Estimation of Potential Nitrogen Losses from the Different Rates of High-Carbon Char Amended Soils

Dinesh Panday* and Bijesh Maharjan
Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE

BACKGROUND

- A significant portion of fertilizer nitrogen (N) added to agricultural soils is generally lost to the environment in forms of nitrate (NO_3), ammonia (NH_3), or nitrous oxide (N_2O).
- These losses can be major limitations for crop production, soil sustainability and environmental safeguard.
- High-carbon Char (char, henceforth), a residue from inefficient burning of coal in a local industry in Western Nebraska contains around 30% carbon (C) by weight in addition to some other essential plant nutrients.
- Char can be a potential soil amendment to reduce N losses through various pathways since N cycle in soil is strongly linked to soil C availability.
- However, there is a lack of information on how industry by-product such as char affects N management in soil.
- This study is an example of a collaborative effort among the research university, industry and agricultural sector to integrate agriculture and local industry.

HYPOTHESIS AND OBJECTIVE

- Char might help to reduce N loss from fertilized soil by
  i) improving retention of applied N by electrostatic adsorption
  ii) immobilization of N by microbial processes
- The objective is to measure N losses in form of N_2O emissions, NH_3 volatilization and NO_3 leaching from fertilized loam and sandy loam soils after adding different rates of char compared to soils with no char at a laboratory setting.

MATERIALS AND METHODS

- A 30 day laboratory study in loam and sandy loam soils.
- Soils were packed to 24 cm depth of column by considering a bulk density of 1.4 Mg m^{-3}. Water was added according to calendar below (weather condition in May, 2017).
- Treatment design: Char at 6 different rates: 0, 6.8, 13.6, 20.4, 27.2 and 34 t ha^{-1} of C in urea ammonium nitrate (UAN) fertilized soil at the rate of 201 kg ha^{-1} N.
- Experimental design: RCBD with 4 replications.

DAY	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NH_3 volatilization																
N_2O emission																
Precipitation (mm)				2.03						0.51	1.27	2.29				
Water added (ml)				3.9						0.9	2.5	4.5				
NO_3 leachate																
Soil residual N																

DAY	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
NH_3 volatilization																
N_2O emission																
Precipitation (mm)	12.4	2.29	11.9	24.1	22.9	2.29	4.32	0.25			0.76	12.4		1.02		
Water added (ml)	24.5	4.5	23.4	47.4	44.9	4.5	8.5	0.5			1.5	24.5		2		
NO_3 leachate																
Soil residual N																

RESULTS

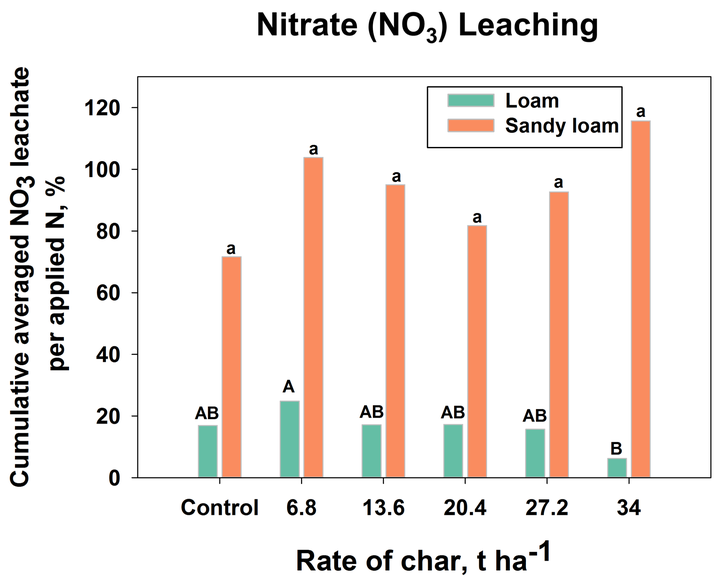

Fig. 1: Cumulative amount of NO_3-N leaching in different treatments

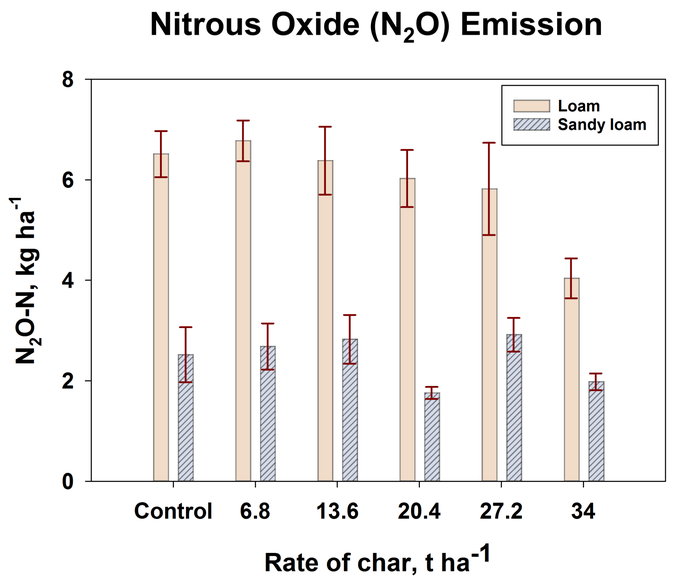

Fig. 2: Cumulative average N_2O-N emission in different treatments

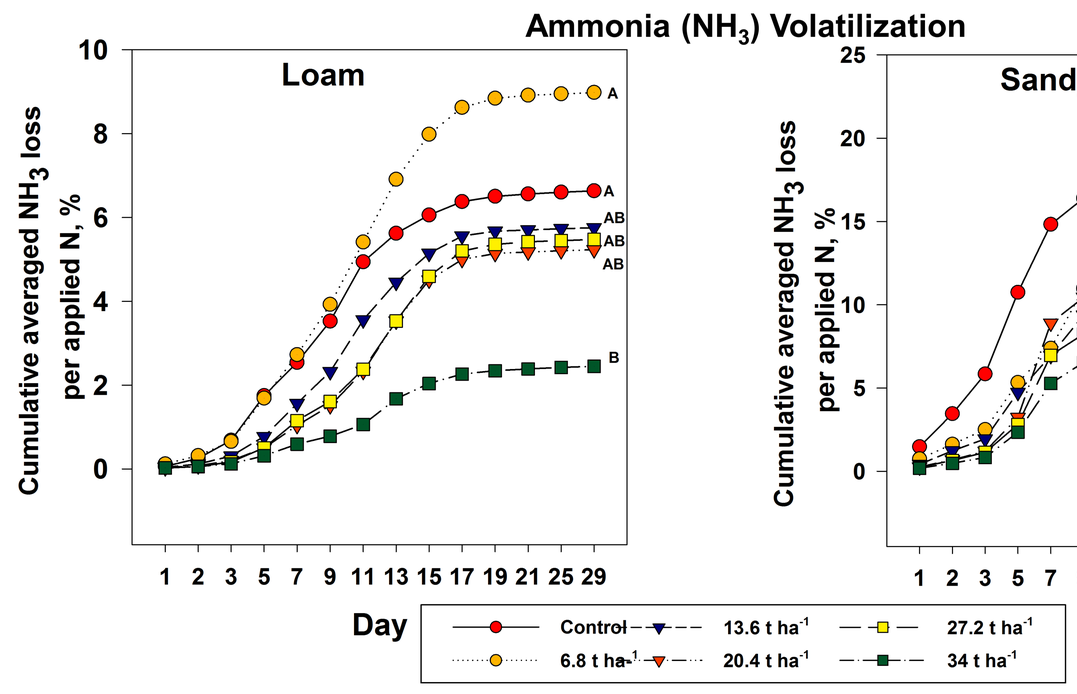

Fig. 3: Cumulative average NH_3-N volatilization in different treatments

SUMMARY AND CONCLUSION

- Char at the highest rate of 34 t ha^{-1} reduced NO_3 leaching compared at the lowest rate of 6.8 t ha^{-1}. Compared to the control, there was a trend for reduced leaching at the highest char rate treatment.
- There is a trend for reduction in N_2O emission with higher char application rate, particularly in fine-textured soil. This can be a potential tool in mitigating greenhouse gas emission.
- The higher the rate of char, the greater was NH_3 volatilization reduction, with an exception of char at 6.8 t ha^{-1} in loamy soil.
- Findings support the hypothesis in char's role as a soil amendment to increase soil N retention and to minimize environmental N losses, particularly NH_3 and N_2O losses.
- This study provides a baseline information to initiate field research to evaluate potential agricultural use of char as soil amendment. Application of char may promote soil sustainability, but further studies are necessary.

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BIBLIOGRAPHY

Maharjan B, Venterea RT, Rosen C. 2014. Fertilizer and irrigation management effects on nitrous oxide emissions and nitrate leaching. Agronomy Journal, doi:10.2134/agronj2013.0179.

Peng X, Maharjan B, Yu C, Su A, Jin V, Ferguson RB. 2015. A laboratory evaluation of ammonia volatilization and nitrate leaching following nitrogen fertilizer application on a coarse-textured soil. Agronomy Journal, 10.2134/agronj14.0537.

*dinesh.panday@unl.edu