Phosphorus management in organic soils for sustainable agriculture

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Introduction

There is an increasing pressure on organic soils (peats, bogs and associated soils) as a consequence of the growing demand to bring more land into pasture and hence increase the milk and meat production. However, these soils have been identified as vulnerable to phosphorus (P) loss due to their poor P retention capacities when fertilizer P is applied: significant differences in the P sorption mechanisms in soils take place depending on the content of organic matter as there are competitive sorption reactions matter for the soil sorption sites between P and the organic acids (humic and fulvic acids, low molecular weight acids) derived from the decomposition of this organic. Hence, soil organic matter content plays an important role regarding P dynamics with regard to agricultural and environmental management. These findings have implications for sustainable use of fertilizer P on peaty soils. Nutrient application to these soils requires a different management strategy compared to mineral soils due to the high potential for P transfer to water. The aim of this research work is to optimize phosphorus use on soils with a high content of organic matter through the execution of a series of agronomic and environmental experiments in lab conditions that will help us to describe P assimilation and transport in these soils.

Material and Methods

A growth chamber experiment (Figure 1) was conducted on six different soils ranging in organic matter content to determine the agronomic optimum fertilizer P application for ryegrass production. The soils were placed in pots (30 cm diameter x 30 cm depth) and 14 different P rates ranging from 0 to 145 kg P ha^{-1} were applied to each soil type. Soils were kept at controlled conditions of 14° C (± 2° C) day time and 8° C (± 2° C) dark period, 70 % relative humidity at day period and 90 % relative humidity dark period, a day length cycle of 16 hours and 8 h darkness.

Figure 1. Growth chamber trial with the pots containing the different soils under controlled conditions of temperature and relative humidity.

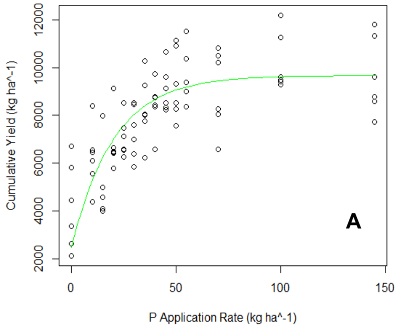
Dry matter yield and herbage content were measure during a period of nine months. The original Mitscherlich equation ($Y = A(1 - e^{-cx})$) was used to fit the yield response to the different P treatments.

From an environmental point of view, a leaching experiment is currently being conducted to ascertain the amount of P lost from two contrasting soils (one organic, one mineral). Soils were packed in 0.3m-deep and 0.104 m-diameter PVC columns. P applications of 15, 30 and 55 kg P ha^{-1} as a single superphosphate fertilizer were applied in either one or two application times. One hundred and eighty ml of distilled water is applied weekly on the surface of the columns to recreate real rainfall conditions in Ireland. The leaching water is collected in individual containers and analysed weekly for Dissolved Reactive P (DRP), Total P (TP) and Total Dissolved P (TDP), along with other nutrients (total nitrogen and carbon)

Results and Discussion

Cumulative yield response curves to the different fertiliser P application rates from the growth chamber experiment are shown in Figure 2. Soils were grouped in organic (A) and mineral (B) based on the percentage of organic matter (OM) content (organic soils have OM > 20 %, minerals have OM < 20 %).

Under P deficient scenarios, organic soils (Figure 2 A) showed a quicker response to the P applications than mineral soils. Mineral soils exhibited slower response, possibly due to build-up required before P is made plant available. This can be due to the ability of mineral soils to absorb and bind phosphate ions into the clay minerals when they are deficient in P. In contrast, the quick response on organic soils suggests that the P applied was not bound but immediately available for grass uptake. The model for the organic soils explained a 56.2 % of the total variation whereas is was lower for mineral soils, only 24.5 %, due to build-up requirement of these soils.



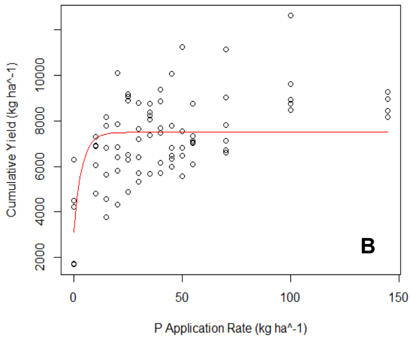


Figure 2. Response of the cumulative yield to fertilizer P for combined organic soils (A) and mineral soils (B)

Conclusions

Fertiliser P requirements for pasture production are higher for organic than for mineral soils. However, further work on leaching and runoff experiments is required in order to understand if these requirements pose a risk of P loss to the environment.

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