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Co-application of organic amendments and urea-N enhanced CO_2 and N_2O emissions from a sandy soil; insights of soil N transformations and organic amendments quality.

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Under the framework of Circular Economy, EU Green Deal and UN Sustainable Development Goals the use of organic amendments is highly promoted as a cost-efficient solution to improve soil quality and agrosystem sustainability. Nonetheless, their agronomic use comes with an uncertainty of their potential to release ample plant-available N, and to emit soil greenhouse gasses.

We investigated short-term (90 d) soil N dynamics of a sandy soil mesocosms receiving four organic amendments (50 t/ha) (i) cow manure compost (CMC), (ii) food waste compost (FWC), (iii) used digestate substrate (UDS) and (iv) municipal sewage sludge (MSS), without and with N fertilization (200 kg/ha; urea-N). An unamended soil mesocosm was included as control. During the incubation soil NO_3^-, NH_4^+, N_2O and CO_2 were regularly monitored. At the end of the incubation potential N mineralization (AMN), total Kjeldahl N, organic C, and trace-metals were determined.

During the incubation, organic amendments increased ~6x soil NO_3- availability (AUC) than C, however soils receiving MSS had similar AUC NO_3- to the fertilized soils (~13x). Only MSS increased ~5x available soil NH_4^+ (AUC) relative to unamended soil. Co-application of urea and organic amendments increased AUC NO_3^- and AUC NH_4^+ ~5x, relative to the unamended soil. Organic amendments increased cum. N2O emission by 10, 20, 1% and 13x relative to the control, and additional 20% increase when urea was co-applied for CMC, FWC, UDS and MSS, respectively. Similarly, organic amendments increased cum. CO_2 emission by 20, 40, 140, and 1% relative to the control, and additional 10% increase when urea was co-applied for CMC, FWC, UDS and MSS, respectively.

At the end, total N increased by 37, 23, 80 and 20% relative to the unamended soil, and an additional 20% when urea was co-applied for CMC, FWC, UDS and MSS, respectively. Org. C increased by 30, 20, 4 and 50%, and an additional 7% when urea was co-applied for CMC, FWC,

UDS and MSS, respectively. AMN increased 2, 50 and 220% and an additional 20% when urea was co-applied for CMC, FWC and MSS, respectively, whereas no change was observed for soil receiving UDS relative to the control. Treatments receiving MSS without and with N had relatively higher amounts of total Mg, Zn, Mn, Cu and S than the unamended soil, whereas no significant differences in trace-metals were observed for CMC, FWC and UDS treatments.

In conclusion, our preliminary results indicate that co-application of organic amendments with urea-N could potentially fuel CO_2 and N_2O emissions from soils, thus offsetting any favorable aspects of the aforementioned policies. Organic amendment, urea-N and their interaction were significant factors ($p \leq 0.05$) driving CO_2 and N_2O emissions. The quality and composition of the amendments may stimulate soil microbial N transformations, and further investigation will elucidate the intrinsic role of soil microbes and their dynamics regulating CO_2 and N_2O emissions from soils.

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