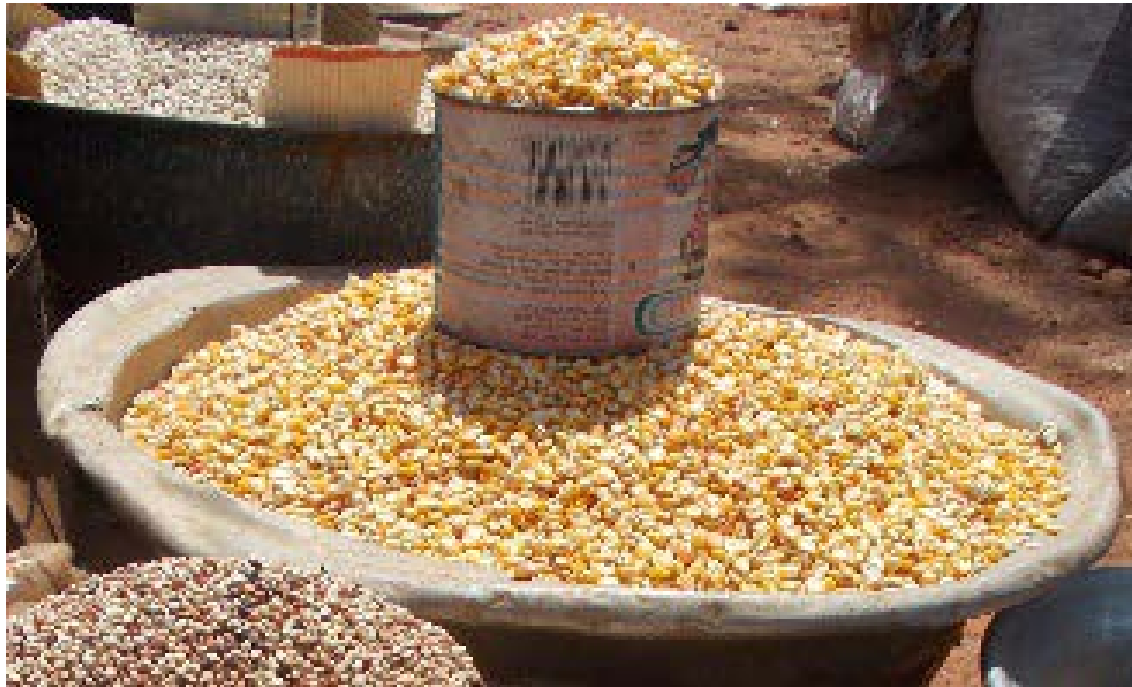


Maize Yield Response to Fertilizer under Different Agro-Ecological Conditions: Evidence and Implication for Burkina Faso



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Motivation

- Achieving food security depends on increasing productivity.
- Agricultural policies are implemented at the national level with “blanket recommendations”.
- Diversity in agro-ecological conditions lead to variable economic incentives to use intensification strategies for smallholder farmers.

Research questions

- Response of maize yields to fertilizer and profitability of fertilizer use on maize vary by agro-ecological factors.



Farming context

- Areas of maize increased by 700% over the last 40 years
- Three agro-ecological zones
 - Sahelian
 - Sudano-sahelian
 - Sudanian
- Ten different types of soil
 - 2/3 of the country is covered by soils that are iron-rich and low in inorganic matter content.



Control function approach with correlated random effects

$$\text{Yield}_{ijt} = \alpha N_{ijt} + \beta X_{ijt} + \rho V'_{ijt} + E_{ijt} + C_{ij}$$

$$N_{ijt} = \pi Z_{ijt} + V_{ijt} + C_{ij}$$

Where, N_{ijt} is the N application rate

X_{ijt} represents a vector of other covariates

V'_{ijt} are unobserved characteristics correlated with N application

E_{ijt} are random errors

C_{ij} are unobservable time-invariant characteristics

Z_{ijt} is a set of covariates & IV

$$c_i = \overline{X}'_i \delta + u_i + c, \quad u_i | X_i \sim N(0, \sigma_u^2)$$

Profitability

- Marginal product of N
- Marginal value-cost ratio (MVCR) & average value-cost ratio (AVCR)
 - Low, average, and high maize farm gate prices
 - Market, official subsidized, and transacted subsidized fertilizer prices



Data

- Continuous farm household survey from the General Research and Sectoral Statistics Department (DGESS)
- National Oceanic and Atmospheric Administration's Climate Prediction Center
- European Union's Soil Atlas of Africa.

Variables

- Plot characteristics
 - Area, location, and topography
 - Management type and tenure rights
 - SWC, trees, intercropping, and fallow
- Climatic zones and soil quality
 - Total rainfall, coefficient of variation of rainfall
 - Excellent, good, or poor/marginal soils
 - Sudano-sahelian or sudanian zone
- Other productive inputs, plot manager, and household characteristics

Estimated maize yield response functions

Variables	CRE	CFA-CRE
N	2.91***	22.46***
N*N	-0.014***	-0.016***
Intercropping	-235.24***	-155.90***
SWC	70.28**	78.85**
Excellent soils	16.26	52.52*
Good soils	178.75***	239.20***
Sudanian zone	-198.46	-65.62
N*excellent soils	-1.82**	-1.68**
N*good soils	-3.12***	-2.09***
N*sudano-sahelien zone	1.22***	1.44***
Others

Controlling for other productive inputs, plot manager and household characteristics, household time-averages and crop years.

Average partial effect of N

	Average partial effect of N- Estimate	Average partial effect of N- 95% CI	Unconditional N (kg/ha)	Conditional N (kg/ha)	Agronomically optimal N
Average	22	13-31	16	38	722

Net loss of ~700 kg/ha of N over a 30 year period (World Bank, 1996 cited by Gruhn, Goletti, and Yudelman 2000)

Nutrient depletion can even reach 100 kg NPK/ha/year (Henao 1992)

Our results suggest a continuous soil fertility depletion in maize farming

Value-cost ratios

Scenarios	Fertilizer at market price		Subsidized fertilizer price		Subsidized + TC price	
	MVCR	AVCR	MVCR	AVCR	MVCR	AVCR
Low price	1.6	1.6	3.2	3.2	2.1	2.2
Average price	1.7	1.8	3.5	3.5	2.3	2.4
High price	1.9	2.0	3.9	3.9	2.6	2.6

Profit maximization at MVCR=1

High incentive if AVCR >2 (Morris et al. 2007); AVCR >3-4 (Kelly 2006)

Conclusions

- Maize yield response to N is ~ 22 kg/ha
- Agro-ecological factors, at the scale of plot, village soil type and climatic zone, do affect productivity
- Optimal N rates $>$ maximum N application rates
- Not always profitable to use fertilizer

Policy implications

- Need to be cautious when generalizing across zones.
- Relevance of a crop targeted fertilizer subsidy program.
- Importance of reducing transaction costs.

Thank you

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