Soil and plant indicators to minimize phosphate inputs in permanent grasslands

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Phosphate (P) losses to surface waters remain a major problem in many European agro-ecosystems supporting a high livestock density. Fertilization with animal manure based on nitrogen (N) demand results in excess P which accumulates in the grassland soils. Decreasing soil available P contents has been suggested as a measure to decrease P losses. However, because of the complexity of a permanent grassland ecosystem it is difficult to foresee how changes in P inputs will affect grassland productivity and soil P availability. The aim of the ongoing project is therefore to develop a set of soil and plant indicators to assess the effect of different P inputs on soil P availability, herbage production and on the fate of P in the environment.

We investigated six permanent grasslands at three locations in Switzerland in 2008 (Baldegg, Watt and Les Verriéres), which differ mainly in cutting regime and fertilization intensity, soil properties and local climate. Four grasslands in Baldegg are intensively managed by local farmers. The other two grassland sites are long term fertilizer experiments with lower cutting frequency and various rates of N, P or K fertilization. Plants were sampled on an area basis and separated in the three botanical fractions grasses, legumes and forbs. Nutrient concentrations were analyzed in above ground biomass and used to calculate the phosphorus nutrition index (PNI). Soil samples were taken in 0-5, 5-10, 10-20 and 20-40 cm depth. Plant available P was determined using anion exchange resins for P extraction. Subsequently available P was correlated to plant parameters such as yield and PNI, and to soil parameters like the degree of phosphorus saturation (DPS) as a measure for the risk of P losses to the environment.

At all locations P availability decreased with soil depth and augmented with increasing P input by fertilization. PNI as a plant indicator reflected the plant nutritional and soil P status. Still, differences in botanical composition need to be considered when interpreting the PNI because legumes have lower and forbs higher P concentrations in above ground plant tissue than grasses. With higher P fertilization the DPS increased, especially on soils with high accumulated P, and therefore indicated a higher risk of P losses from those grasslands. Using the specific P desorption factor (derived from a P33 exchange kinetic experiment) for DPS calculation seems adequate for field specific P loss risk assessment.

In conclusion we saw that even in little intensive managed grasslands relatively high yields were obtained, but with lower forage quality because of a late first cut. With management intensification the forage quality rises but also the risk of P losses to the environment. The investigated indicators can be used for a field specific risk and fertilization evaluation to improve grassland management and thus reduce P losses.