Soil-Plant System Response to Lime and P Fertilizer Amendments in an Andisol in the Ecuadorean Andes

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Introduction & Objectives

Andisols are soils derived from volcanic ash that make up a mere 1% of the world's soils. They are geographically localized to regions marked by volcanic activity, including the Andean Highlands of Ecuador, part of the Ring of Fire. Andisols have high organic matter content, high water holding capacity, and high overall native fertility as a result of their unique parent material. However, high rates of phosphorus sorption are also characteristic of many volcanic soils (Andisols) and can limit agronomic productivity. Acid Andisols, like those evaluated in this experiment, experience phosphorus sorption as a result of ligand bonding with amorphous minerals and organic matter, and fixation of phosphate with aluminum and iron oxides. Phosphate removed from the soil solution is strongly held by soil minerals and is not available to plants.

The major objective of our work was to investigate the use of lime and P fertilizer amendments in order to reduce P sorption, increase P bioavailability, and increase plant P uptake and biomass production.

Here we report on the immediate results of this work and potential long-term benefits of application of these amendments to acid Andisols that have high rates of P sorption.

Materials & Methods

General properties of a soil within the watershed of the Chimbo River within the SANREM study site in Ecuador was selected to be used in a greenhouse experiment:

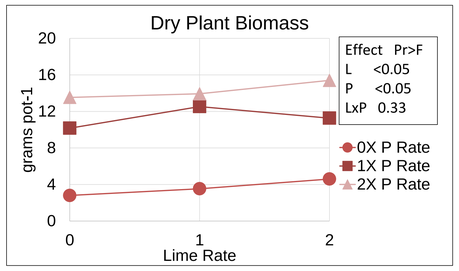
Measurement	Result
pH	5.88
Olsen extractable P	6.32 mg/kg
Aluminum (Mehlich-3)	1707.9 mg/kg
Iron (Olsen)	927.42 mg/kg
Plant Available Water Content	37.2 g H_2O/g soil
Organic Matter	13.2%
Texture	Silt Loam

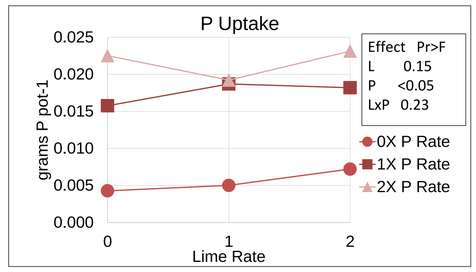
Nine treatments were established in the greenhouse study using three rates each of lime and phosphorus:

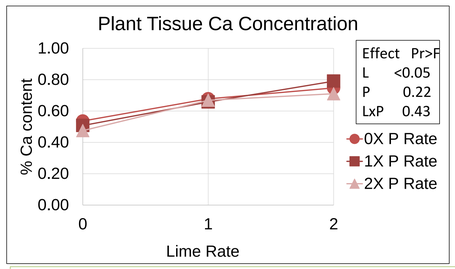
	Field Rate		Applied Rate	
Treatment Code	Lime	P_2O_5	Lime	P_2O_5
	ton ha^{-1}	kg ha^{-1}	g pot^{-1}	
T1: 0L, 0P	0	0	0	0
T2: 0L, 1P	0	90	0	0.32
T3: 0L, 2P	0	180	0	0.63
T4: 1L, 0P	3	0	11.74	0
T5: 1L, 1P	3	90	11.74	0.32
T6: 1L, 2P	3	180	11.74	0.63
T7: 2L, 0P	6	0	23.48	0
T8: 2L, 1P	6	90	23.48	0.32
T9: 2L, 2P	6	180	23.48	0.63

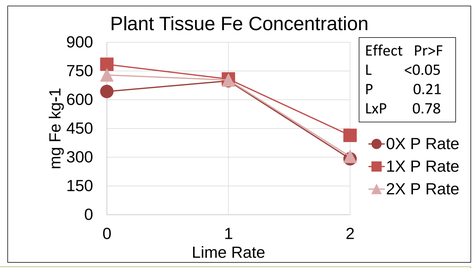
Plant tissue was digested in nitric-perchloric acid solution while soil samples were analyzed in a Modified Olsen and a Mehlich-3 solution.

Results

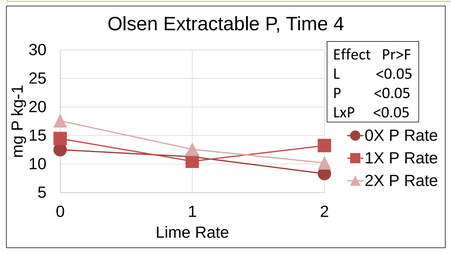


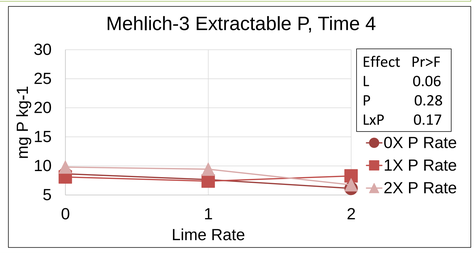




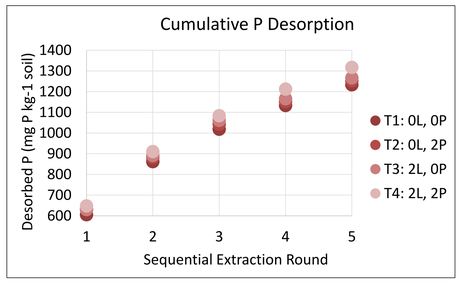


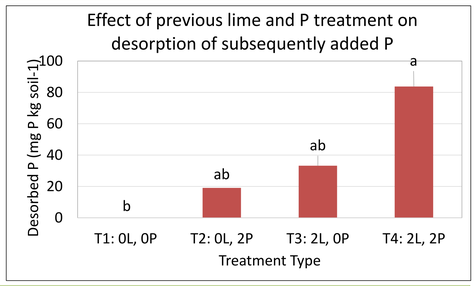
Plant biomass and calcium and iron tissue concentrations were influenced by liming, as well as other micronutrient concentrations. P fertilizer increased biomass production and P uptake, but P concentration did not change.



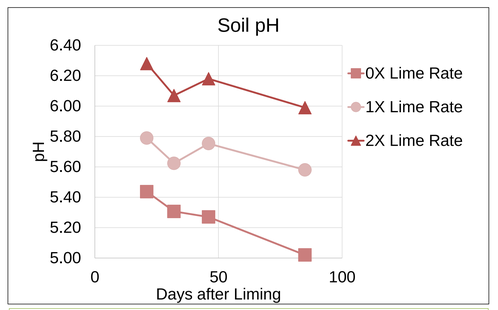


Differences in the amount of phosphorus recovered between the two extracting solutions show variability and the importance of calibration of results with field data, as well as investigation of new methods for measurement.

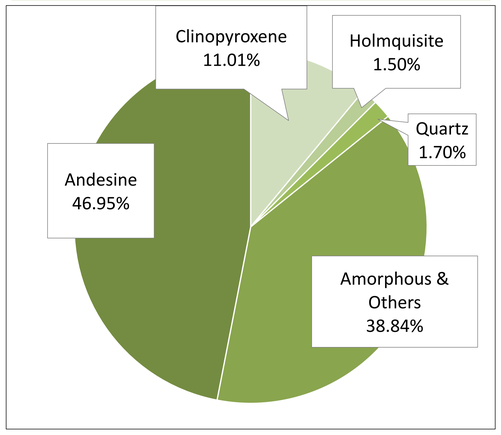




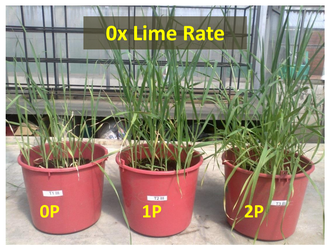
The use of lime in a first cropping cycle was shown to have an impact on the desorbable phosphorus from the same soils after a secondary phosphorus application, suggesting that liming increases future P availability in these soils.

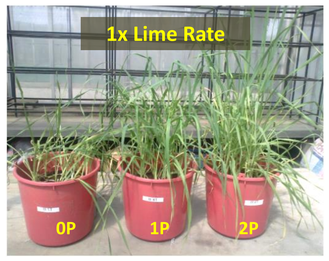


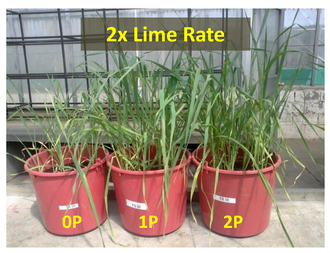
Lime did increase soil pH (which then decreased over time).



Analysis of soil mineralogy gave the above results. Amorpohous minerals, clinopyroxene, and holmquisite all have high variable charge and high rates of P sorption. Andesine is a very typical plagioclase feldspar developing in volcanic soils.







Differences in barley response to lime and phosphorus application are shown.

Young Andisol profile showing many depositional volcanic ash events.

Conclusions

The use of lime is shown by the plant bioindicators to have a positive effect on biomass production, however, the same treatments were shown to have no effect or a negative impact on available soil phosphorus. This discrepancy highlights the need for future development and calibration of a soil test for this region.

Plant nutrition, including tissue calcium, iron, and others concentrations were all improved for the plant with the use of lime. Plant P concentrations nor uptake changed due to liming.

The use of lime in these volcanic soils to improve the long-term phosphorus availability is a potential theme for future work on this subject. Results from our tests show an improved phosphorus desorbability over time with liming, in addition to the increased P availability directly linked to the addition of P fertilizer.