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Geographic variations of soil phosphorus induced by long-term land and manure nutrient management practices

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Most natural and agricultural ecosystems are deficient in phosphorus (P), and supplemental P must be provided to attain optimal levels of agronomic production. Animal manure is often used to supply needed plant nutrients to enhance production of feed and fiber crops for human and livestock consumption. Soils have been treated with large amounts of P-enriched manure, and have shown elevated P levels in watersheds where there is a high density of intensive confined animal agriculture. Long-term additions can have lasting effects on the geographic distribution of soil microbes associated with the turnover of major soil nutrients, in particular non-mobile one such as P. We determined the distribution of soil P forms in a 10-ha no-till field that received annual additions of dairy manure at 0, 15, and 30 kg P ha^{-1} at the field scale for 16 consecutive years. Spectroscopic analyses of the near-surface zone were performed by X-ray fluorescence in soil cores taken to a depth of 0.2 m. Geostatistical methods were used to determine the spatial structure of the soil compositional data. Soil X-ray fluorescence spectral attributes were obtained based on a set of five parallel transects established across five experimental blocks, i.e. a 5×5 rectangular grid pattern. Three subsets of each soil attribute were identified for the three rates of manure addition. Long-term manure addition, albeit liquid manure, resulted in significant variability in soil P distribution in the near surface zone. The heterogeneity persisted over years of continuous no-tillage management. Therefore, a high density of geo-referenced soil measurements must be made to estimate the status of a required plant nutrient, especially a non-mobile nutrient in soil. A large number of timely measurements would require a rapid geo-referenced soil sensing spectroscopic method such as X-ray fluorescence to manage in near real-time the observed spatial variability of manure-treated fields.