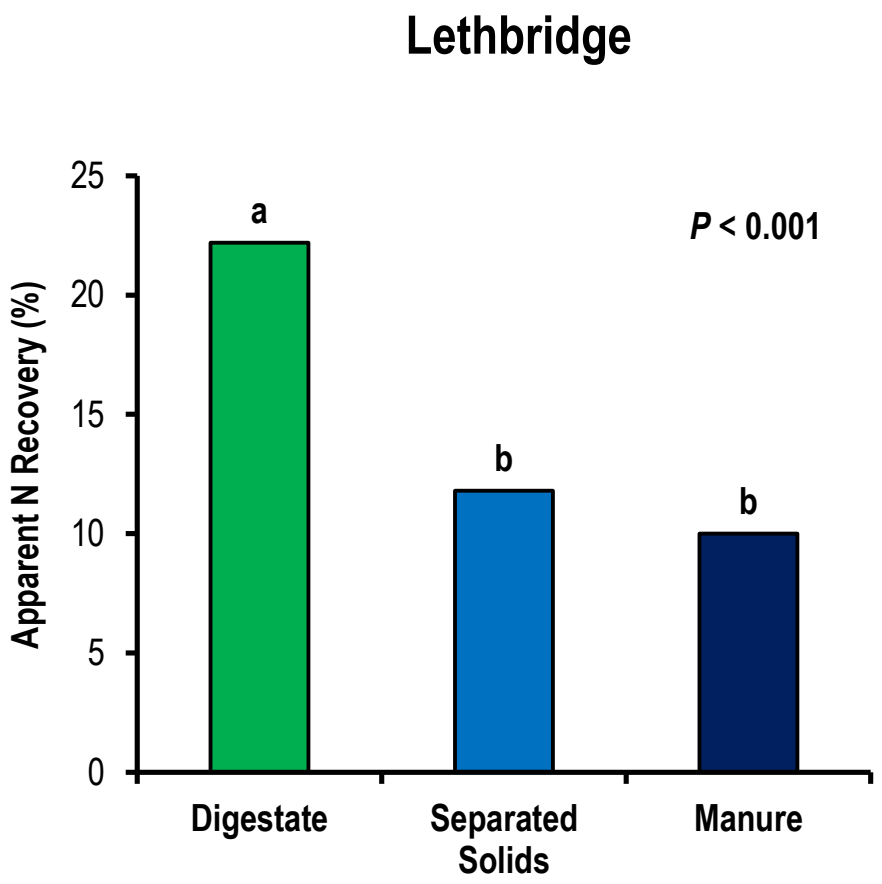
Results: Barley Forage P Uptake





Results: Apparent N Recovery (Amended-soil N uptake / N applied)





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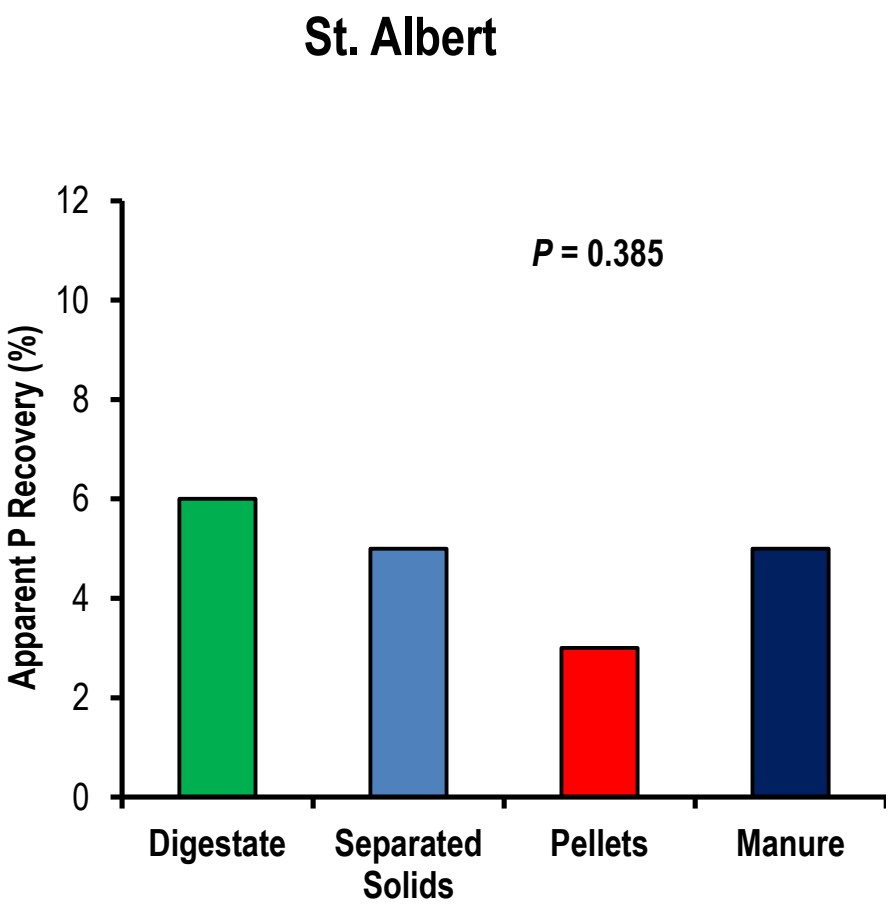
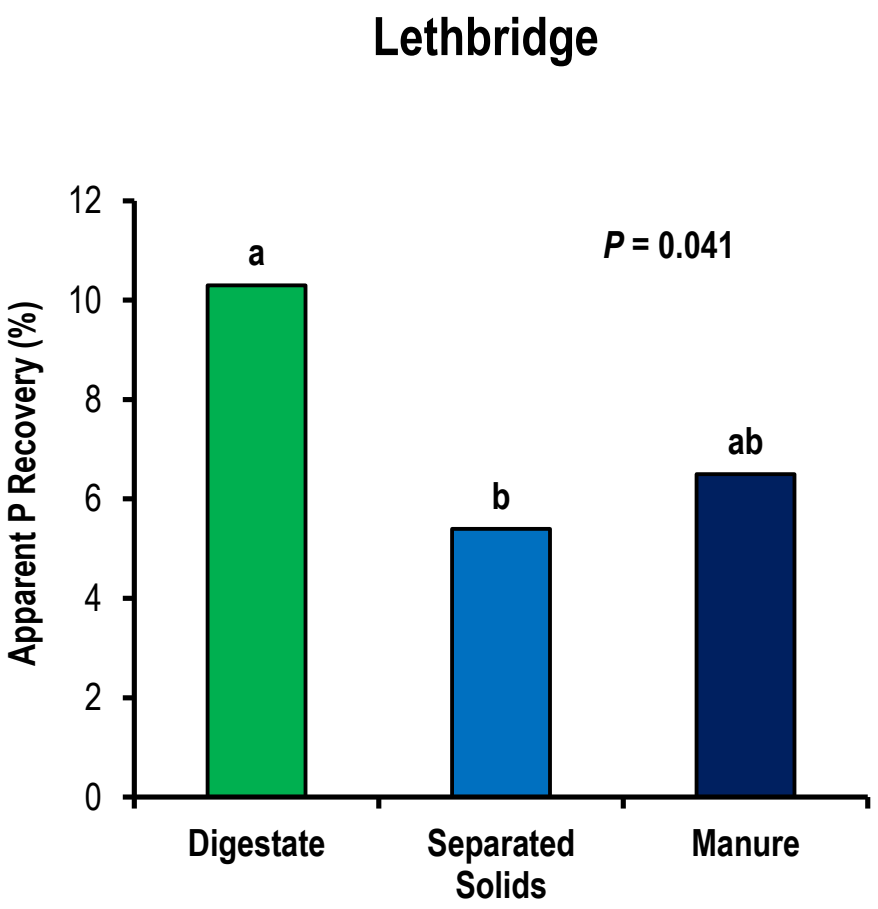
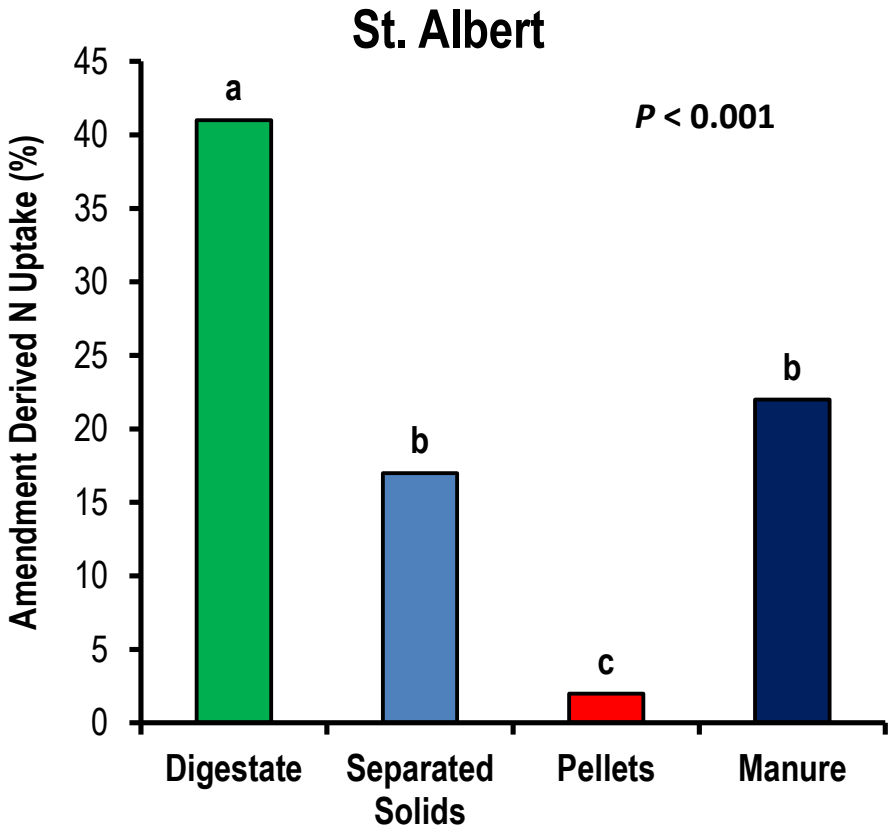
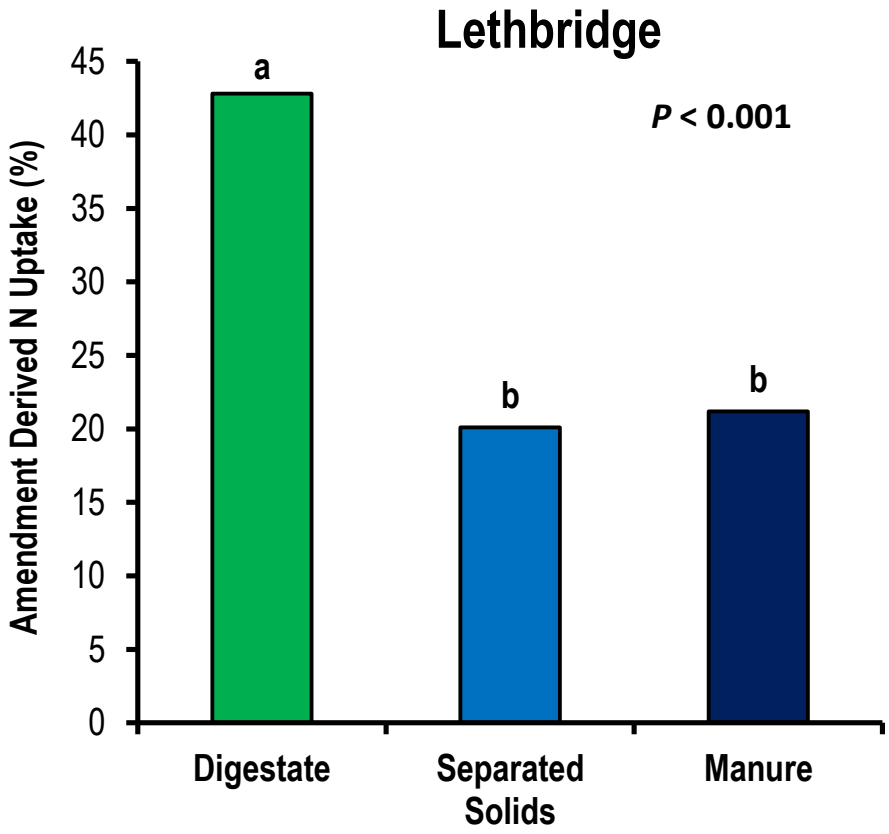




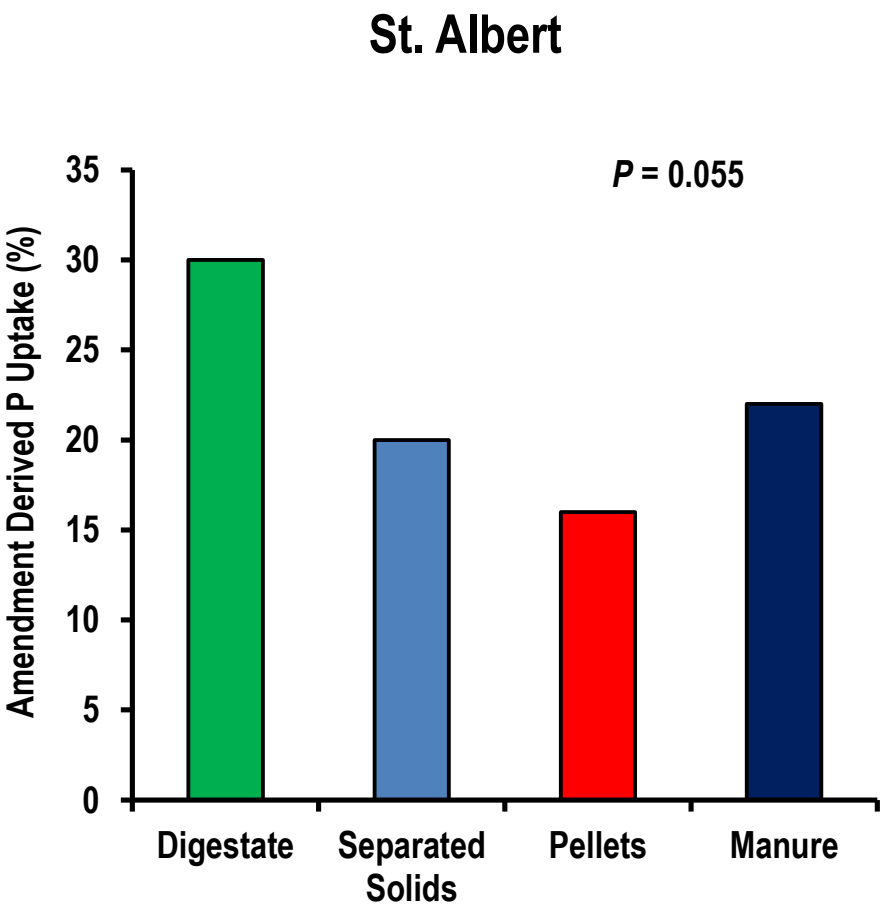
Results: Amendment Derived N Uptake

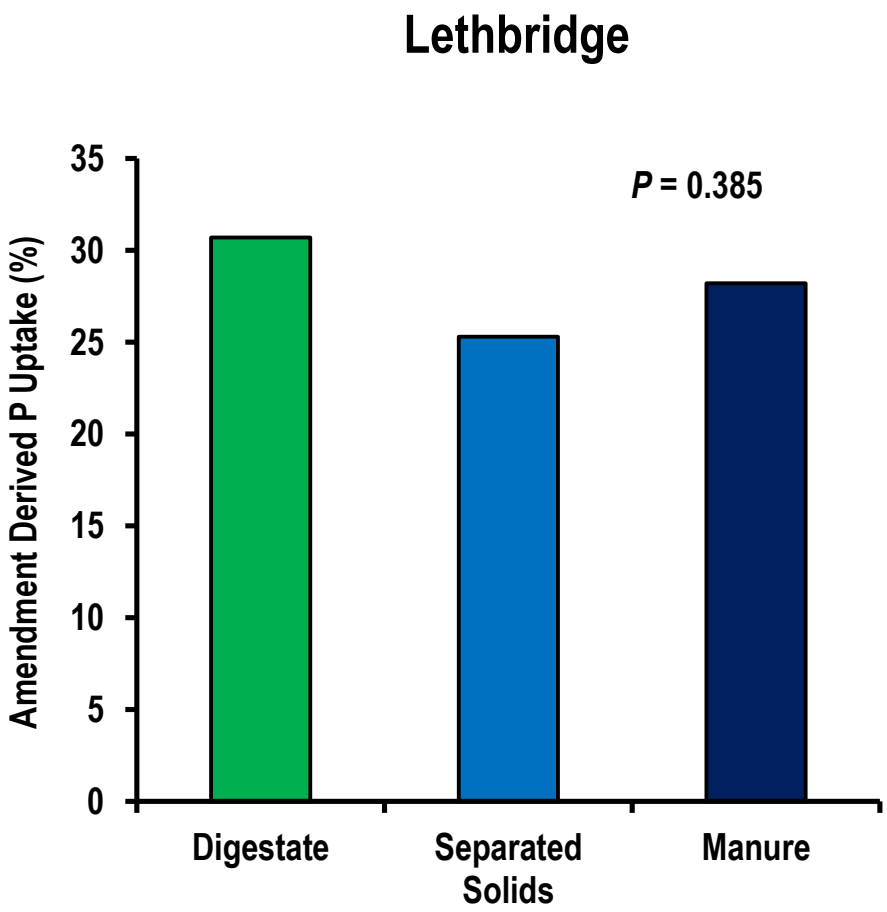




(Amended-soil N uptake – Control soil N uptake) / Amended-soil N uptake

Results: Amendment Derived P Uptake





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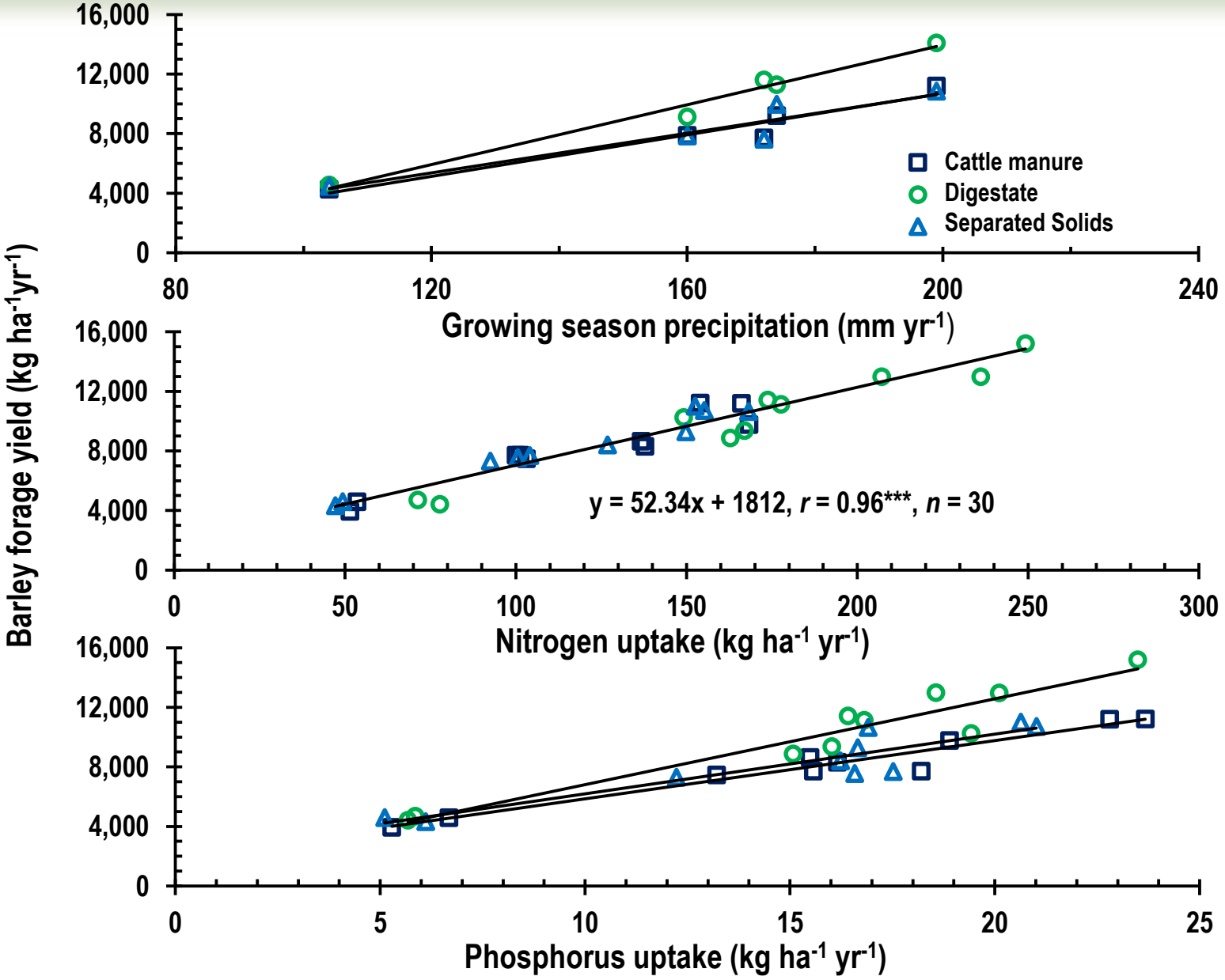

Hao et al., 2016. *Soil Science Society of America Journal*

Summary

- **Digestate led to 31 to 50% greater barley forage yield in St. Albert, and 24 to 26% greater yield in Lethbridge**
- **At both sites, barley recovered two times more N from digestate than undigested cattle manure**
- **Digestate led to greater barley forage P uptake in St. Albert**

Hao et al., 2016. *Soil Science Society of America Journal*
Thomas et al., Under Minor Revision, *Agronomy Journal*

Summary

- **Pellets performed poorly, likely due to low surface area**
- **Separated solids performed similar to raw cattle manure**
- **On farm management strategies developed for raw cattle manure may be used for separated solids**

Hao et al., 2016. *Soil Science Society of America Journal*
Thomas et al., Under Minor Revision, *Agronomy Journal*

Future Directions

- Improve nutrient recovery from pellets
  - Why?
- Pelleting decreases the mass and volume of the separated solids, making transportation and land application more economical
- Pellets supply C and may act as useful slow release fertilizer

Acknowledgements

- **Collaborators:**
  - **Alberta Agriculture and Forestry**
  - **University of Manitoba**
- **Technical staff at AAFC Lethbridge and AAF**
- **Digestate from Highmark Renewables Inc.**

Funded by

Alberta Innovates Bio Solutions

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Thank you!!

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