Maximizing phosphorus investments with soil management: Amplifying phosphorus use efficiency by site-specific soil fertility management

Andrew J. Margenot
University of California, Davis
PhD candidate, Soil Science and Biogeochemistry
Department of Land, Air and Water Resources
1 Shields Avenue
Davis, CA 95616, USA
ajmargenot@ucdavis.edu

Rolf Sommer
International Center for Tropical Agriculture
Senior Scientist, Soil Health and Climate Change
c/o International Centre of Insect Physiology and Ecology
Duduville Campus off Kasarani Road
P.O. Box 823-00621
Nairobi, Kenya
r.sommer@cgiar.org

The majority of soils in sub-Saharan Africa (SSA) are highly weathered with limited intrinsic soil fertility. Smallholder farmers face crop production challenges and consequently food insecurity as a result of soil phosphorus (P) deficits. Investing in the P capital of these regions by increasing P inputs is a recognized strategy for lifting P limitations to agricultural productivity. However, this strategy has met difficulties as infrastructure, economic, and soil-based challenges tend to limit access, affordability, and efficiency of P investments, and thus the average adoption of P fertilizer (and any other type) is low. The forecasted global limitation of rock phosphate reserves may further exacerbate availability and economic barriers to P transfers into regions where building P capital is most needed.

To address the issue in a holistic way, P investments must go hand in hand with site-specific soil fertility management. We describe the multiple advantages of such management as the key to success of current and future investment strategies toward P security. This reflects strong soil controls on the fate and crop use of P, and the potential to capitalize on the 'master variable' of soil pH to promote efficient use of added P, i.e. to increase agricultural P use efficiency (PUE). Resources for soil fertility management to improve PUE may be more abundant regionally and accessible locally relative to minable P deposits. Such integrated management also has the potential to lower the risk perceived by farmers to invest in P fertilizers given the increased return from such investment.

The strong propensity of acid soils prevalent in SSA to fix or 'lock up' P in unavailable forms undermines P investments in this region. Liming agents can be used to correct soil acidity, thereby increasing PUE of inputs. Unlike global rock phosphate reserves, lime deposits are generally more common and widely distributed. For example, calcium carbonate reserves recently identified in several SSA nations could be used as a lime source, improving availability of added and existing P in soils. Treating soil acidity can also improve PUE indirectly by alleviating non-P constraints on crop production, most notably aluminium toxicity and nutrient deficiencies like molybdenum—a critical element for legume crops to fix atmospheric nitrogen. Furthermore, using a regional resource like lime to achieve higher PUE offers an opportunity to improve P security by lessening dependence on imported P inputs.

Finally, improved PUE by soil management requires basic but long-lasting investments in knowledge of soils, particularly at sub-regional scales. For example, P fertilizer recommendations in Kenya are highly generalized and overlook significant variability in soils that dictate efficient use of added P by crops. This is largely due to incomplete and poor-resolution soil maps of the region. Building information and knowledge infrastructure through soil mapping and basic soil testing are necessary to appropriately target P and supporting PUE investments spatially and over time.