Nitrogen Mineralization and CO_2 Release of Spent Coffee Grounds: Their Potential Use as a Slow Release Fertilizer

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BACKGROUND: Thousands of tons of spent coffee grounds (SCG) are sent to landfills each year, and with the recent growth in cold-brew coffee production (Figure 1) this is expected to increase. Given their chemical properties, SCG may offer opportunities for agronomic use as a source of nutrients or organic matter. The high lignin content of SCG provides durability, preventing them from breaking down too quickly, and provides habitat and C for microbial communities.

Recent multi-year field and greenhouse studies at Texas A&M, showed minimal benefit of surface-applied SCG on 'Celebration' bermudagrass (*Cynodon dactylon*) quality and growth rates. However, when used to amend sand root zones (figure 2), water holding capacity, shoot growth, and leaf tissue N content were greater compared to peat moss and sand alone (Flores et al., 2020).

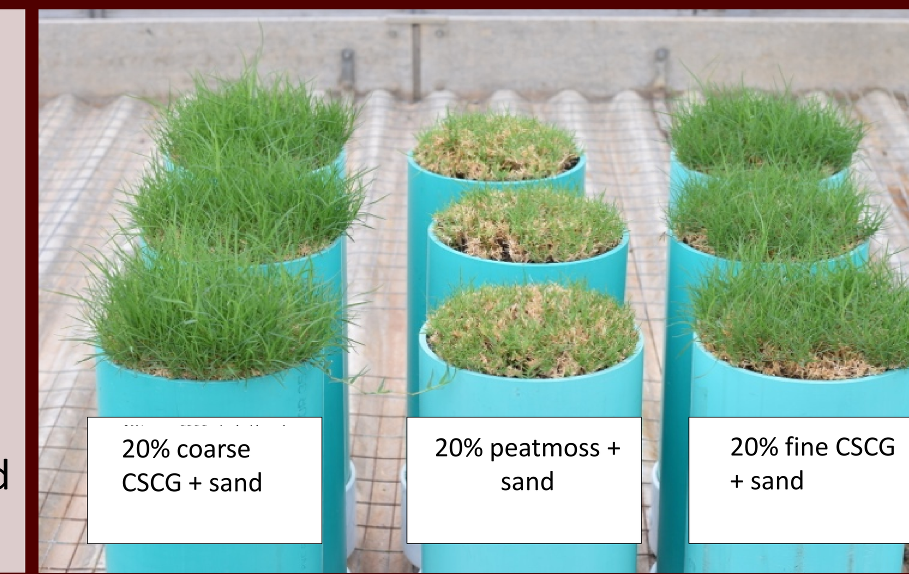
Given the inconsistencies observed between surface and root zone applications of SCG, questions remain regarding the mechanisms driving these responses. Therefore, the objective of this incubation study was to characterize N mineralization rates from SCG compared to other natural organic and synthetic N sources commonly used in the turfgrass industry.

METHODS: This laboratory study was conducted at Texas A&M University during Fall 2019.

- Fresh SCG, composted SCG, as well as Milorganite (5-2-0), and Urea (46-0-0) fertilizers were mixed into 50 g of a fine-sandy loam field soil at 9.8 g N m^{-2}
- Microcosms were held at 25°C for 73 days and sampled at regular intervals.
- NH_4^+, NO_3^-, and soil C extraction method followed Keeney and Nelson (1982)
- CO_2 extraction method followed Franzluebbers et al., 2000
- Total inorganic N was calculated as the sum of $NH_4^+ + NO_3^-$
- Data were analyzed through ANOVA (SAS 9.4, Cary, NC) Mean separation procedures were performed using Tukey's HSD Test at *P≤ 0.05*

Fig. 1: Dumpsters of SCG generated from cold-brew coffee production

Fig. 2: SCG increased vigor, water holding capacity, shoot growth, and leaf N, compared to peat moss and sand alone



Microbial respiration is greater for SCG treatments

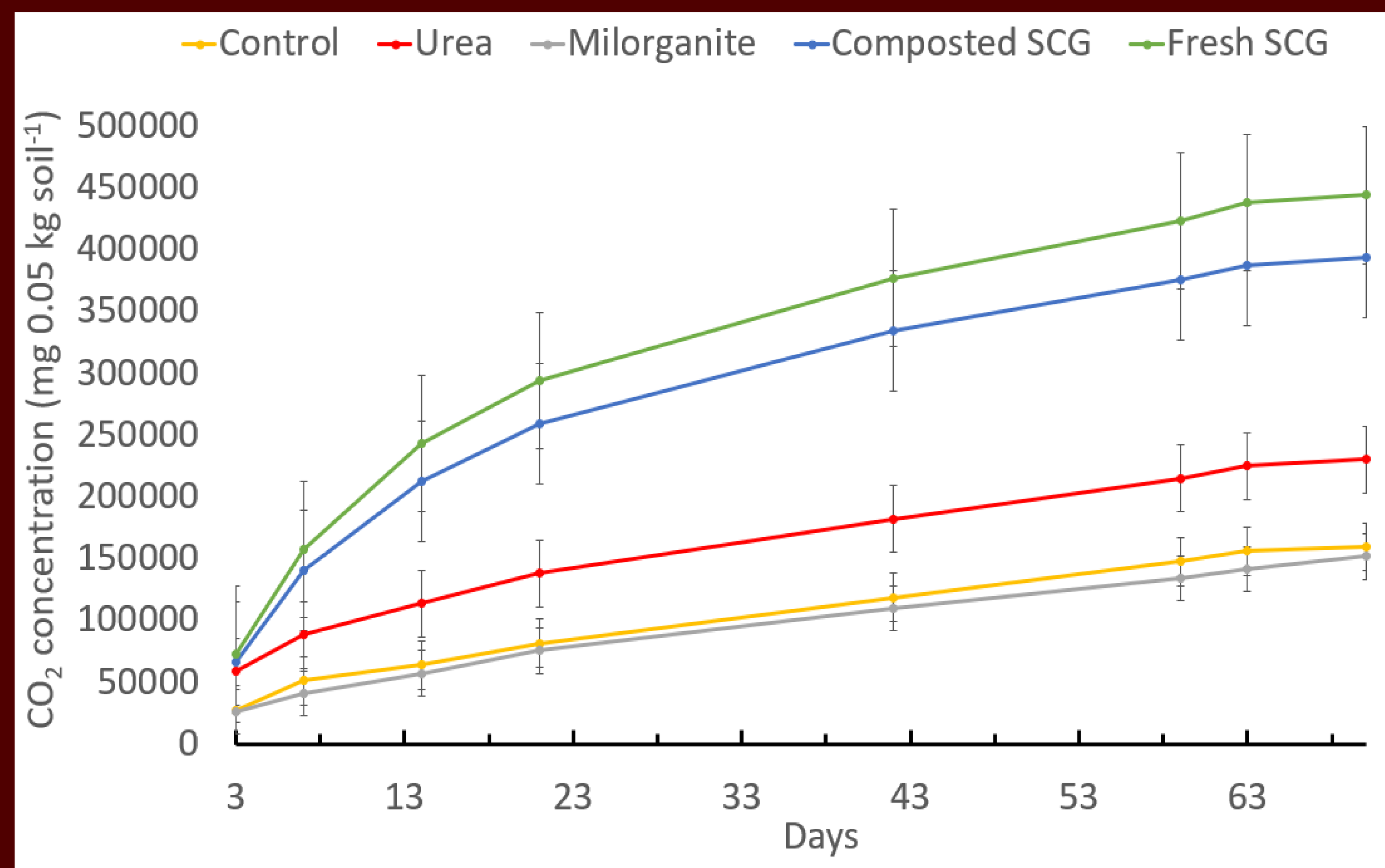


Fig. 3: Cumulative CO_2 concentration over a 73 day incubation. Bars represent Standard error.

Inorganic N is immobilized with SCG

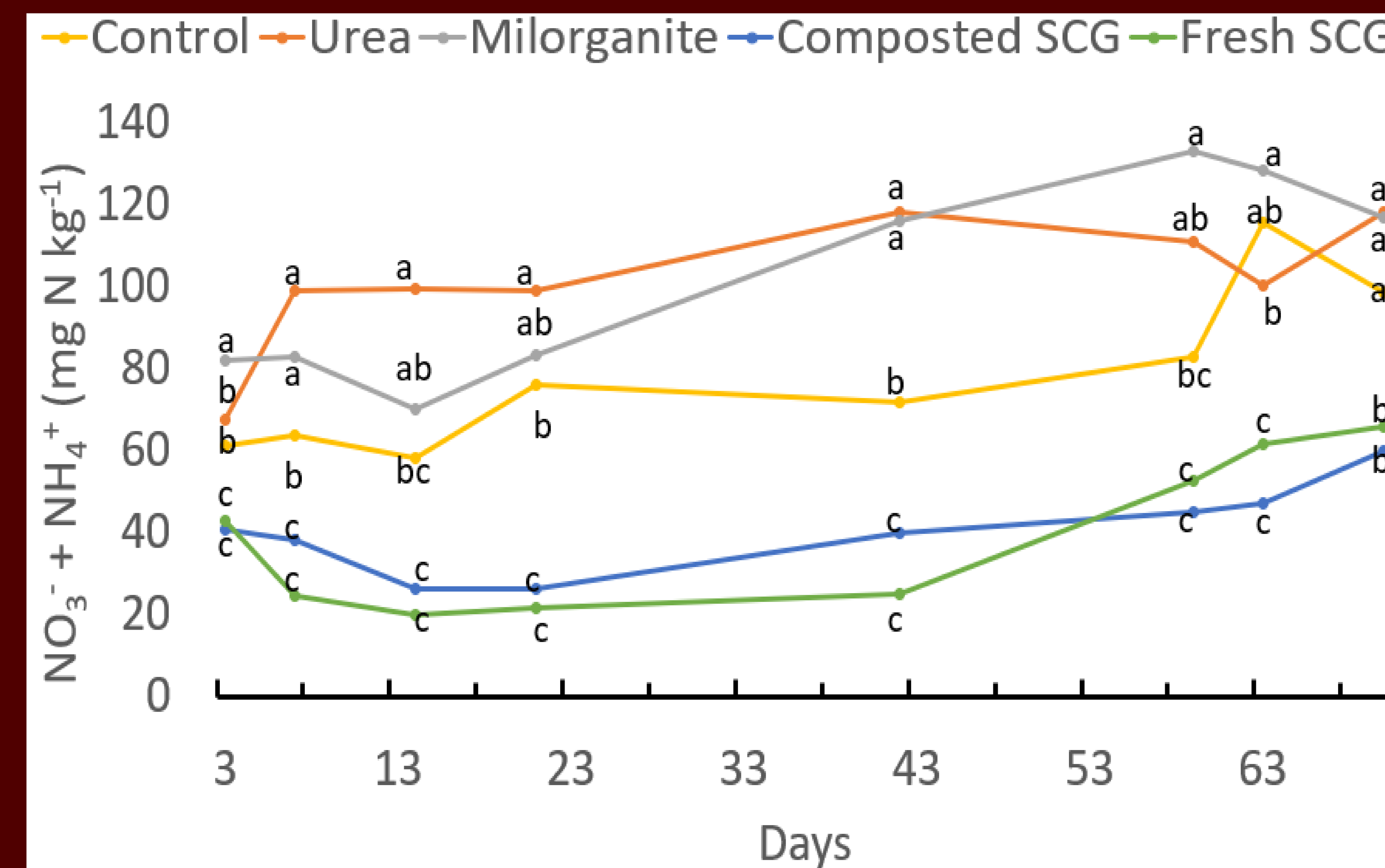


Fig. 4: Total inorganic N concentration extracted from soils over a 73 day incubation. Means with the same letter on a given day are not statistically different based on Tukey's HSD (0.05).

Nitrate release from SCG was lower than control until day 70

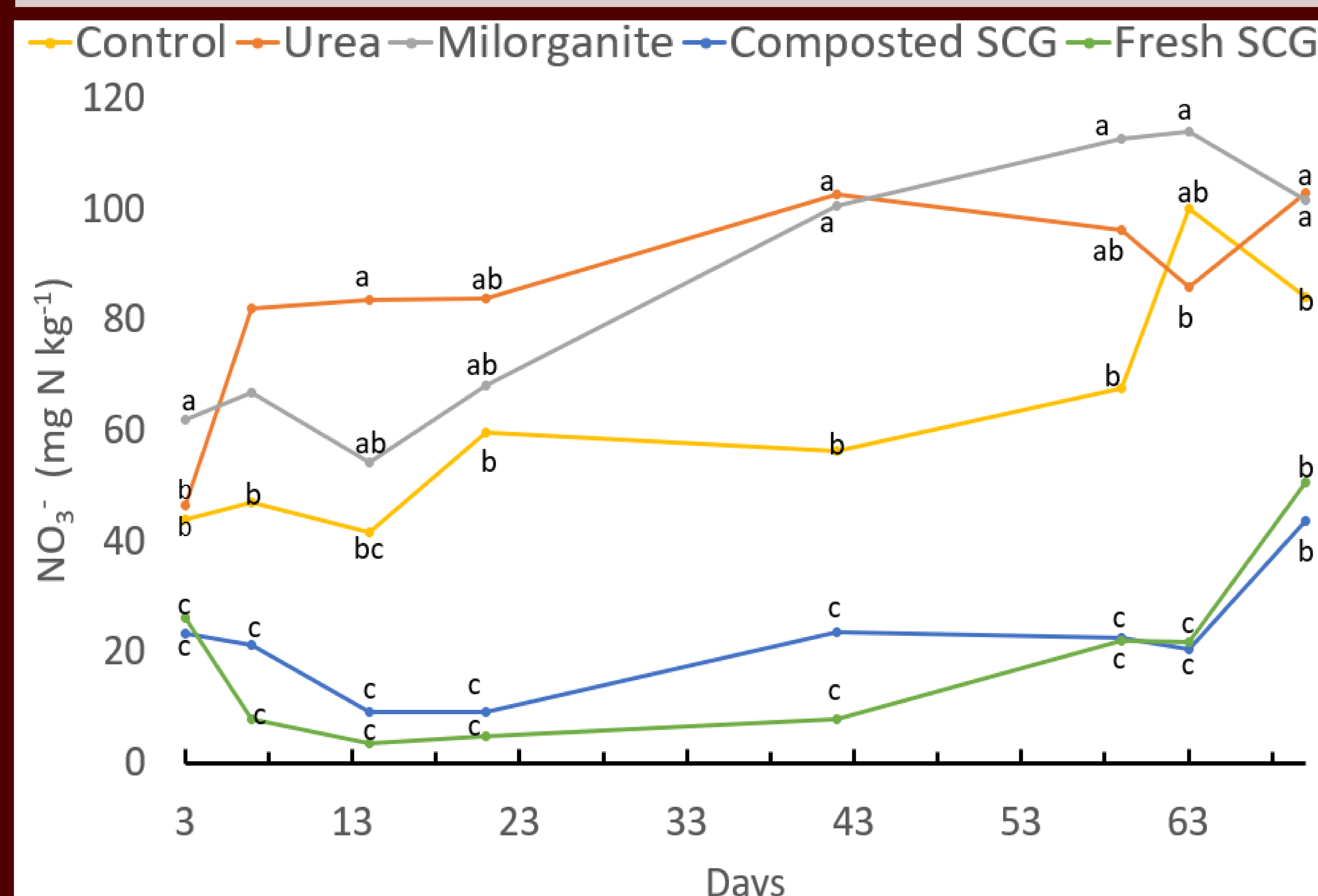


Fig. 5: Nitrate concentration extracted from soils over a 73 day incubation. Means with the same letter on a given day are not statistically different based on Tukey's HSD (0.05).

Ammonium release from SGC occurred from 42 to 63 days

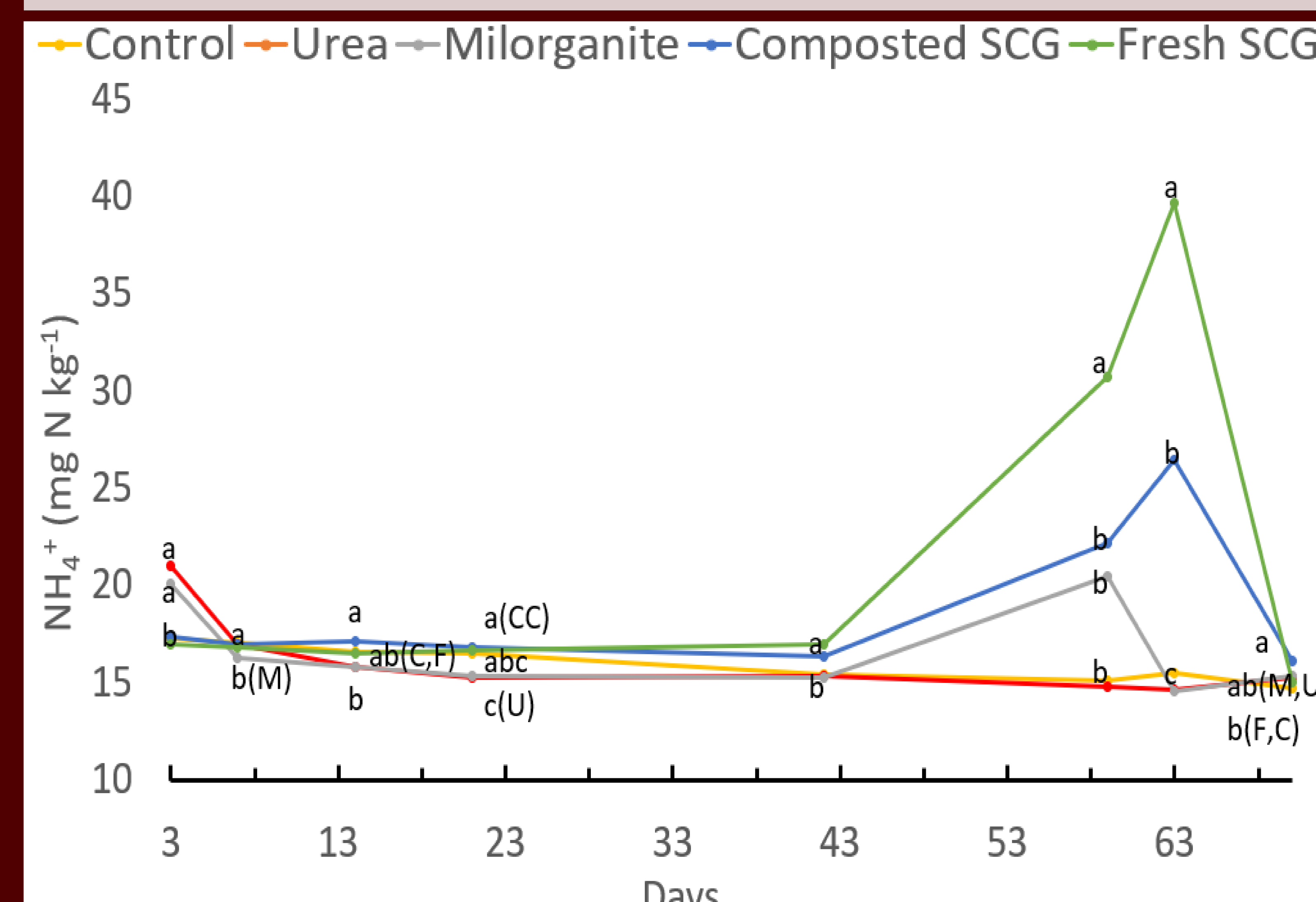


Fig. 6: Ammonium concentration extracted from soils over a 73 day incubation. Means with the same letter on a given day are not statistically different based on Tukey's HSD (0.05). Letters in parenthesis represent treatments (M = Milorganite, U = Urea, C = Control, CC = Composted SCG, F = Fresh SCG).

Fresh and Composted SCG begin releasing inorganic N after 42 days

RESULTS

- Despite their relatively favorable N content (2.3%N) and C:N ratio (20:1), SCG appear slow to mineralize. Net immobilization of N was seen during the initial 42 days, with net mineralization of N occurring later on.
- No significant differences were seen between fresh and composted SCG for any of the parameters tested.
- The high levels of CO_2 respiration observed with SCG demonstrates higher amounts of microbial activity are required for the breakdown of SCG, relative to other fertilizers.
- Given that N mineralization appears slow, the positive benefits previously seen following sand amendment suggest microbial or physical factors may be responsible.

Table 1: Fresh and composted SCG are similar in their total N and inorganic N contents

	Fresh SCG	Composted SCG
% N	2.3	2.9
$NH_4^+ + NO_3^-$(mg kg^{-1})	314.3	323.0
% P	0.1	0.1
% K	0.5	0.5
% Ca	0.2	0.2
% Mg	0.1	0.1
% Na	0.1	0.02
Zn (mg kg^{-1})	17.9	19.8
Fe (mg kg^{-1})	409.2	750.0
Cu (mg kg^{-1})	27.5	25.5
Mn (mg kg^{-1})	42.7	52.2
S (mg kg^{-1})	1574.6	1890.0
B (mg kg^{-1})	4.9	5.6
C:N	20:1	20:1
pH	5.5	5.3

FUTURE RESEARCH

- Data from this study suggest that longer timeframes should be examined for fully understanding N release dynamics from SCG.
- Evaluation of microbial communities and diversity in SCG-amended is needed.
- Characterization of the classes of compounds making up SCG should be examined.

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