Compliance Methods to determine the Agronomic Performance of Bio-Based Fertilisers

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Abstract text:

Bio-based fertilisers (BBFs) are a potentially more sustainable source of nutrients in agriculture than conventional synthetic or mined fertilisers. Given the diverse nature of BBFs, predicting their nitrogen (N) and phosphorus (P) bioavailability is crucial for their proper and efficient use in agriculture. To address this, we conducted a comprehensive assessment of potentially mineralizable N and carbon (C) content, as well as NH_3 volatilisation, for a representative selection of 42 N-BBFs, and explored various chemical extraction methods to predict their N bioavailability. With respect to P-BBFs, we tested the P extractability of 30 P-BBFs through six different extraction methods and related P extractability to P uptake as determined by a suite of three pot experiments conducted up to maturity in different soils and conditions.

The 84-day aerobic incubations showed a cumulative mineral N and C release varying between -13% of amended N (composts) and 106% of amended N (digestates) and between 10% of amended C (composts) and 117% of amended C (liquid plant-based and animal by-product BBFs), respectively. Based on the results of the mineralisation assays, N-BBFs were classified into five significantly different groups, which however did not match the current component material category (CMC) and product function category (PFC) classification systems applied in the new EU Fertiliser Regulation (EU 2019/1009). Potential NH_3 volatilization varied from 0% of applied total N (olive oil compost) to 64% of applied total N (manure and crop digestate). Characteristics of BBFs (pH, NH_4-N, NO_3-N, DM, C:N) and their interaction with time could explain 89% of the variation in accumulated potential NH_3 volatilization, which was best

predicted by a categorisation based on the original feedstock and processing technology (Wester-Larsen et al. 2022). Cold water extractable N was most strongly correlated with mineralisable N at the start of incubation, while hot sulfuric acid extractable N was correlated with mineralisable N after the first month of incubation and the C:N ratio showed the highest correlations to mineralisable N at the end of the incubation. Even though the combination of those three indicators was not sufficient to discriminate BBFs into the five N and C mineralisation classes without ambiguity, a combination of these three chemical N extraction methods appears to provide a cost-effective yet accurate estimation of their N mineralisation dynamics.

Water-extractable P was not well correlated to plant P uptake (expressed as mineral replacement value), while the coefficient of determination (R^2) was around 0.5 for the other extraction methods, with the iron-bag method (ferrihydrite-filled membranes) giving the best prediction of P availability. However, the iron-bag method is not feasible for compliance testing, given the time, expertise and difficulty needed to carry it out. Instead, even though it overestimates the availability of iron phosphates, the less accurate but more practical neutral ammonium citrate (NAC) method is advised, with a minimum threshold value of 60% P-NAC solubility for all fertilizers.

In conclusion, we have identified potential proxies and compliance methods to predict N- and P-bioavailability and potential NH_3 loss risk of a wide range of BBFs. Since the classification of BBFs according to the PFC and CMC in the EU fertiliser regulation showed no relation to neither N mineralisation, NH_3 volatilisation nor P release, we recommend to use the identified chemical indicators for the development of a novel BBF classification system.

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References

Wester-Larsen L., Müller-Stöver D.S., Salo T., Jensen L.S. 2022. Potential ammonia volatilization from 39 different novel biobased fertilizers on the European market – A laboratory study using 5 European soils. *Journal of Environmental Management* 323, 116249