Proposal for IAAE Organized Symposium

Soil Management and Crop Response to Fertilizer Use in sub-Saharan Africa: Methodological and Policy Issues

Thom Jayne, Michigan State University
William Burke, Stanford University

Theme

The utilization of information from soil samples and/or newly available GIS databases to estimate crop yield response to inorganic fertilizer application in developing countries is increasing. This approach has many benefits. First, it overcomes a source of potentially substantial omitted variable bias that has stymied earlier estimates of fertilizer effectiveness. Second, incorporating soil information into yield models can provide a better understanding of the factors associated with fertilizer effectiveness, allowing for interesting new insights to emerge in agricultural economics. Third, beyond understanding soil quality effects on yield and yield response, this approach allows us to model soil characteristics as endogenous at the household level, which they clearly could be because individual households can make soil-improving investments or adopt practices that degrade their soils. In much of Africa, for example, rising rural population density is leading to subdivision and fragmentation of holdings, smaller average farm sizes, the elimination of fallows and more intensive cultivation of cropland. Farmers’ resources, knowledge, and management practices condition the resulting effects on soil quality, but soil has rarely been treated as endogenous using economic data because that data simply did not exist.

It is widely accepted that inorganic fertilizer use must be raised dramatically in most of Africa in order to achieve many of the region’s agricultural and food security goals. Fertilizer promotion policies have been a cornerstone of many African governments’ agricultural strategies in recent years. However, there are concerns that the promotion of higher fertilizer application rates in isolation may not be cost-effective, profitable for farmers, or sustainable. Specifically, the heavy focus on fertilizer may preclude the promotion of more holistic strategies involving the adoption of complementary inputs and management practices on farmers’ fields. Moreover, there are signs that crop response to fertilizer application may be lower than expected, stagnating or even declining over time due to unfavorable initial conditions and adverse changes in soil characteristics associated with continuous cultivation. Agronomists understand that in some cases crop yield response to fertilizer may be low because soils are not deficient in the macro-nutrients (Nitrogen, Phosphorus and Potassium) that most inorganic fertilizers provide (in which case yields may be constrained by a lack of other nutrients). Even more likely, plant yield response to fertilizer may be low due to structural and chemical problems in the soil that hinder plants’ ability to uptake macro-nutrients.
There are many research and policy questions flowing from these concerns. Combining modern soil analysis tools with household survey data is a practice in its infancy, but strides have been made in the past 3 years. In parts of Africa, nationally representative household survey teams have collected and analyzed thousands of soil samples. These soil surveys have been integrated with thorough farm practice and household economic surveys about plot-level management practices in prior seasons, paving the way for an unprecedented opportunity to understand and possibly improve input effectiveness.

This symposium brings together a diverse group of researchers whose work is increasingly highlighting the important nexus where agronomics meet economics. The proposed symposium has three goals: 1) to assess the “state of the art” of our field of research with regards to how we might integrate physical characteristics of soils with household economic data and why that is important; 2) to refine our understanding of yield responses to input use, particularly fertilizers, using models that explicitly remove soil characteristics from the error term; and 3) push our discussion beyond the debate over response rates and further into how we can expect them to be improved (regardless of their current state).

Organized Symposium Format

Moderator: Keith Fuglie, Economic Research Service/USDA

Presenters: Understanding Fertilizer Use and Effectiveness in Zambia, William J. Burke, Stanford University (15 min)

Plot History, Soil Characteristics and Crop Response to Fertilizer in Kenya. Milu Muyanga, Michigan State University (15 min)

The role of relative prices, agro-ecology, and household soil and crop management practices in explaining smallholder profitability of fertilizer use on maize in Tanzania. David Mather, Michigan State University (15 min)

Discussant: Julius Mangisoni, Lilongwe University of Agriculture and Natural Resources, Malawi (8 min)

Open discussion (37 min)

Total session time: 90 minute

Abstracts of the papers to be presented

1. Understanding Fertilizer Use and Effectiveness in Zambia. William J. Burke (Stanford University), Emmanuel Frossard (ETH Zurich), Stephen Kabwe
Africa today would benefit greatly if farmers were more productive agriculturally per unit of land. Regardless of how it is defined, the majority of the world’s worst off live in Africa and are primarily agrarian, but net buyers of most food. In the not-too-distant future, the need for increased production per unit of land on a continual basis will become even more urgent. Considerable effort has focused on promoting inorganic fertilizers, usually with pan-territorial recommendations. This paper quantifies the impacts of soil characteristics on yields and response to fertilizer on Zambian maize. We use a nationally representative sample of 1,653 rural fields. In addition to economic and farm management surveys, composite soil samples were collected and analyzed for several characteristics at the Zambia Agricultural Research Institute. To the best of our knowledge, no data with this scope of geography and content has ever been analyzed in the literature.

2. **Plot History, Soil Characteristics and Crop Response to Fertilizer in Kenya.** Milu Muyanga and T.S. Jayne, Michigan State University.

This study addresses perceptions that crop response rates to fertilizer are declining over time in parts of the region due to changes in soil conditions, adversely affecting fertilizer profitability. We use plot-level information on farm management practices over the prior decade, soil characteristics from soil sample data, population density and other community characteristic data to examine the drivers of change in soil quality. We then estimate production functions to determine the influence of soil quality on maize yields and yield response to fertilizer in Kenya. Lastly, we draw on soil information from the 1990s in the same villages to simulate the ceteris paribus impacts of changes in soil characteristics on maize yields, response rates to fertilizer use, and fertilizer profitability. This study will shed light on the local perceptions that crop response rates are declining, and identify actions that can restore the profitability of using fertilizer and intensive farming.

3. **The role of relative prices, agro-ecological factors, and household soil and crop management practices in explaining smallholder profitability of fertilizer use on maize in Tanzania** by David Mather (Michigan State University), Betty Waized, Daniel Ndyetabula, Anna Temu (all Sokoine University of Agriculture, Tanzania) Isaac Minde and David Nyange (Michigan State University).

We analyze smallholder plot-level data from the National Panel Survey (NPS) of 2008/09 and 2010/11 to understand the community-, household- and plot-level determinants of maize productivity in Tanzania. This survey contains season-plot-level data on production as well as plot characteristics and management, family and hired labor, and the quantities and types of seed and organic and inorganic fertilizers used. Geo-spatial coordinates from each village match secondary data on agro-ecological potential, soil type, seasonal rainfall and rainfall stress, and market
access. Quantitative analysis is supplemented with rapid interviews in three production zones to understand the factors affecting input demand. Combining quantitative and qualitative analyses enables us to investigate: 1) factors explaining wide spatial and within-village yield variation; 2) the extent this variation is explained by ecological factors relative to factors a farmer controls; and 3) the determinants of whether inorganic fertilizer is profitable under a range of prevailing conditions and prices.

**Position and affiliation of session participants**


William J. Burke is Research Scholar, Center on Food Security and the Environment, Stanford University.

Milu Muyanga is Assistant Professor, Department of Agricultural Economics, Michigan State University.

David Mather is Associate Professor, Department of Agricultural Economics, Michigan State University.

Julius Mangisoni is Professor of Agricultural and Applied Economics in the Department of Agricultural & Applied Economics at Lilongwe University of Agriculture and Natural Resources.