Soil phosphorus (P) budgets, P availability and P use efficiencies in conventional and organic cropping systems of the DOK trial

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Cropping systems rely on the provision of adequate amounts of phosphorus (P) to enable stable crop yields. A balanced application of P is necessary to avoid reduced crop yields (in case of too low application rates), but also to avoid P losses to other ecosystems (in case of too high application rates). While in conventional cropping systems the use of synthetic P fertilizers is common practice, organic cropping systems mostly rely on organic P inputs such as farmyard manure or compost. We aimed to answer if different cropping systems attain balanced P application rates in the long run, and how plant P availability is affected by different cropping systems and forms of fertilizers applied.

We used data obtained from the DOK (dynamisch, organisch, konventionell) long term field trial obtained during a 35-year period. The trial was established in 1978 near Basel (Switzerland) and consists of four different cropping systems using different sources of P fertilizer: BIODYN: biodynamic (composted farmyard manure and aerated slurry), BIOORG: bioorganic (rotted manure and slurry), CONFYM: conventional with farmyard manure and slurry, complemented with mineral fertilizer and CONMIN: conventional with mineral fertilizer only. Rates of fertilizers application equal 1.2 livestock units (increase to 1.4 at the 3rd crop rotation period of 7 years each). All cropping systems except CONMIN are also maintained at a reduced (i.e. halved) fertilization level. We calculated a soil surface P budget considering all relevant P inputs (fertilization, seeds) and outputs (removal by crops) on a plot level (12 plots per cropping system). At commence and at the end of each crop rotation, plant P availability was estimated by soil P extraction with carbon dioxide saturated water as well as by determining isotopically exchangeable P.

Phosphorus inputs surpassed the outputs in conventional cropping systems CONFYM and CONMIN, resulting in a positive P-budget between +3 and +6 kg P / ha * yr in average. The trend was reversed in organically managed cropping systems BIODYN and BIOORG, having negative P-budgets between -3 and -6 kg P / ha * yr in average. Additionally, all cropping systems with reduced fertilization levels had a negative P budget as well (-11 to -13 kg P / ha * yr). Plant P availability generally decreased within the first crop rotation period in all cropping systems, likely as a result of depleting high soil P stocks that were established before the start of the field trial. Plant available P continued to decrease since then in cropping systems with reduced fertilization, while it stabilised in the more balanced cropping systems.

In summary, while conventional cropping systems risk to apply P at rates higher than actual plant removal, a P limitation for crops in organically managed cropping systems may establish in the long run if current fertilization recommendations are pursued. The results of the P budget will be further discussed including data on soil P stock changes, evaluations on P availability to crops (derived from isotopically exchangeable P) and estimates on fertilizer use efficiencies in different cropping systems.