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The response of soil biota to phosphate fertilization in grassland columns

Israel Ikoyi (1,2), Henry Winstanley (2), Andrew Fowler (2), and Achim Schmalenberger (1)

(1) Department of Biological Sciences, University of Limerick,Limerick, Ireland (Israel.ikoyi@ul.ie), (2) Department of Mathematics and Statistics, University of Limerick,Limerick, Ireland

The United Nations has predicted that food production is expected to rise by 50% in the year 2020 to feed the increasing world population. Grasslands play significant roles in food production and occupy about 70% of the world's agricultural land. However, intensive use of inorganic fertilizers often associated with increased food production can lead to poor soil quality and environmental pollution. For instance, excessive phosphorus (P) application can lead to eutrophication in surface waters. Although P plays vital roles in many metabolic processes in plants, its primary source rock phosphate is finite. Consequently, the development of more P efficient agricultural systems is paramount. P cycling within the microbial biomass is essential to the P cycle within the soil with its key pathways for P mobilization and mineralization from various soil pools into plant available forms. In this study, soil columns were setup in a greenhouse using a P deficient Irish soil (P index 1). The columns were planted with Lolium perenne and fertilized with 0, 5, 10 and 20 kg/ha inorganic P representing control, low, medium and high rates respectively alongside a full complement of other nutrients. Each treatment was replicated six times and managed for 14 weeks. Results after 14 weeks showed that the weekly measurements of phosphate at different soil depths identified only traces of P in soil solution for the duration of 14 weeks, even after P application. There was a significant increase in alkaline and acid phosphatase activities with the high P compared to the control but no significant effect on plant shoot and root biomass, abundances of cultivable calcium phosphate-, phytate- and phosphonate-utilizing bacteria upon P fertilization. L. perenne rhizosphere of the highest P treatment had significantly lower abundance of bacterial phoD genes, mycorrhizal hyphal and arbuscular colonization rates compared to the control. Likewise, the abundance of bacterial- and fungal-feeding nematodes, enrichment index were significantly higher in the control compared to the P treatments. In addition, denaturing gradient gel electrophoresis analysis showed that high and medium P significantly shifted the bacterial, fungal and Glomeromycota community structures compared to the control. The Next Generation Sequencing data revealed that the control had a significantly higher abundance of certain bacterial families when compared to the high P treatment (e.g. Bacillaceae, Paenibacillaceae, Nocardioidaceea, Micrococcaceae, Bradyrhizobiaceae) that have been associated with P mineralization in the past. Our results show that some of the parameters are more sensitive to P application though the effect on others may have been masked by the low P status of the soil. Results from this study suggest that a positive effect of a single inorganic P fertilizer application on plant growth in a soil is largely cancelled out by its negative effect on the soil microbiota. These findings support the hypothesis that soil microbiota play an important role in plant P supply in low P index soils. The findings from this study will be included in a mathematical model on biotic P cycling to better predict the effects of fertilizer application in grassland agriculture.