Smallholder maize-nitrogen response rates, soil fertility, and profitability of inorganic fertilizer use on maize in Tanzania

David Mather, Isaac Minde, Betty Waized, Daniel Ndyetabula, Anna Temu, and David Nyange

Fertilizer Stakeholder Workshop, 8 Sept 2015,
Serena Hotel, Dar es Salaam

Department of Agricultural, Food & Resource Economics
Michigan State University
Department of Agricultural Economics & Agribusiness
Sokoine University of Agriculture

GISAIA/Tanzania project

- Guiding Investments in Sustainable Agricultural Intensification in Africa
  - Funded by BMGF
  - Collaborative research between MSU or Purdue & local universities in 7 African countries
- GISAIA/Tanzania
  - Collaborative research & policy outreach by MSU & SUA faculty
  - MSU Ag Policy Advisor (Dr. David Nyange) embedded in DPP/MAFC
    - Demand-driven policy analysis, capacity building and policy coordination

GISAIA/Tanzania MSU/SUA collaborative research themes

#1) Informing design/implementation of ag input subsidy programs

- *Ex post* evaluation of NAIVS 2008-2014
- *Ex ante* evaluation of Ag Credit Subsidy Program

#2) Informing policies/investments to strengthen private sector fertilizer/seed supply chains

- Assess effect of NAIVS on supply chains
- Assess alternative policies to lower unit costs of fertilizer in rural areas

GISAIA/Tanzania MSU/SUA collaborative research

#3) Assess profitability of inorganic fertilizer use on maize/rice among smallholders

- Importance / relevance ??
  - NAIVS designed to provide smallholders & fertilizer supply chain with multi-year experiment
  - Smallholders' returns to fertilizer must be > additional cost (including margin for risk) or NAIVS will not stimulate long-term increase in smallholder commercial fertilizer use

Key factors that determine profitability of fertilizer use

- Marginal Value Cost Ratio (VCR) =

(Maize-fertilizer response rate * Maize price/kg) / Fertilizer price/kg

(Value of additional kg maize produced given an additional kg of Nitrogen) / N price/kg

- MVCR > 1 means "net returns > 0"
- MVCR >=2 means "net returns are large enough to be profitable, including risk

Sources of estimates of maize-fertilizer response rates

- Most maize-fertilizer response estimates from research station trials
  - Best practices, optimal input rates, etc
- On-farm trials often implemented with 'model / advanced' farmers
- What is the average smallholder Maize:N response rate..?
  - Malawi, Zambia → 50% or less compared with research stations
  - Smallholder fertilizer use in much of Zambia not profitable – response rates low (soil acidity)

Determinants of maize-N response rates

- Agro-ecological factors (village):
  - Season rainfall (rainfed production)
  - Drought shocks
  - Elevation
- Plot-level factors
  - General soil type, characteristics
  - Plot-specific nutrient levels, soil organic matter, soil chemistry --> plot/soil management practices
  - Years since fallow, type of fallow
  - Crop rotation, planting legume
  - Biomass left on field after harvest (forage?), etc

Determinants of maize-N response rates (2)

- Fertilizer type, dosage, application
  - Type and dosage optimal for soil characteristics
  - Proper application & timing
- Complementary input use:
  - Use of improved OPV or hybrid seed
  - Seeding rate, seed spacing
  - Timely / frequent weeding
  - Intercropping

Background: Maize-N response rates, soil fertility, profitability

- Recent soil sampling & zonal center trials in Tanzania (2010 & 2011)
  - Small subset of districts & trials, but with some dispersion
  - Maize-N response rates of 20 (kg/kg), yet response rates lower than in 1993; many areas now need more fertilizer
  - Fertilizer still improves yields and is profitable in some areas -- in others, no longer
  - Why? Tests show soil organic matter (SOM), macro & micronutrients quite low
    - Downward cycle of low fertilizer use, less frequent fallows, lower yields, lower SOM..?

Background: Design of Accelerated Food Security Program (AFSP)

1) NAIVS = targeted fertilizer/seed voucher subsidy program to address some key constraints
   - Improve smallholder physical access to inputs
   - Subsidy reduces farmer credit constraints, risk
   - 3+ years of voucher receipt helps address lackj of smallholder experience with fertilizer use
2) Included technical training of agro-dealers
   - Fertilizer/seed types, rates; business mngt
   - Yet blanket NAIVS-specific recommendations were taught, despite district-level recommendations (1993)

Background: Design of AFSP

3) Improve extension

- $30 million for extension (ASDP) extension
- W.Bank provided $US 30mil for ISFM research, extension .. Was it used..??

Motivation / Objective: Test key assumptions of GOT strategy

- We test assumption that fertilizer use on maize is profitable under smallholder conditions
  - What are average maize-N response rates?
  - How do they vary by zone, complementary input use, plot characteristics, etc?
  - How profitable is fertilizer on maize?
  - GOT main emphasis to improve access, reduce credit constrain & providing experience.. Is that sufficient to build sustainable demand for fertilizer at commercial prices?

Data

- National Panel Survey
  - National Panel Survey, 3 waves (2008/09, 2010/11, 2012/12)
  - Representative at national & zonal levels
    - n=1,591 HHs in each of 3 years, n=310 HHs 2 years
  - Plot-level data on plot characteristics, plot-level input use & crop production
    - N=2,787 plots in each of 3 years; n=511 plots 2 years
- Geo-spatial data
  - Estimates of seasonal rainfall, elevation

Methods: OLS-FE of smallholder maize yields (plot-level)

- Community level
  - Estimated main season rainfall (mm)
  - Elevation (m)
- Plot-level explanatory factors
  - N, P, manure & squared terms (kg/ha)
  - 1=improved OPV or hybrid seed used
  - Years since fallow (or 1=plot was fallowed)
  - 1=maize intercropped with legume
  - 1=maize intercropped with non-legume
  - 1=plot soil is sandy
  - 1=plot soil is loam (clay/other is intercept)

Methods: OLS-FE of smallholder maize yields, plot level (2)

- Household-level
  - # of adults age 15-64 per ha
  - Maximum adult education in HH
  - Ln(value of livestock & farm equipment)
- Other
  - Dummies for 2010/11, 2012/13

Maize plots by year

2008/09 Zone	% report fallow	Yrs since fallow (median)	% mono-crop	% intcrop with legume	% maize with fertilizer	% maize with IV seed	% maize with fertilizer & IV	% maize with manure
Southwest	10.1	18.8	43.6	34.2	30.0	8.6	5.0	11.6
North	7.4	21.0	19.0	42.3	17.3	31.4	13.8	31.8
Eastern	6.3	15.0	30.3	22.7	1.7	11.9	1.7	3.8
Western	7.1	16.0	15.4	59.6	11.8	6.9	0.9	9.3
Total	9.6	17.0	33.3	36.6	15.9	12.7	4.3	12.7
2010/11								
Southwest	8.0	18.5	44.2	35.9	40.9	9.9	6.8	15.0
North	5.3	23.5	23.6	49.0	17.8	30.1	10.8	34.4
Eastern	9.3	16.6	31.8	25.3	2.5	4.8	0.0	3.3
Western	2.3	16.0	33.8	36.8	17.1	0.0	0.0	7.4
Total	7.8	17.5	37.8	34.9	20.6	9.2	4.1	15.5
2012/13								
Southwest	2.1	23.0	41.1	35.3	36.2	14.5	7.4	14.5
North	1.5	26.0	26.0	50.3	17.0	58.9	12.1	34.5
Eastern	1.5	18.5	33.9	24.2	1.9	15.4	0.9	4.5
Western	2.7	23.0	35.4	48.2	16.5	10.7	4.1	10.5
Total	2.6	21.0	36.4	35.6	17.9	21.3	5.0	15.9

Maize-N response rates (kg maize/kg N)			MVCR	MVCR	MVCR
maize-N response rate	S.West	9.6	1.79	1.47	1.92
	North	9.6	1.66	1.49	2.73
	Eastern	7.2	1.05	1.32	1.73
	Central	7.2	1.48	1.52	1.78
	West	7.2	1.27	1.49	1.55
southwest & northern highlands		9.6	1.72	1.48	2.29
medium/lower potential zones		7.2	1.23	1.44	1.68
did not use improved OPV/hybrid		8.2	1.43	1.45	1.93
used improved OPV or hybrid		9.2	1.61	1.63	2.17
plot fallowed within 1-6 yrs		10.2	1.78	1.81	2.41
plot fallowed within 7-12 yrs		9.9	1.73	1.75	2.33
plot fallowed within 13-18 yrs		9.2	1.61	1.63	2.17
plot fallowed within 19-25 yrs		7.7	1.34	1.36	1.82
plot fallowed within 26+ yrs		6.8	1.19	1.20	1.60
sandy soil		3.6	0.63	0.64	0.85
clay / other soil		6.0	1.05	1.06	1.41
loam soil		10.2	1.78	1.81	2.41

Policy implications

#1) Urgent need to update knowledge of current soil characteristics and fertilizer recommendations

- Wide-spread soil sampling
- Update fertilizer recommendations by crop, zone
- Update improved variety asessements (given new releases) together with fertilizer (or not)
- Discuss results with fertilizer importers & distributors, then communicate new recs to extensionists & agro-dealers --
- Run trials with 'researcher' and 'typical farmer' input levels & management

Policy implications (2)

#2) Is there sufficient focus from GOT on research/extension (knowledge generation & transfer) to improve smallholder maize yields..?? More holistic approach needed..?

- # of extension workers increased.. But do they have the proper recommendations..?
- Substantial donor funding for ISFM extension efforts available.. Was it used..?
- Fallowing rates are very low, SOM is low
- Agro-dealer training used blanket recs
- Many farmers are using fertilizer but not improved varieties (why?)

Policy implications (3)

#3) There is a vital link between output market policy & sustained technology adoption

- Need for predictable, transparent, rules-based trade & marketing policies to reduce risk/uncertainty in farmer/trader/etc maize price expectations → increase demand for commercial fertilizer
- Recent trade/marketing decisions (not rules-based) are undermining 2008-14 effort to build demand for commercial fertilizer
  - Maize export bans (several times); unpredictable NFRA buying price / time; unexpected rice tariff removal

Research gaps

- More analysis of existing data
  - Analysis of how profitability varies within a zone given market access differentials
- Need to add many more ISFM measures to plot-level survey work
  - Plot-level soil testing
  - Recall data on plot use between survey waves (types of fallows, cropping, etc)
  - Plot preparation methods
  - Use of improved fallows, simultaneous fallows..?

ASANTE SANA

David Mather matherda@msu.edu

Isaac Minde minde@iagri.org

Betty Waized yzbetty@suanet.ac.tz

Daniel Ndyetabula ndyetabula@suanet.ac.tz

Anna Temu aatemu@suanet.ac.tz

David Nyange nyange@msu.edu