Identification and quantification of organic phosphorus forms in soils from fertility experiments

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In order to investigate the influence of different fertilizing regimes and fertilizer types on the soil content of organic phosphorus (P), soils of different characteristics were investigated with nuclear magnetic resonance spectroscopy (P-NMR). Four soils were chosen for the study, of the following types: silty clay loam, loamy sand, sandy loam and clay. On each of these soil types 4 different levels of fertilizer additions were made, corresponding to zero P addition, P addition equivalent to the amount of P removed annually by harvest etc (henceforth called P addition), P addition + 15 kg P/ha, and P addition + 30 kg P/ha. In addition, each of the additions was made in two crop rotations, one with commercially available fertilizer, and one with manure. On the zero P addition soils, were no fertilizer was added, the potential influence of using ley farming on the organic P content of the soil was investigated. Each of the tested set ups were made in replicates. The study was thus aimed both at investigating the impact of various fertilizing regimes on the composition of organic P compounds in the soil, as well as increasing the knowledge on organic P in typical Swedish soils in general.

Results show that without P addition the soils contain a majority of phosphate monoesters (40-80%), which is a rather refractory form of P, not generally available to plants and microorganisms. Other P species in these samples were primarily orthophosphate (20-60%) and pyro/polyphosphate (1-4%), species that generally are more available than the phosphate monoesters. The ratio between monoesters and ortho-P varied significantly depending on the soil type, with the loamy sand having the lowest amount of monoesters, and the silty clay loam the highest. These differences were diminished with increasing fertilizer addition. Already a P addition equivalent to the replacement level changed the relative distribution of the identified P compound groups, making orthophosphate the dominant species in the samples. This trend increased with increasing fertilization, and with fertilization corresponding to P addition + 30kg/ha the orthophosphate constituted more than 70% of the extractable P in all soils, while the proportion of monoesters decreased correspondingly. No differences due to fertilizer type or use of ley farming on the composition of organic P compounds in the soil could be concluded in the study.

In general, the addition of fertilizer changed the organic P composition of the soils markedly. Without fertilizer the majority of the P in the soils existed in the form of relatively refractive and unavailable organic compounds, while addition of fertilizer increased the proportion of available P, which with the highest P addition was over 80% of the total P content. In addition to this, fertilizing the soils increased the total extractable P by 2-3 times, and this seemed to in part depend on the soil type, with the soils with the coarsest particle sizes showing the lowest amount of tot-P, both before and after fertilizing.