Phosphorus for turfgrass – the SUSPHOS project

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Photo 1. *In the case of phosphorus deficiency, the plants turn dark green to purple (Photo: Doug Soldat).*

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Phosphorus is an essential plant nutrient. At the same time, it is a major source of pollution of lakes and streams primarily through surface runoff, but phosphorus can also be leached through the soil into drains, especially in soils where the phosphorus bonding capacity is low. In the SUSPHOS project, we focus on the sustainable utilization of phosphorus on golf courses. We are testing MLSN fertilization (Minimum Level of Sustainable Nutrition), which is a new international standard for fertilizing turf grass. Based on soil analyses of phosphorus and other macronutrients, this new norm is significantly lower than traditional agricultural standards.

Phosphorus for plants

Phosphorus is a macronutrient found primarily in plant DNA and in phospholipid membranes. Phosphorus is important for enzyme activity and for several other essential mechanisms in plants. A turfgrass area lacking phosphorus has a lower tiller density and the single plants change color to dark green or even purple. The phosphorus requirement is usually considered to be higher during establishment or re-establishment than to established turf.

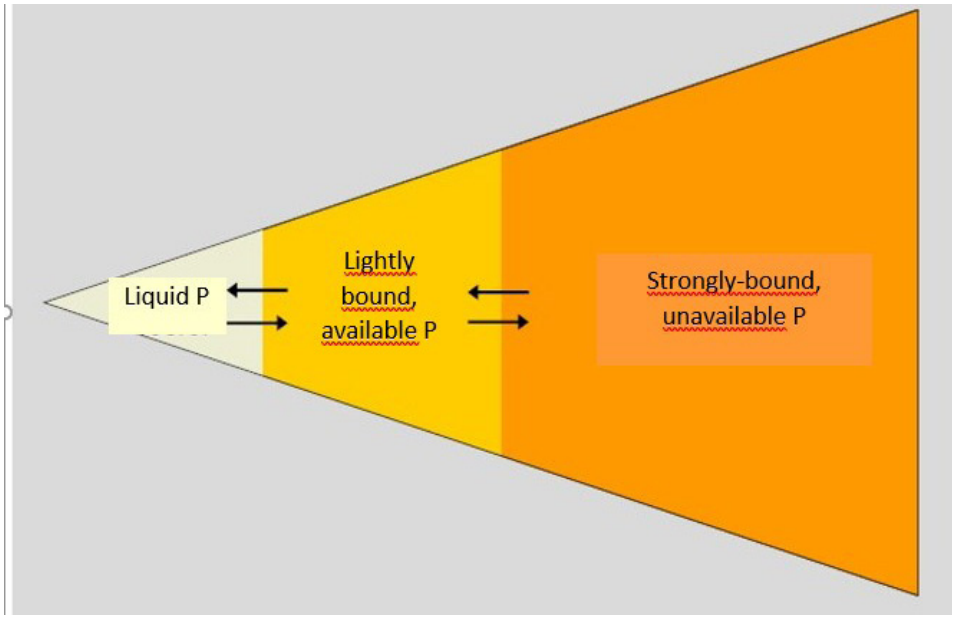

Figure 1: *The soil contains large amounts of phosphorus not readily available to the plants (Rubæk et al. 2018).*

Phosphorus in the soil

Plants take up phosphorus as phosphates dissolved in the soil liquid. However, only a very small proportion of the total phosphorus content of the soil is found dissolved in the soil liquid (the outermost tip of the triangle in Figure 1).

Most of the phosphorus in the soil is part of organic and inorganic compounds, which are often difficult to access for plants. The available phosphorus is the amount of inorganic phosphorus that the soil can release to the growing plants, and this is estimated by various soil testing methods (P-Al in Norway and Sweden, Pt in Denmark, Mehlich-3 or other methods internationally). The entire triangle in Figure 1 illustrates the total inorganic phosphorus content in the soil. The soil contains a large pool of organic phosphorus too, which can be as large as the inorganic pool.

When the plant absorbs phosphorus, the phosphorus concentration drops in the soil liquid. Thereby, phosphorus is released from the soil pools. The opposite happens when we add easily soluble phosphorus in the form of fertilizers. Therefore, there are typically only minor changes in the available phosphorus pool from year to year, because the large pools of «hard-to-reach» phosphorus act as a buffer. The ability of plants to absorb phosphorus also depends on the pH of the soil. At low pH, phosphorus is bound to aluminium (Al) and iron (Fe) and at high pH, phosphorus is bound to calcium (Ca).

A limited resource

Phosphorus causes eutrophication of lakes and streams, and since phosphorus is a limited resource globally, we should minimize the consumption of this plant nutrient. We can do this by only fertilizing with phosphorus when needed, and by using renewable sources of phosphorus instead of rock-phosphate.

In agriculture, the levels of phosphorus to crops have been reduced in recent years. The MLSN-standard is based on more than 3500 soil samples from ”good looking turf” from around the world, and it is a good indication of how we can add phosphorus to golf grass only when it is needed. (See the special article about MLSN nutrition in the STERF library).

The golf industry should contribute to a reduction in the import of phosphorus in commercial fertilizers. We can do this by using phosphorus in residual products from local sources, eg. from wastewater treatment plants. A vision may be that all phosphorus used on golf courses comes from local renewable sources.

What does the SUSPHOS project show so far?

The SUSPHOS project comprises three subprojects. The first two are greenhouse trials, where we have investigated the need for phosphorus especially during turfgrass establishment or reestablishment at low soil temperatures. We also look at how increasing amounts of phosphorus in the form of liquid or granular fertilizers affect overall impression (turfgrass quality) and spring green-up on established greens.

We will return to the results of these trials in a later article, but we can already reveal that the need for phosphorus is greater in the establishment phase than on established greens. However, we have not found that the need for phosphorus is greater at low soil temperatures. Low temperature slows down plant uptake, and thus the need for nutrients does not increase at low temperature.

In the third work package of the SUSPHOS project, the MLSN standard for phosphorus is tested on five different golf courses with different grass species, soil types and climates. Here, we compare MLSN with

traditional fertilizer standards for phosphorus, as well as with «precision fertilisation», where phosphorus is applied as 12% of the N rate (N = 100, P = 12, K = 65, etc.) regardless of soil analyses.

The trials started in 2017 and continue until 2020, taking place in Europe (Norway, Sweden, the Netherlands and Germany) and in Asia (China). We are registering the overall impression of grass (turfgrass quality), root depth and invasion of *Poa annua* in the trials. Overall, the preliminary results show that there are small differences between P-treatments. At Falkenberg Golf Club, between Gothenburg and Malmö, phosphorus fertilization has tended to increase the amount of *Poa annua* in the green.

Alternative sources of phosphorus fertilizer

To minimize the import of phosphorus in commercial fertilizers, the golf industry should support the recycling of nutrients. Therefore, more knowledge on the fertilising value of various residual products is needed.

In 2019, we initiated a small project at NIBIO Landvik to investigate the fertilizer value in struvite from the HIAS treatment plant at Hamar (north of Oslo). Struvite is a precipitation product from wastewater treatment plants formed in the process of dewatering the wastewater sludge. Struvite is a crystal containing Magnesium (9%), ammonium (5%) and phosphate (12%) with the chemical formula $MgNH_4PO_4 \cdot 6H_2O$. Struvite is approved in Norway and Denmark for use as a commercial fertilizer in agriculture. This means that the content of heavy metals and other foreign substances is below the limit values. Agricultural experiments have shown that struvite has almost the same phosphorus fertilizer value as triple superphosphate.

At Landvik we test the phosphorus fertilizer value of struvite in pot experiments in the greenhouse and compare it with triple superphosphate. In the preliminary project, we have sown three different grass species (red fescue, creeping bentgrass and perennial ryegrass), to gain experience and knowledge that we can hopefully use for the coming season's field trials with struvite. The company HIAS would also like to test their product on a golf course or a similar area in order to market their struvite as a fertilizer.

Photo 2: *Falkenberg golf club is testing the MLSN in the SUSPHOS project (Photo: Majvor Sintorn)*

Conclusion

Phosphorus is an essential plant nutrient, and lack of this nutrient can impair growth and turfgrass quality. However, excess phosphorus can also lead to surface water pollution - both locally on the golf course and in the surrounding environment. Since phosphorus is a limited resource globally, the golf courses should not use more phosphorus than absolutely necessary. The MSLN standard, which on most soils implies lower requirement for phosphorus fertilisation than used previously, is a good indication of how we can reduce the consumption of P. At the same time, golf courses should make their contribution to the circular economy by testing alternative sources of phosphorus fertilizers such as struvite from wastewater treatment plants.

References

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