Amending agricultural soils with crude glycerol, a biodiesel byproduct, to temporarily immobilize leachable nitrogen and then recycle immobilized nitrogen

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1. INTRODUCTION

- Loss of nitrate-nitrogen (NO_3–N) from Midwestern U.S. agricultural fields can impair water quality and be an economic loss to farmers.
- Winter cover crops have shown promise as a remedy to mitigate the NO_3–N loss, but low adoption rates illustrate the need for alternatives.
- One alternative strategy is to add a carbon (C)-rich soil amendment to increase soil microbial biomass (MB) and promote immobilization of inorganic N, especially highly mobile NO_3–N.
- The rapid growth in U.S. biodiesel production has led to large concurrent production of crude glycerol (IUPAC name: Propane-1,2,3-triol; chemical formula: $C_3H_8O_3$; Fig. 1). Given the large production of crude glycerol in the U.S. Midwest, and potential for glycerol to immobilize N, it could serve as a viable alternative for farms where winter cover crops will not work.

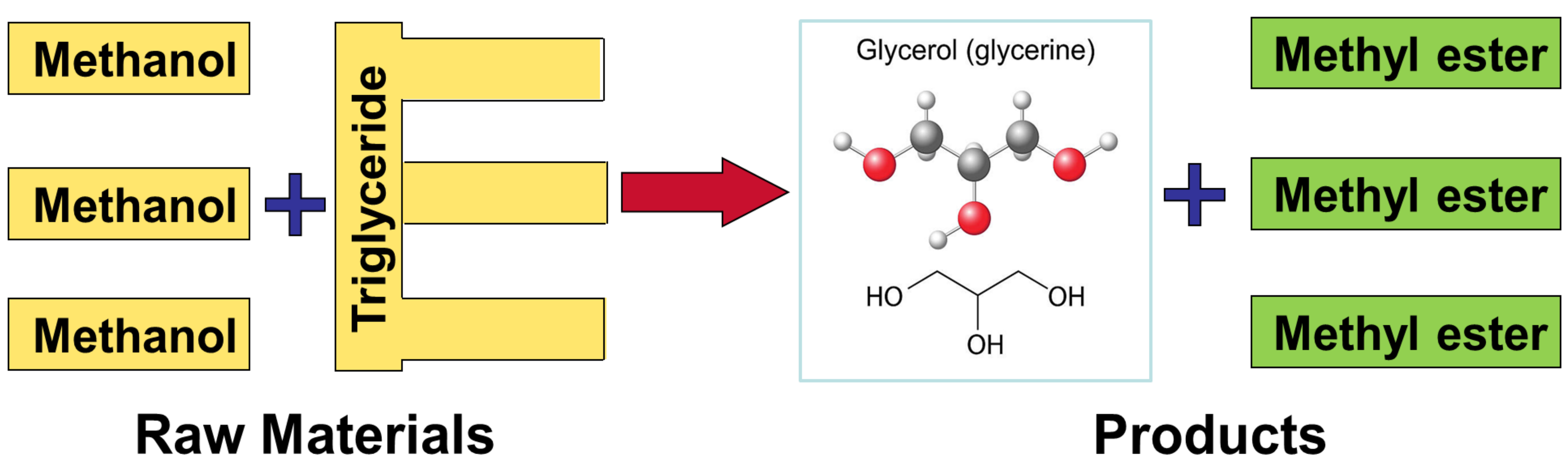


Fig 1. Crude glycerol is generated during biodiesel production (through transesterification process).

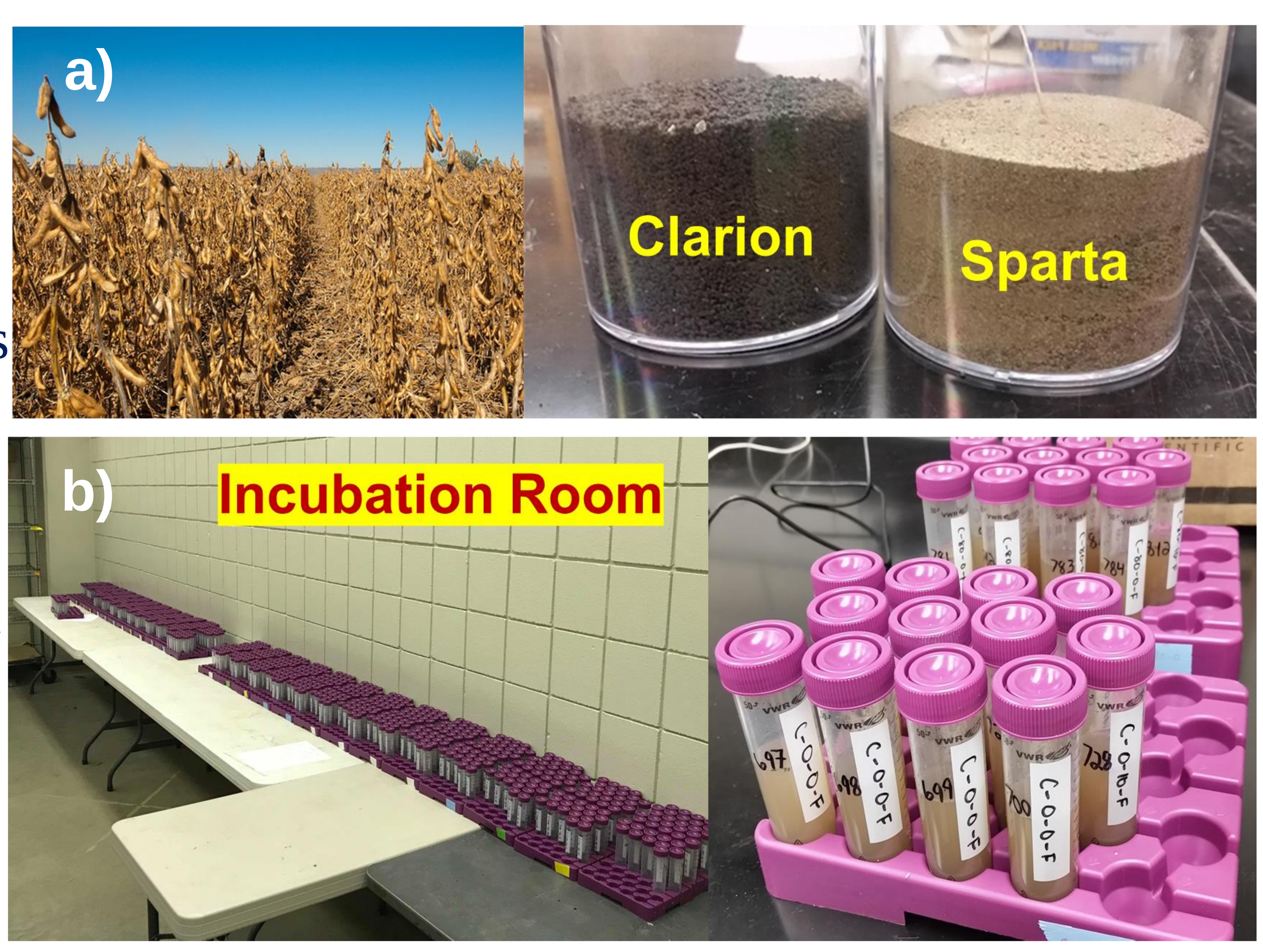
2. OBJECTIVES

- Evaluate whether glycerol would increase MB and reduce residual NO_3–N that potentially could be lost via leaching.
- Determine whether and when immobilized N in MB would be re-mineralized and become plant-available NO_3–N.
- Determine how soil type and amount of added NO_3–N would affect N dynamics.

3. MATERIALS AND METHODS

- Two contrasting soils (Fig. 2a) from soybean fields (at 0-15 cm soil depth):
  - ✓ Clarion soil (Clay Loam; 6.4 ± 0.01 % SOM)
  - ✓ Sparta soil (Loamy Sand; 2.0 ± 0.01 % SOM)
- ~5 g of field moist soil incubated aerobically at ~25^{0}C (77^{0}F) for 98 days at 60% water holding capacity (Fig. 2b).
- Soils were extracted at 1, 3, 7, 14, 28, 63, and 98 days after adding four glycerol (0-, 117-, 468-, and 1872-mg C kg^{-1} soil) and three calcium nitrate rates (0-, 10-, and 40- mg N kg^{-1} soil).
- Analyzed for inorganic-N (NH_4^+ + NO_3^-) and MBC and MBN.

Fig 2. a) Two contrasting soils from soybean fields b) 50 mL centrifuge tubes with soils, glycerol and nitrogen treatments in an incubation room.



4. RESULTS

Table 1. Net nitrogen (N) mineralization (calculated as slope of NH_4–N+NO_3–N) during incubation after release at different time points during the 98-day incubation (mean ± standard error). Significant difference (*p < 0.05*) among N rates indicated with capital letters, among glycerol rates within each N rates with lower case letters.

		Clarion soil		Sparta soil	
N rates (mg N kg^{-1} soil)	Glycerol rates (mg C kg^{-1} soil)	Release period (days)	Net N mineralisation rate (mg kg^{-1} day^{-1})	Release period (days)	Net N mineralisation rate (mg kg^{-1} day^{-1})
0	0	0	0.44 ± 0.03 bB	0	0.49 ± 0.02 bB
	117	28–63	0.59 ± 0.07 aB	14–28	0.58 ± 0.02 aB
10	0	0	0.46 ± 0.03 bB	0	0.47 ± 0.02 bB
	117	28–63	0.74 ± 0.07 aB	14–28	0.57 ± 0.05 aB
40	0	0	1.16 ± 0.04 aA	0	1.32 ± 0.03 aA
	117	7–14	0.64 ± 0.01 bB	7–14	0.75 ± 0.04 bA

ANOVA factor[b]	df	Clarion F value	Clarion *p value*	Sparta F value	Sparta *p value*
Glycerol rate (GR)	1	0.39	0.54	25.9	**<0.001**
N rate (NR)	2	35.7	**<0.001**	177.3	**<0.001**
GR × NR	2	39.7	**<0.001**	75.6	**<0.001**

[b]Summary of two-way ANOVA on the effect of adding glycerol and nitrogen rates in Clarion and Sparta soils.

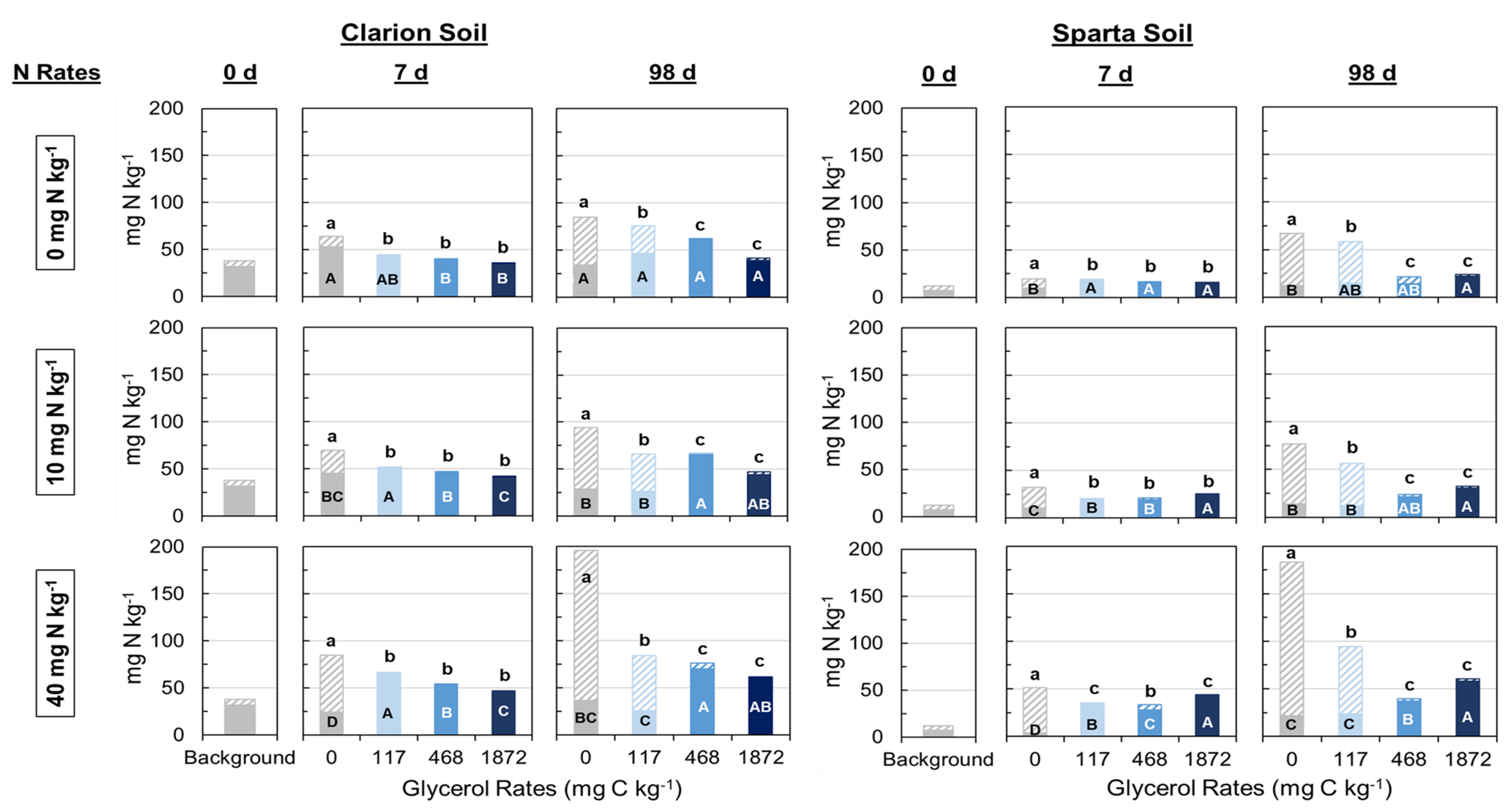


Fig 3. Microbial biomass N (MBN; solid bars) and inorganic N (IN; NH_4–N + NO_3–N; hatched bars) in the Clarion and Sparta soils at 0d (background or no glycerol/N added), 7d, and 98d of the incubation. The significant difference amongst glycerol rates indicated by capital letters (MBN) and lowercase letters (IN) at *p < 0.05*.

5. CONCLUSIONS

- Crude glycerol strongly increased soil MB and decreased NO_3–N under all conditions (Fig. 3).
- Net N immobilization was temporary, and N was eventually released from the lowest glycerol C rate through MB turnover (Table 1).
- Glycerol rates, N rates and soil type affected N immobilization-mineralization dynamics.
- Overall, this laboratory incubation was a proof of concept that shows promise of using glycerol as a soil amendment to immobilize NO_3–N and may increase the sustainability the biodiesel production supply chain.
- Further field trials are needed to evaluate the broader and long-term impacts of glycerol application on yield, soil contamination, N leaching, and green house gas emissions from maize-soybean rotations of the Midwestern United States.

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