FEED THE FUTURE

AGRILINKS

Soil Variation and Why It Matters

Speakers: *Hope Michelson, University of Illinois Urbana-Champaign;*
Carolina Corral, Precision Agriculture for Development (PAD) Kenya;
Emilia Tjernström, University of Wisconsin-Madison

Moderator: *Julie MacCartee, USAID Bureau for Food Security*

Date: *June 29, 2017*

The Dirt on Dirt – Learning About Soil Variability From Kenyan Household Data

Speakers: Emilia Tjernström, University of Wisconsin – Madison

Moderator: Michael Carter, University of California, Davis

Date: June 29, 2017

Why do we care about soil heterogeneity?

- Increased use of improved inputs is a pathway to reduced rural poverty and increased food security
- Governments, researchers, and NGOs struggle to understand how to increase adoption of these inputs
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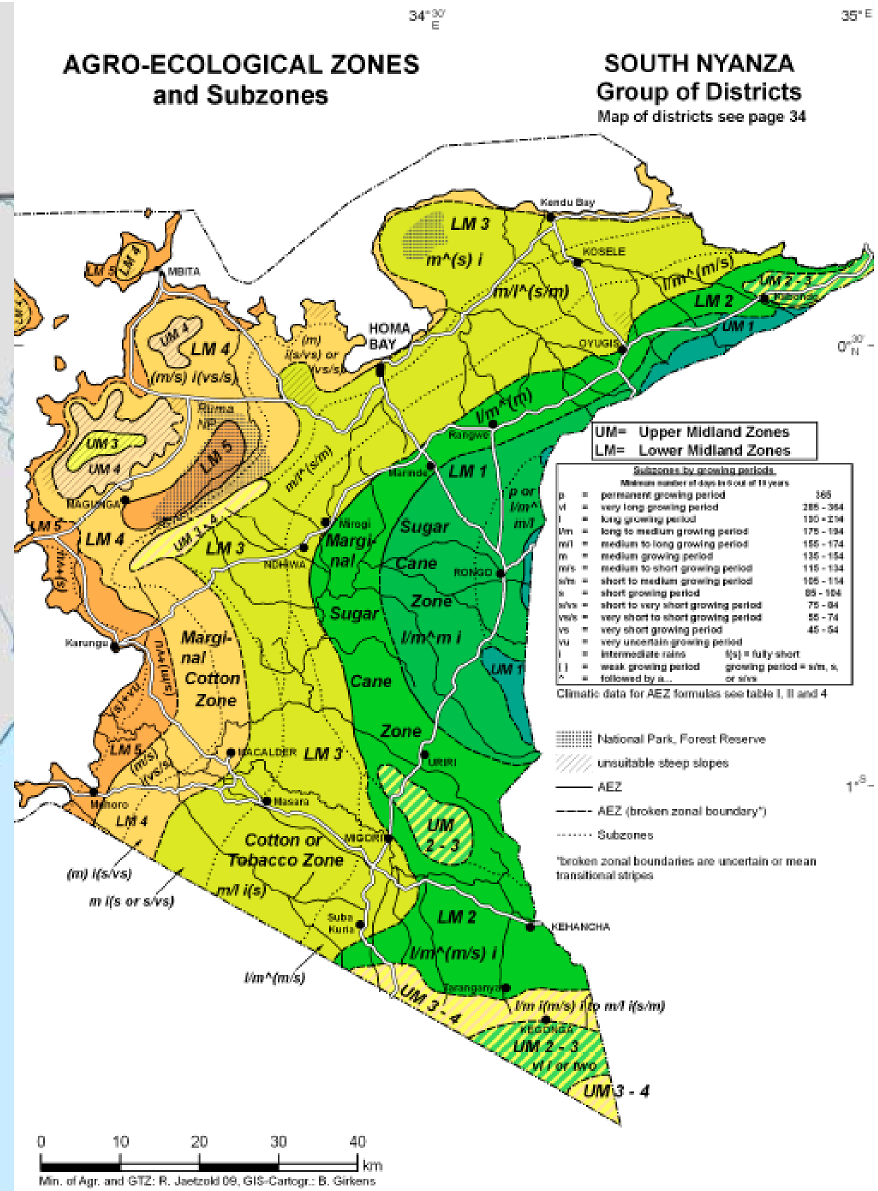
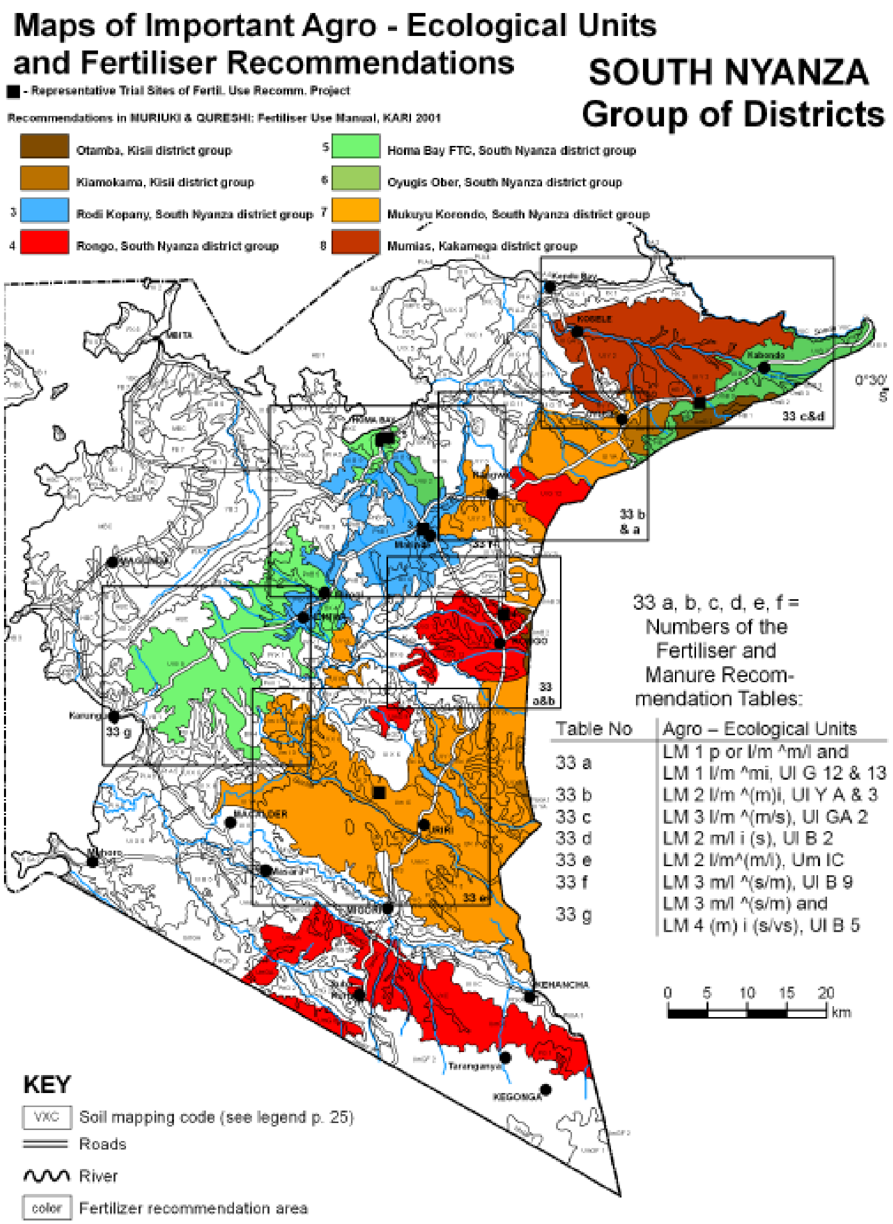
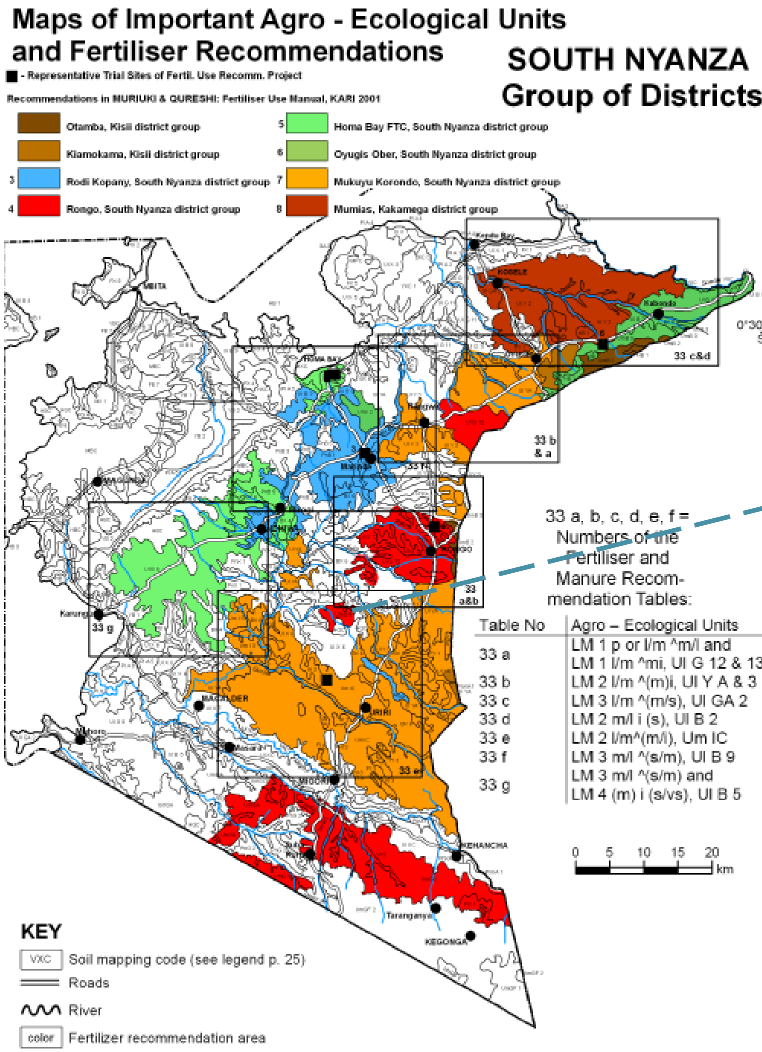
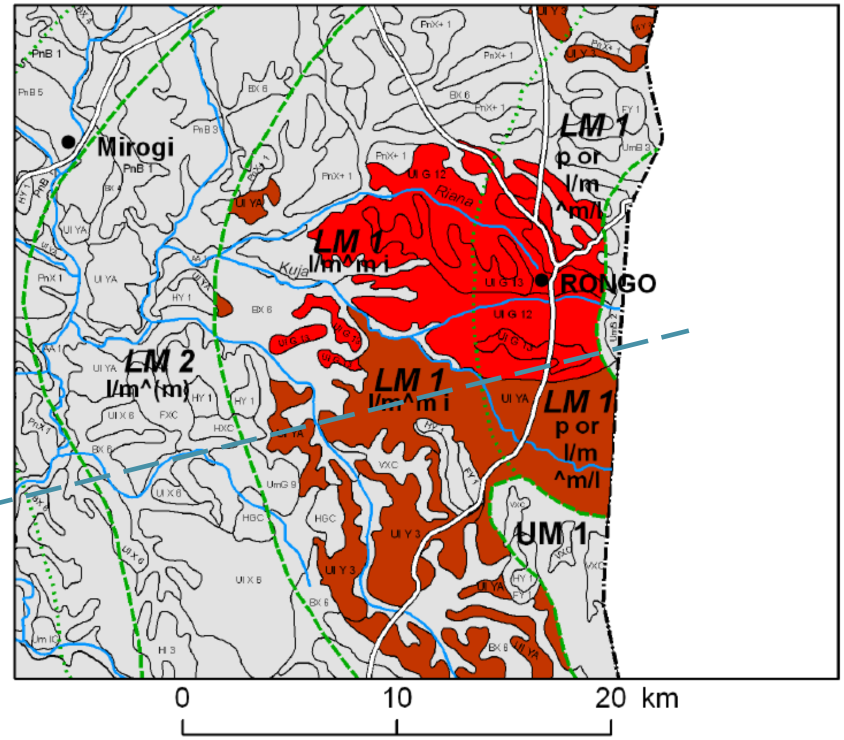
  - How "low" should we go?


AGRO-ECOLOGICAL ZONES
and Subzones
SOUTH NYANZA
Group of Districts
Map of districts see page 34
34° 30' E
35° E
HOMA BAY
MBITA
Kendu Bay
KOSELE
OYUGIS
Rangwe
RONGO
URIRI
MIGORI
KEHANCHA
Karungu
MACALDER
Masara
Muhoro
LM 3
m^(s) i
m/l^(s/m)
l/m^(m/s)
LM 2
UM 1
LM 4
(m/s) i(vs/s)
UM 3
UM 4
LM 5
LM 1
Sugar Cane Zone
l/m^m i
Margi-nal Cotton Zone
Cotton or Tobacco Zone
UM 2 - 3
UM 3 - 4
(m) i(s/vs)
m i(s or s/vs)
m/l i(s)
l/m^(m/s)
l/m^(m/s) i
l/m i(m/s) i to m/l i(s/m)
vl i or two
UM= Upper Midland Zones
LM= Lower Midland Zones
Subzones by growing periods
p = permanent growing period 365
vl = very long growing period 285 - 364
l = long growing period 180 - 284
l/m = long to medium growing period 175 - 184
m/l = medium to long growing period 155 - 174
m = medium growing period 135 - 154
m/s = medium to short growing period 115 - 134
s/m = short to medium growing period 105 - 114
s = short growing period 85 - 104
s/vs = short to very short growing period 75 - 84
vs/s = very short to short growing period 55 - 74
vs = very short growing period 45 - 54
vu = very uncertain growing period
i = intermediate rains
( ) = weak growing period
^ = followed by a...
i(s) = fully short growing period = s/m, s, or s/vs
Climatic data for AEZ formulas see table I, II and 4
National Park, Forest Reserve
unsuitable steep slopes
AEZ
AEZ (broken zonal boundary*)
Subzones
*broken zonal boundaries are uncertain or mean transitional stripes
0 10 20 30 40 km
Min. of Agr. and GTZ: R. Jaetzold 09, GIS-Cartogr.: B. Girkens



Careful work has been done to provide localized recommendations!





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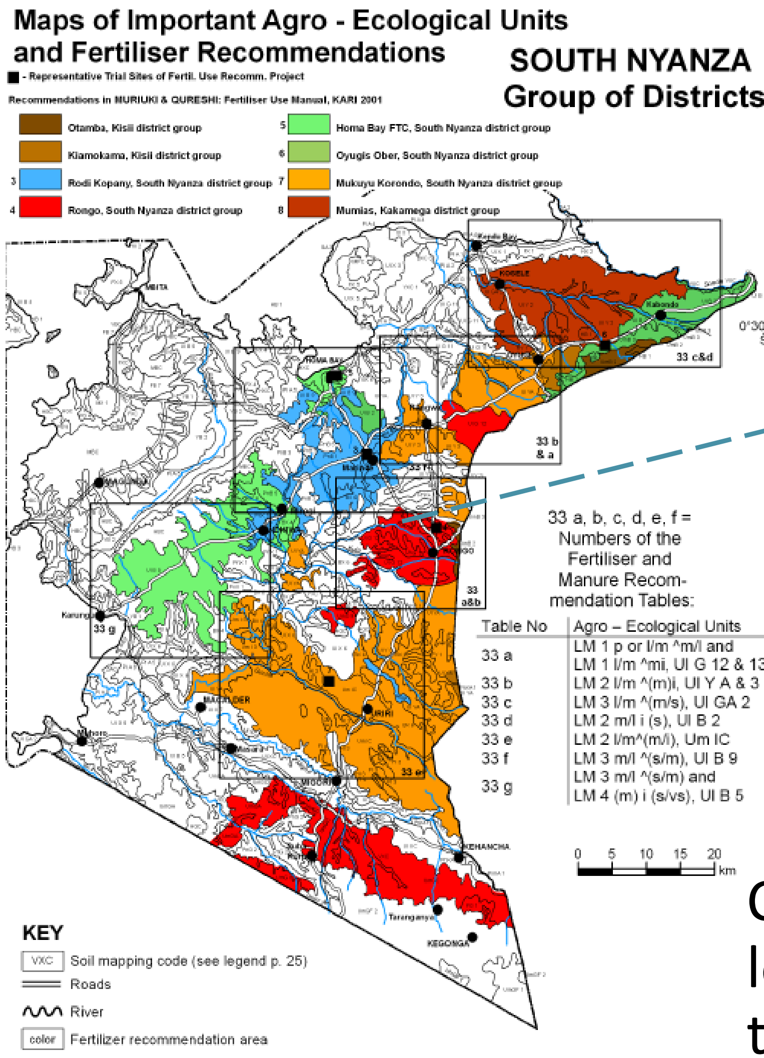
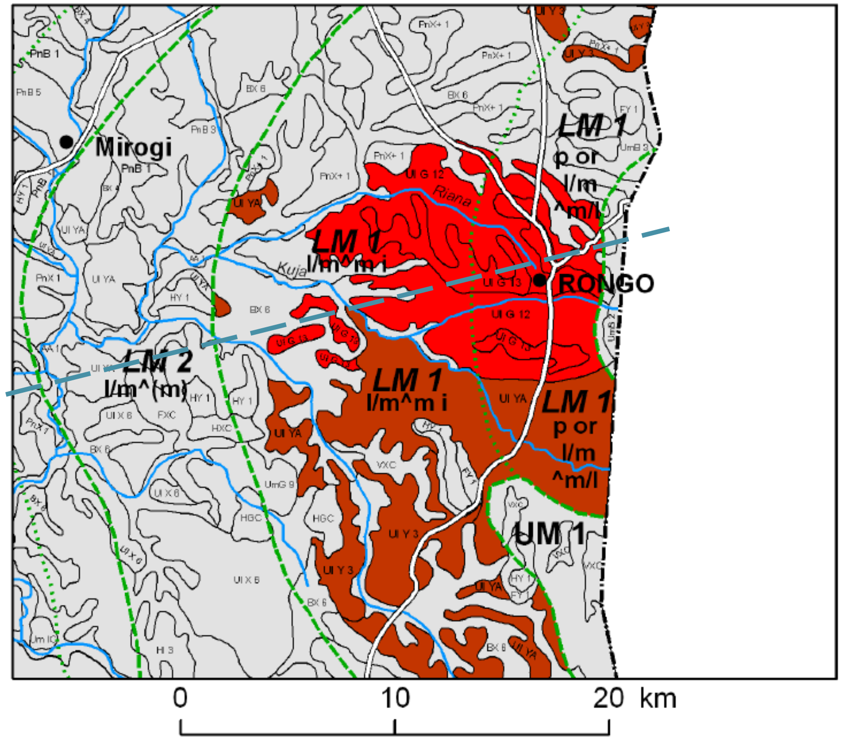
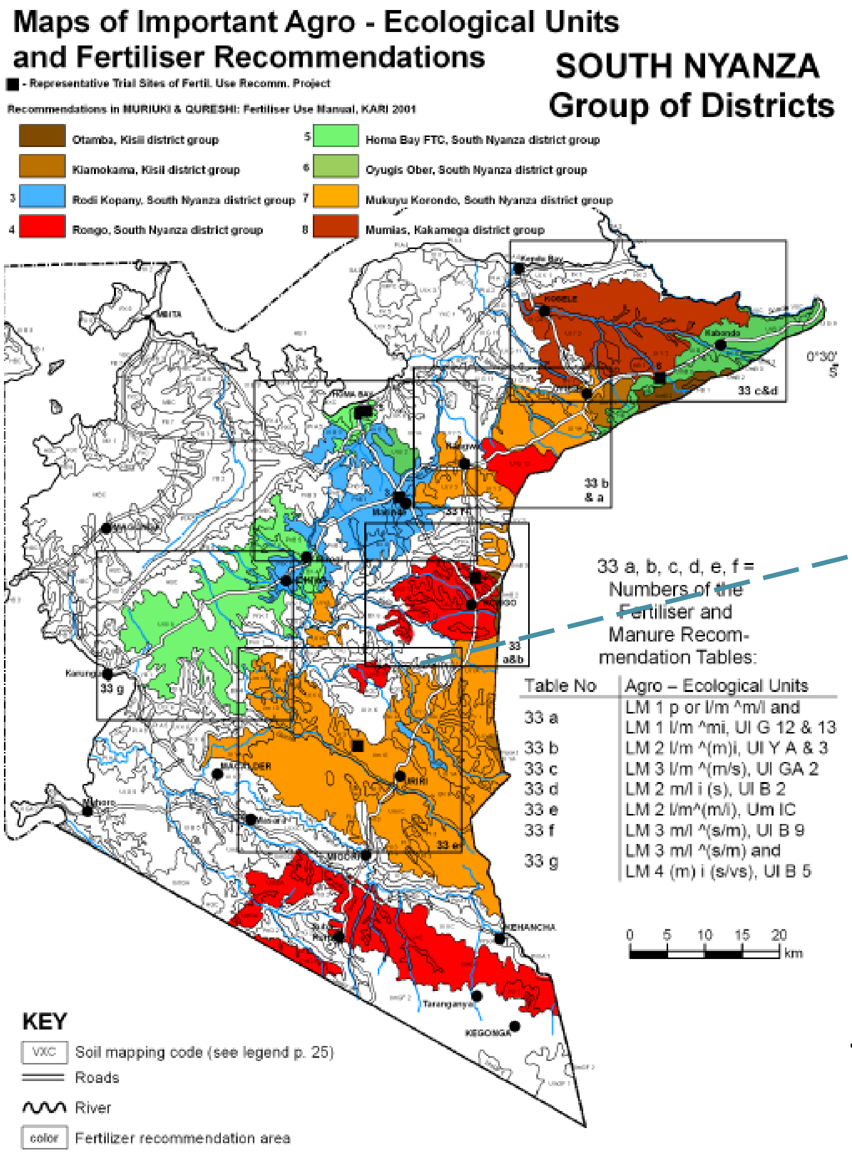
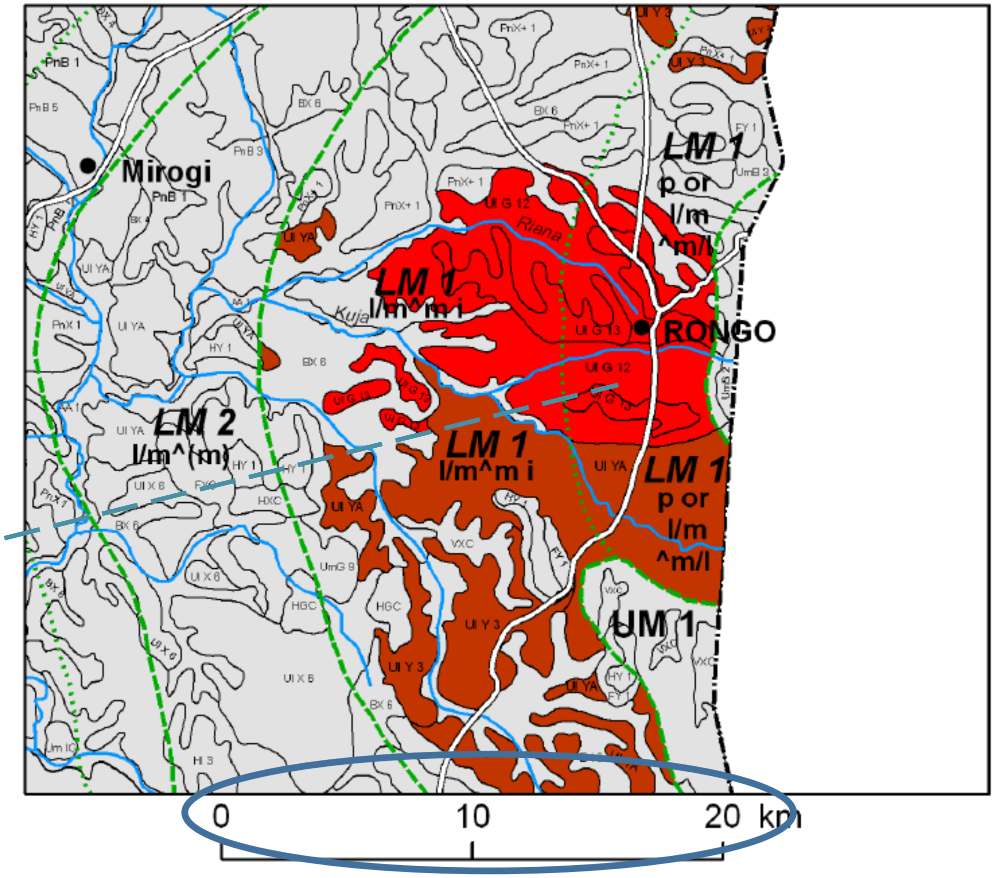




Careful work has been done to provide localized recommendations… but what if these are still not local enough?





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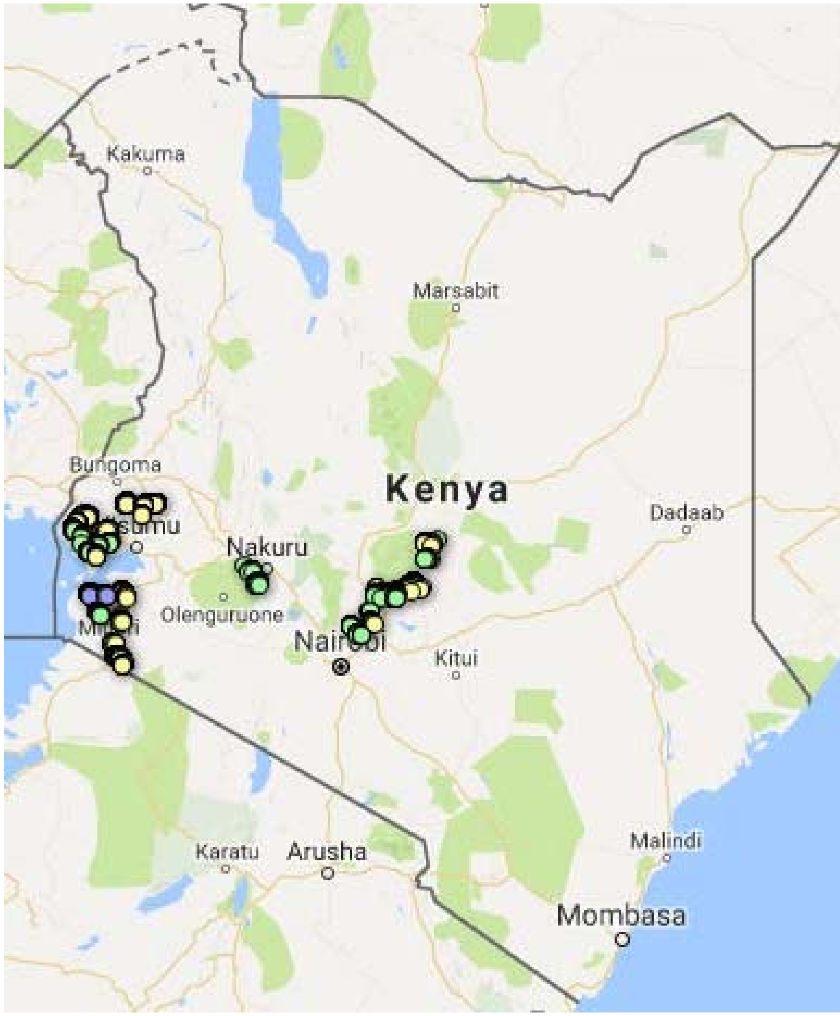
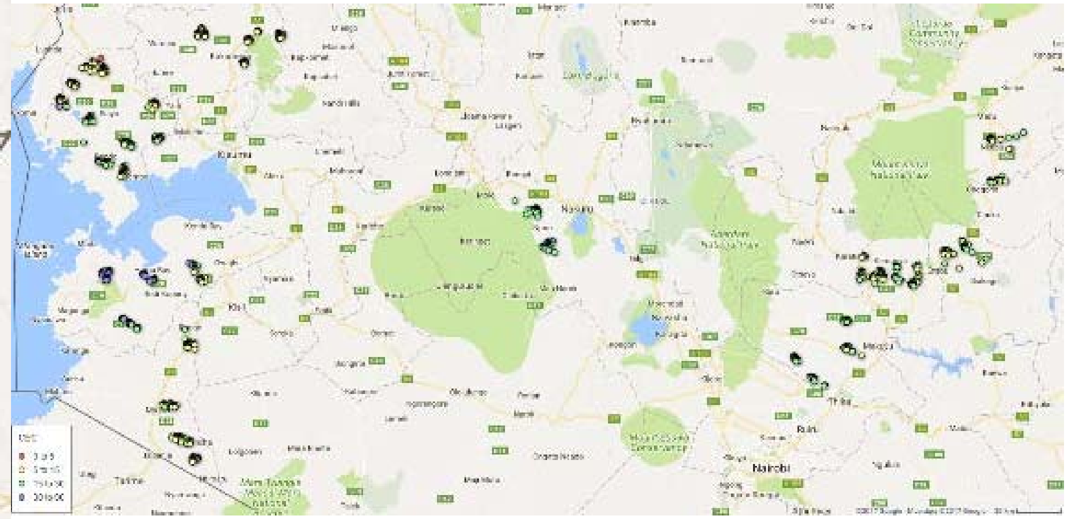
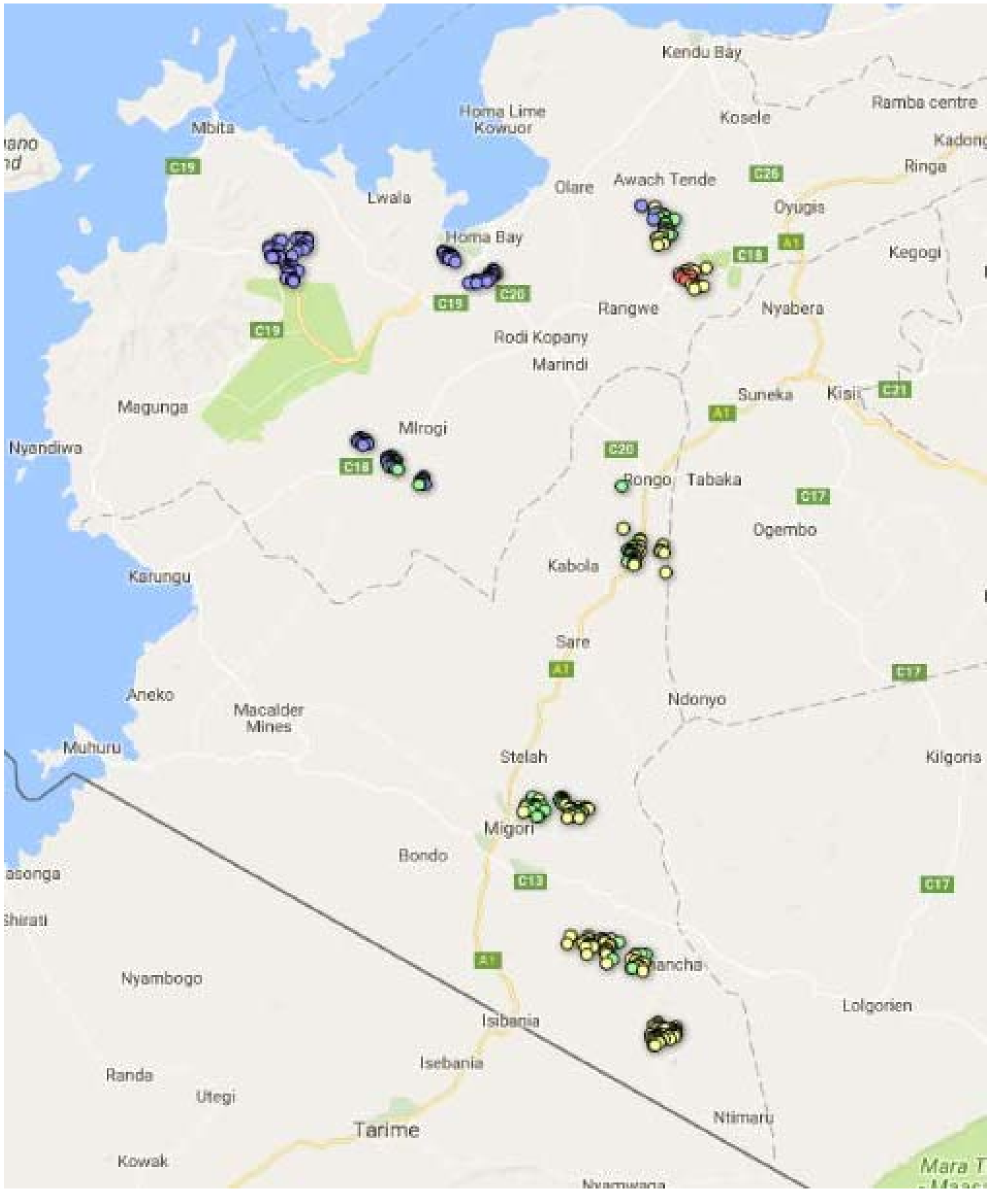




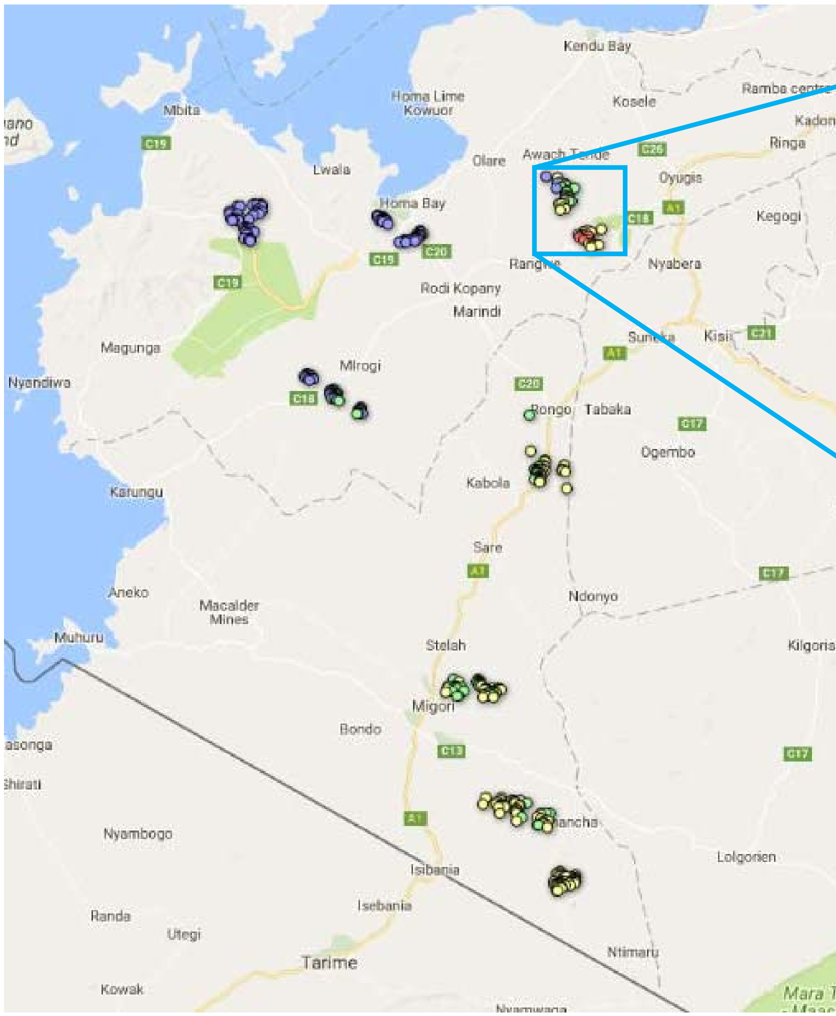
We collected soil samples on 1,800 farm households' fields and tested them at an ISO-certified lab

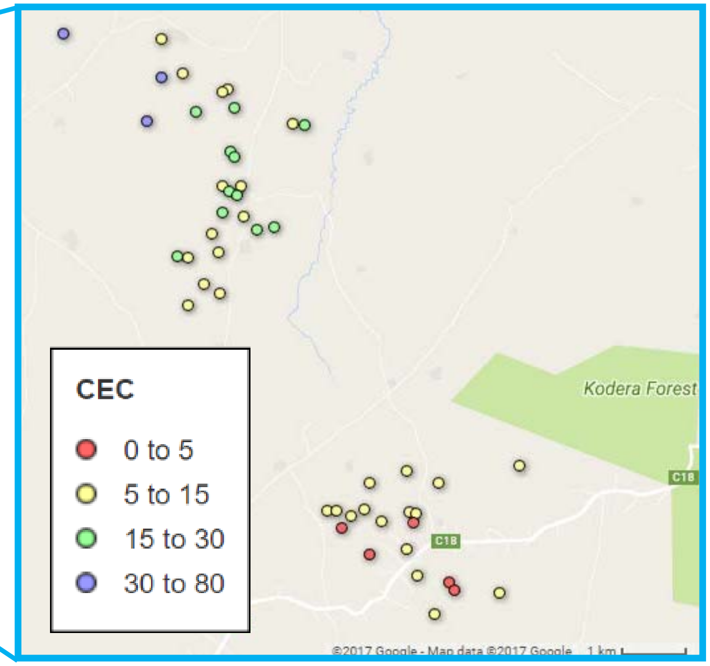
- 20+ measures, including pH, organic matter, CEC, and a large number of nutrients and micronutrients



This map shows the distribution of Cation Exchange Capacity (CEC) for Southern Nyanza

- CEC is often used to gauge a soil's fertility & affects optimum practices





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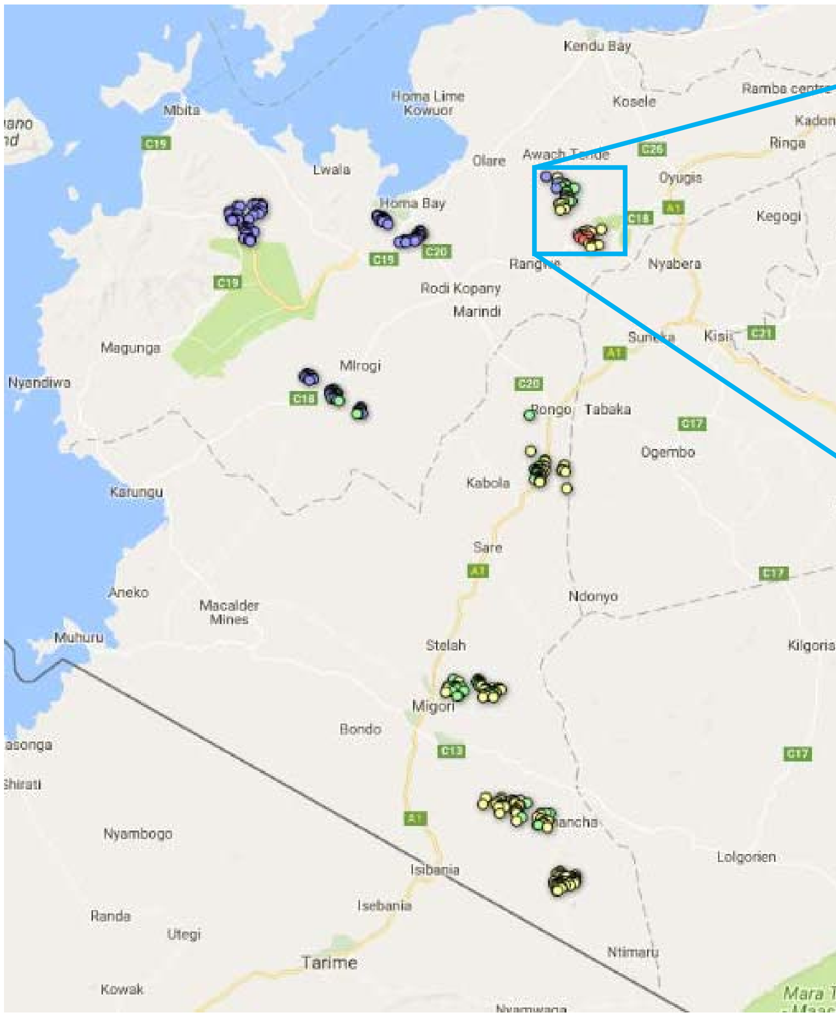

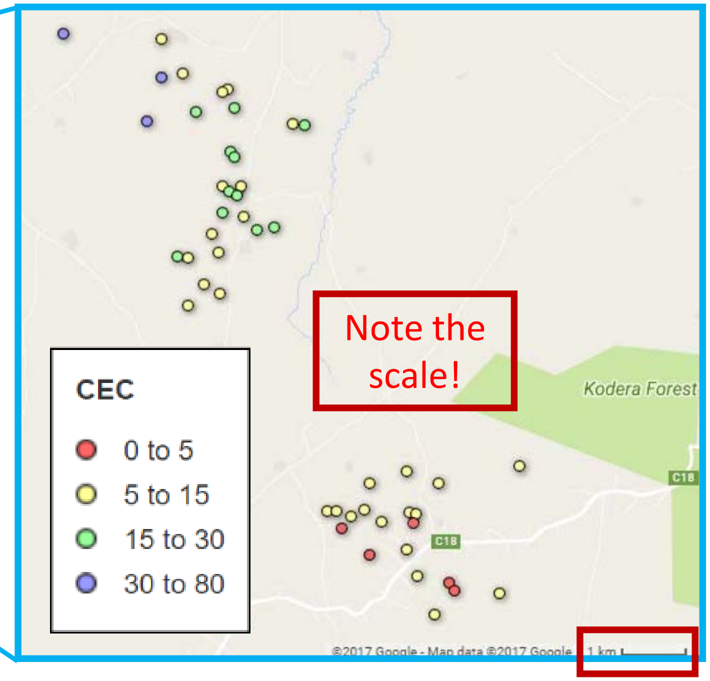

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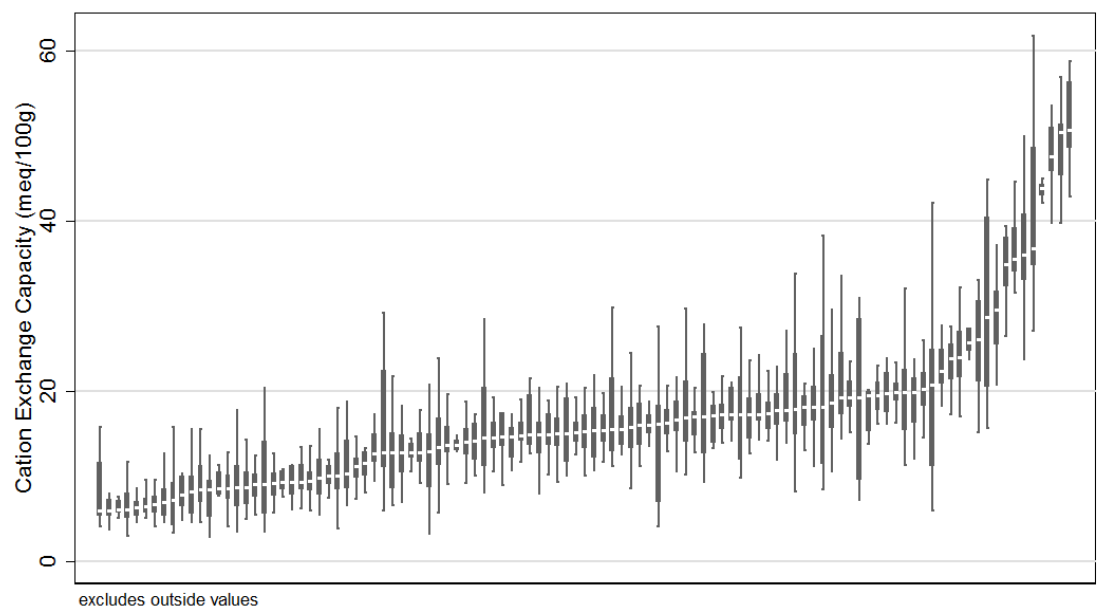

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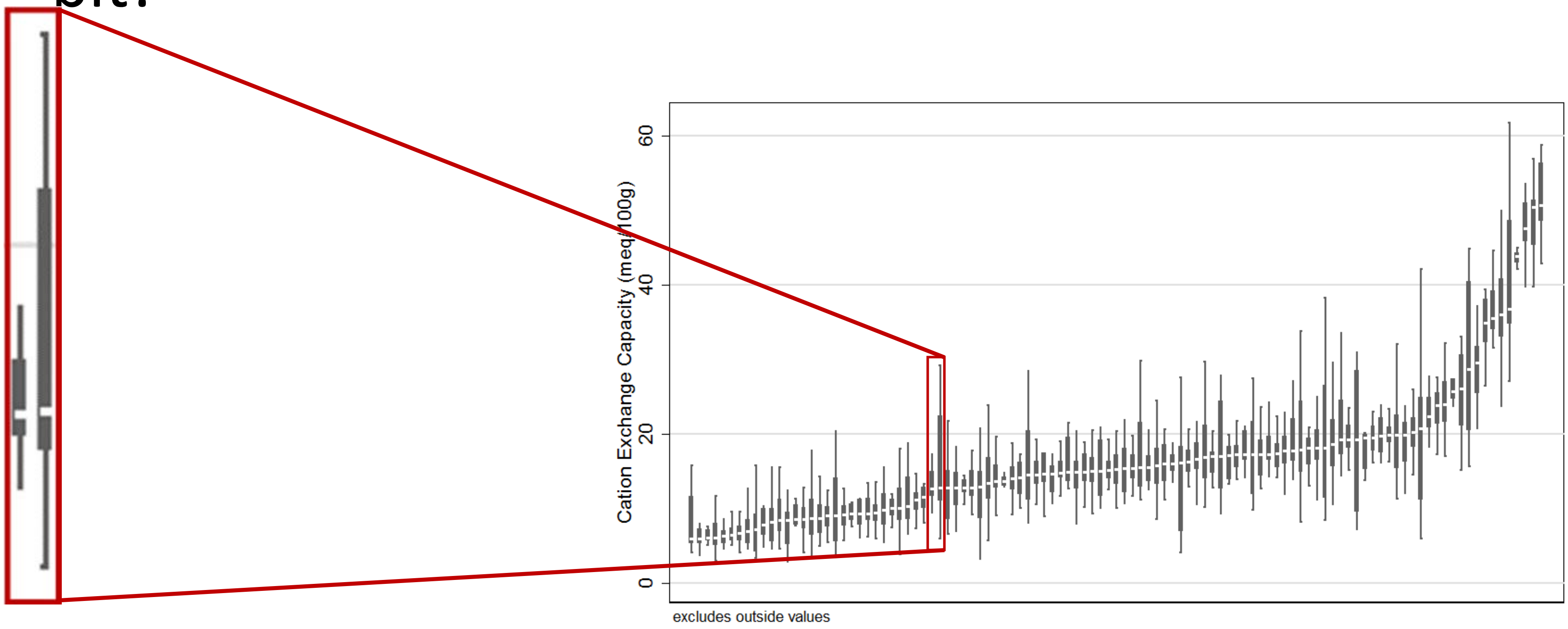

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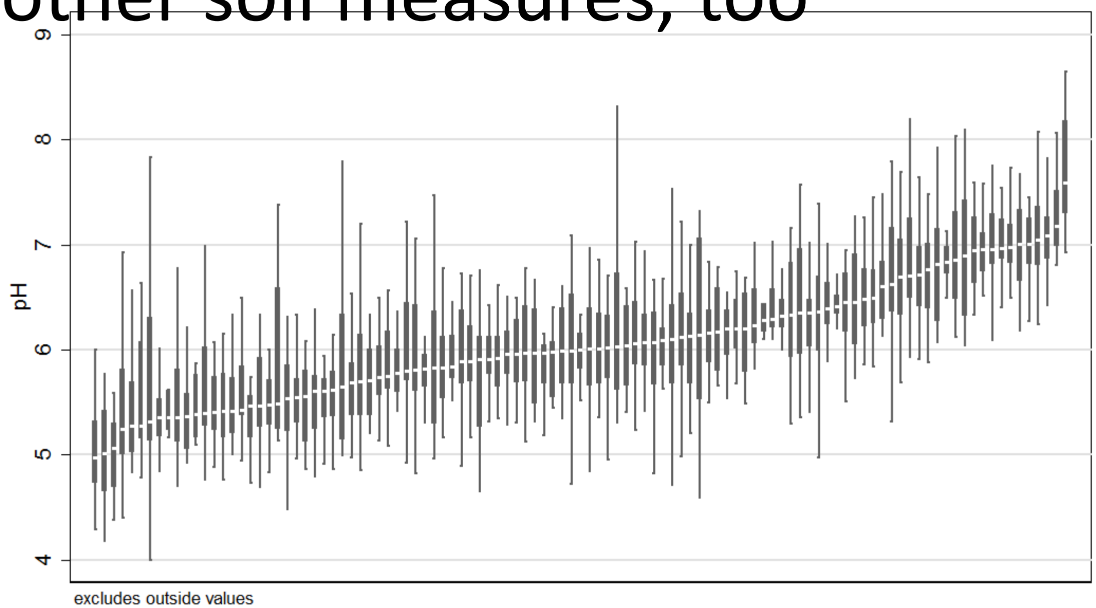
- So even within a village, soil quality can vary quite a bit!
- And this is true for other soil measures, too
  - CEC
  - pH



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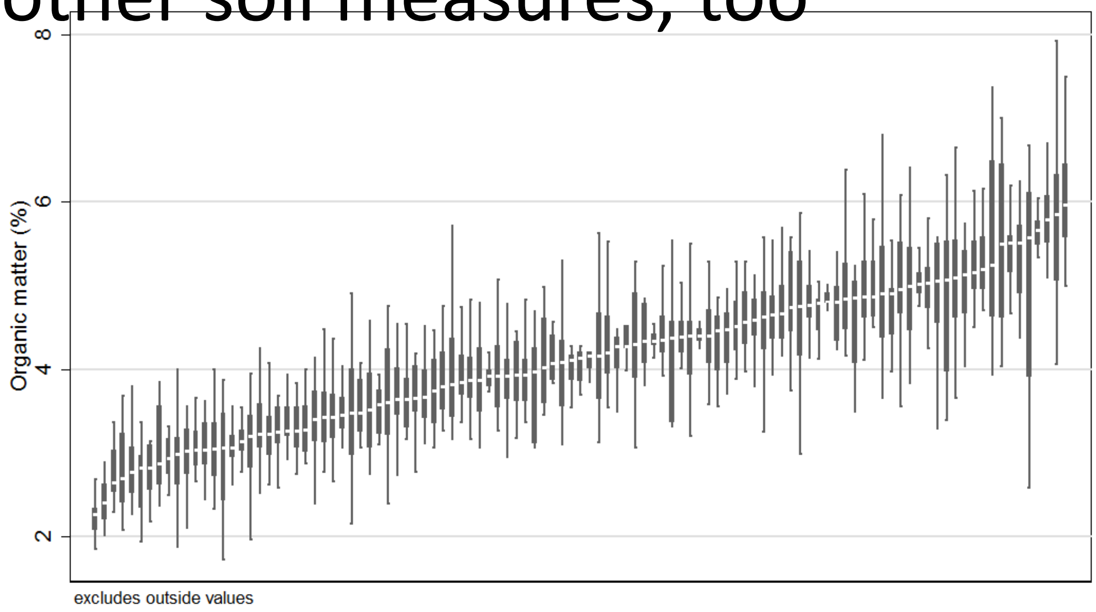
  - etc.



Does soil variability affect optimal inputs?

- So there is variability at hyper-local levels, but does this matter?
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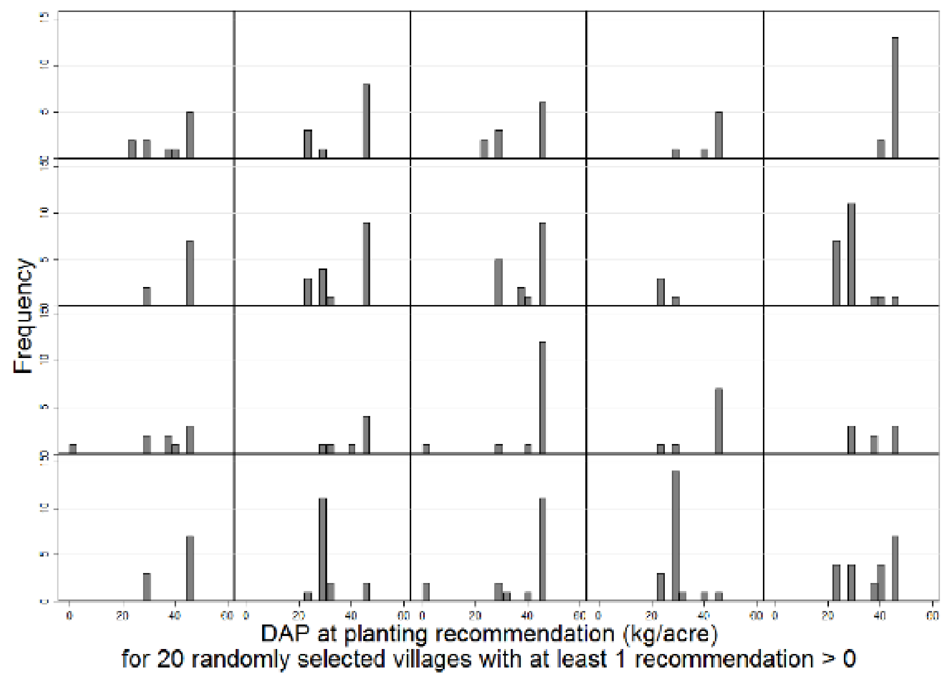

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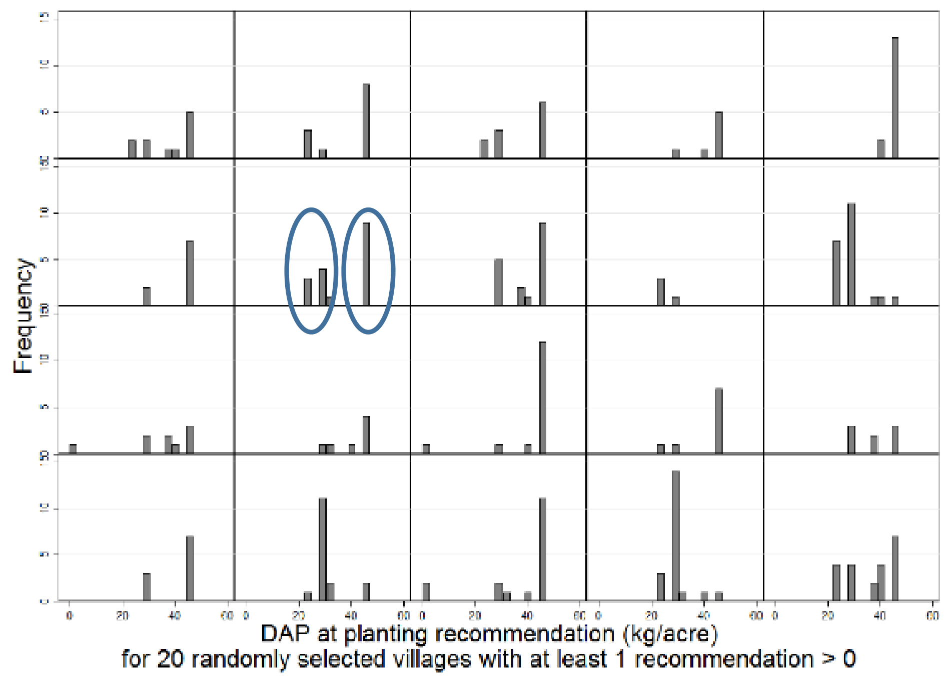
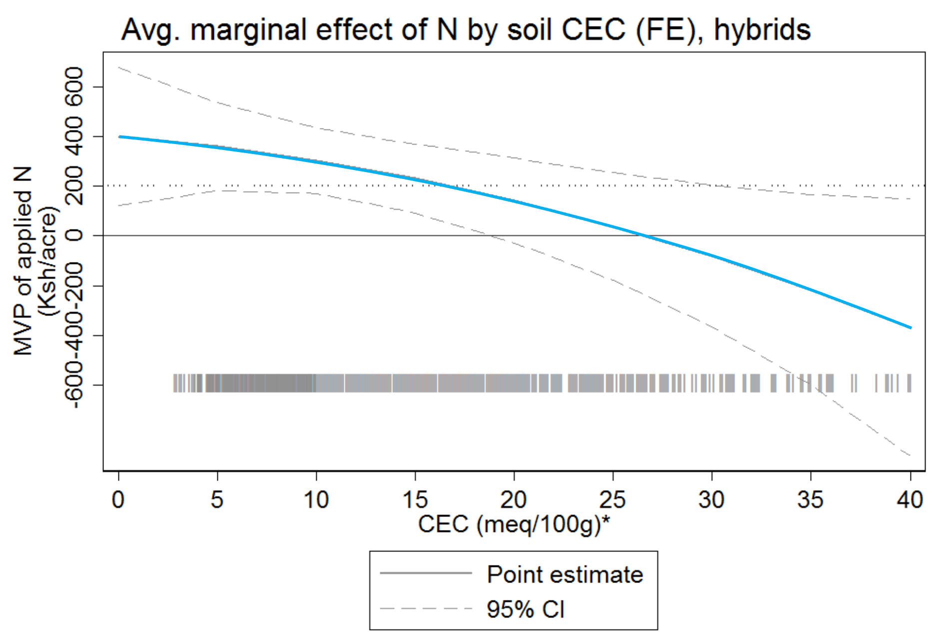
  - The soil testing lab also provided e of our farmers with recommendat for optimal input application, and there are substantial differences within villages
  - If the ideal fertilizer application rat for some farmers is 20 kg/acre, bu for others 40 kgs/acre – may not sound like much but has importan efficiency / profit implications



Does soil variability affect optimal inputs?

- So there is variability at hyper-local levels, but does this matter?
- Longer answer includes production function estimation:
  - Using a generalized quadratic production function estimation approach (linear in parameters, quadratic in covariates) with fai fixed effects, we estimate how to N varies with soil quality and
  - The returns to an additional kg fertilizer varies markedly with s conditions



*x-axis truncated at the 95th percentile of CEC

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    - when soils vary widely, the experience that one farmer has with improved inputs does not provide a good example for other farmers who may have a different soil type – and farmers seem acutely aware of this!
    - suggests an important role for individual experimentation & localized recommendations

TOP TAKE-AWAYS

1

Hyper-local variation

Soil quality can vary in important ways at very local levels – even within a single village

2

Input rec's vary, too!

The optimal inputs vary substantially at this highly localized scale; recommendations for the median farmer may not be profitable for the majority

3

Variability makes learning difficult

These underlying environmental characteristics vary locally – and this makes learning from other farmers more difficult

4

Soil variability may be contributing to slow adoption

By worsening the 'fit' of un-tailored recommendations and by reducing farmers' ability to learn from neighbors, soil variability might be slowing adoption of improved inputs

Effects of Soil Information on Small Farmer Agricultural Investment and Productivity

Nyambi Amuri[3] Aurélie P. Harou[1] Malgosia Madajewicz[2]
Christopher Magomba[3] Hope Michelson [4] Cheryl Palm[5]
Johnson Semoka[3] Kevin Tschirhart[2]

[1]McGill University

[2]Columbia University

[3]Sokoine University

[4]University of Illinois

[5]University of Florida

June 29, 2017

Problem: low mineral fertilizer use impacting small-farm crop yields in numerous regions of Sub-Sarahan Africa.

Addressing soil variation's importance:

- Information: Sub-regional calibration of fertilizer and management recommendations will be necessary.
- Extension: Within-village farmer learning about technologies related to underlying agronomic heterogeneity (Munshi, 2004)
- Inputs: Improvement of agricultural input supply chains to meet needs re varieties, balance, and quality.

Research Questions

- Localized variation in soil quality: how much does it matter, and is assessment feasible?
- How are farmers responding to soil information and management recommendations? What is the impact on input purchases and crop yields?
- What is the optimal scale now for soil testing: field? farm? village? region?

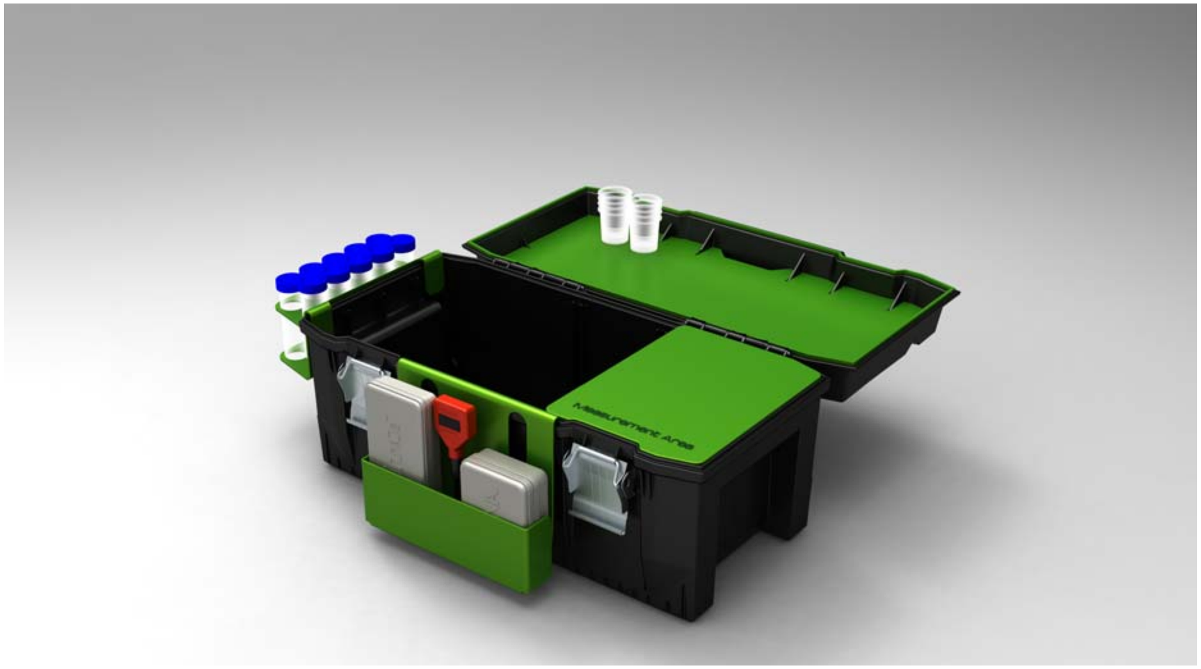
Experimental Design

Randomized control trial with 1100 small-scale maize farmers in Morogoro Region, Tanzania. Tested primary maize plot for all farmers.

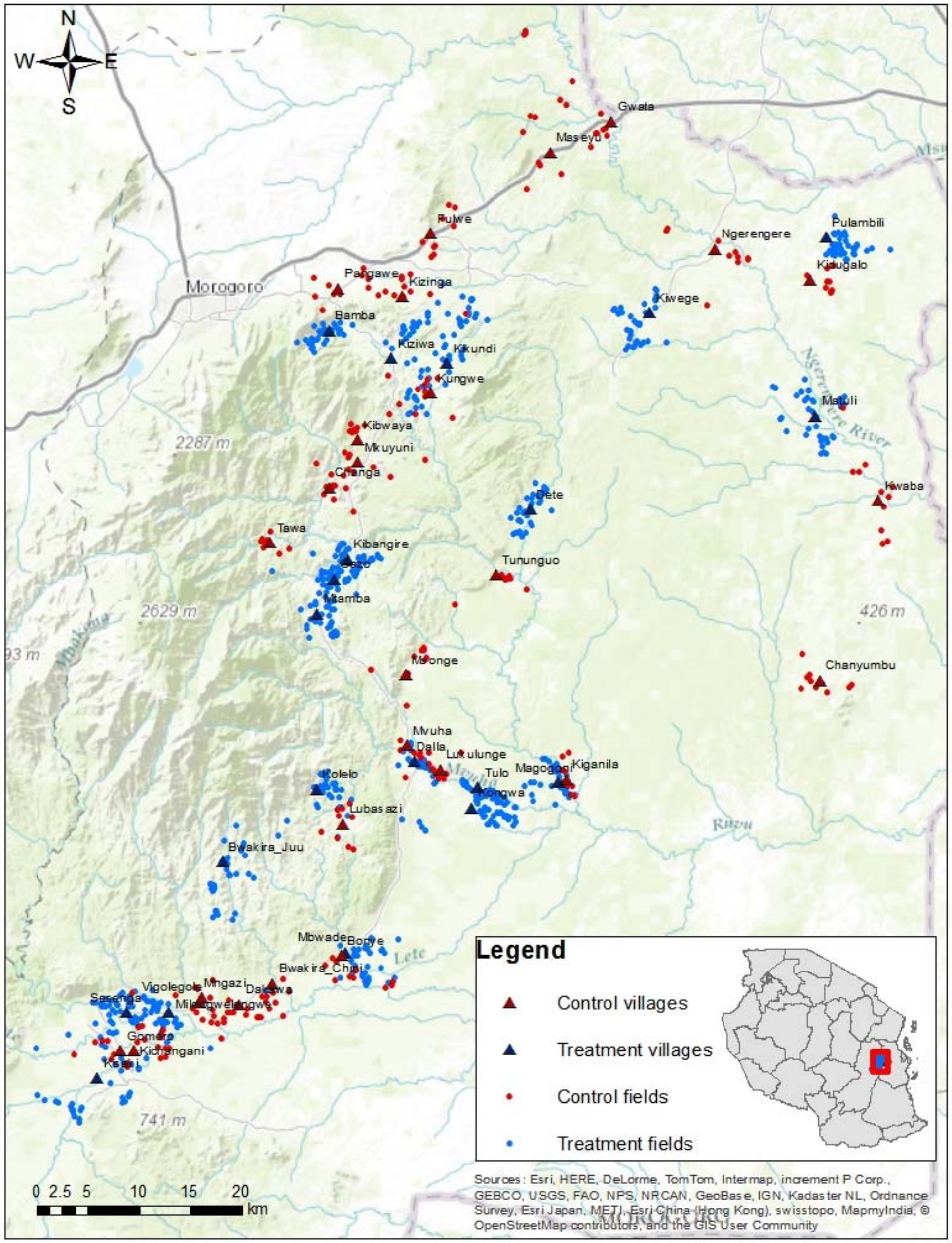
- Two components to treatment:
  - Plot-specific management recommendations for the 2014 growing season based on soil test results.
  - A voucher worth $40 redeemable for agricultural inputs.
- Three treatment groups
  - Treatment group 1: farmers receive soil management recommendations only.
  - Treatment group 2: farmers receive soil management recommendations and inputs vouchers.
  - Treatment group 3: farmers receive input vouchers only.
- Control group receives management recommendations at endline.

SoilDoc

SoilDoc kit developed by Ray Weil from the University of Maryland used for soil testing and associated recommendations



Locations of Treatment and Control Farmers



Recommendation sheet

NS Jina: <<name>> Kijiji: <<village>> Nambari ya utambulisho: <<ID#>> <<treatment group>>

KUPANDIA

Chimba shimo lenye upana wa sentimita 20 na kina sentimita 10; weka mbolea kizibo kimoja cha soda kwenye pembe moja ya shimo, fukia nusu ya shimo kisha panda mbegu kwenye sehemu ya shimo iliyobaki na kufukia.

EKARI MOJA

50 kg

NUSU HEKARI

25 kg

KUKUUZIA SIKU 25-30 BAADA YA KUPANDA MBEGU

Weka vizibo viwili vya mbolea kwenye duara inayozunguka mmea. Funika mbolea kama unyevunyevu ni haba.

EKARI MOJA

50 kg

NUSU HEKARI

25 kg

Gharama ya mbolea kwa nusu ekari ikizidi kiwango cha vocha, gawanya kiwango kilichopendekezwa kwa mbili na weka kwenye robo ekari.

Intervention Part II: vouchers

FERTILIZER VOUCHER

VALUE: 80,000 TZS

This voucher can be used to do ONE of the following:

- **Purchase fertilizers only**
  You may redeem this voucher to purchase any type of fertilizer (Urea, AS, DAP, MOP, SOP, Yara Mila Tobacco, and Minjingu Mazao) worth up to **80,000** TZS. Spending **80,000** TZS does not require any contribution of cash from you. You can contribute your own money to increase the amount bought if you wish.
- **Receive cash only**
  You may redeem this voucher for 68,000 TZS cash.
- **Purchase fertilizers and receive cash**
  You may decide to only use part of this voucher to purchase fertilizers and then receive 85% of the balance remaining on the voucher as cash.

<<Dealer>> will be in your village during the month of December 2015 or January 2016 to deliver inputs. Your village extension worker will contact you with the exact delivery date. Failure to be present during this date will render this voucher void. If you are not the recipient printed on this voucher, you *must* present the National ID Card of the recipient printed on this voucher in order to receive fertilizers. This voucher must be submitted to the <<dealer>> to receive the requested fertilizers.

RECIPIENT:

Name: <<Respondent name>> ID Number: <<Respondent ID>> Village:___________

REDEEMED:

Date: __________________ Recipient Signature:_______________

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK — Sokoine University of Agriculture

If <<dealer>> runs out of fertilizer supply, <<dealer>> is required to return to your village within 1 day of the original delivery date

Result: Soil Variability

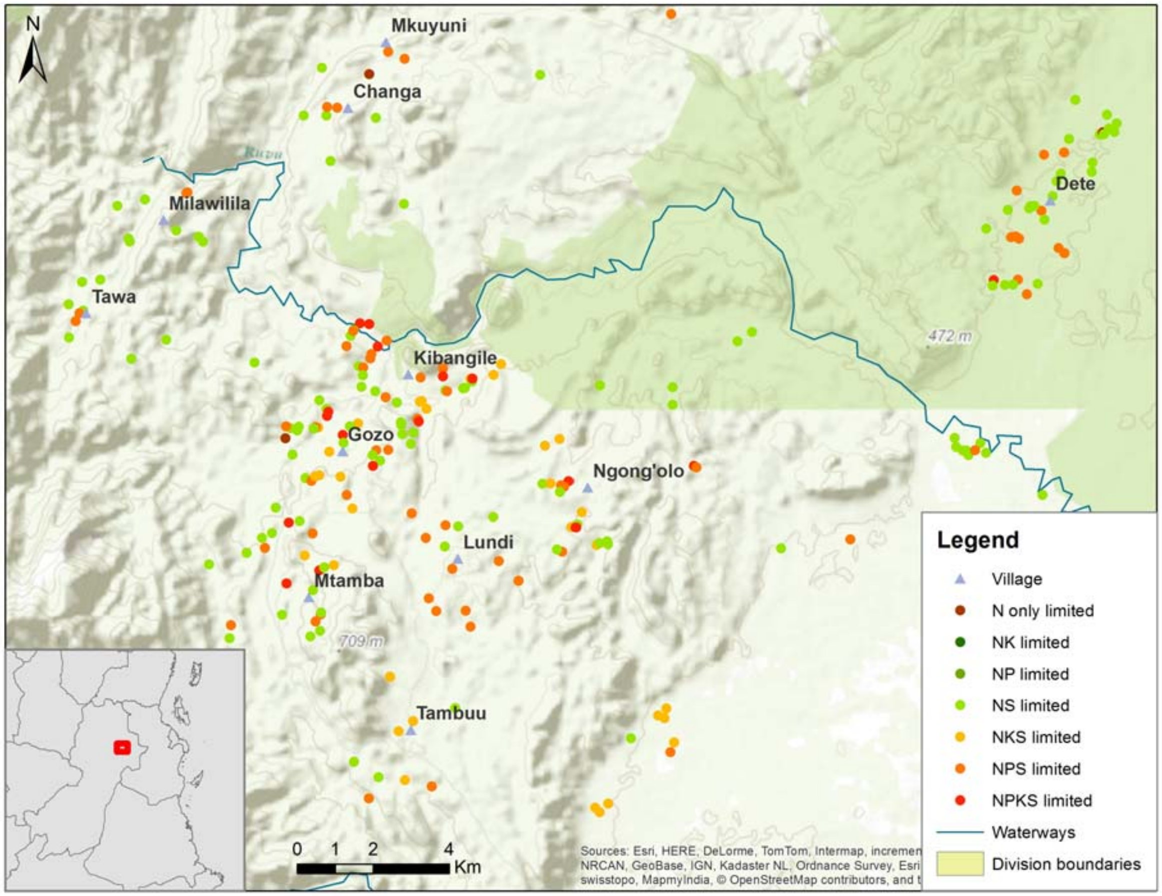


Figure: Nutrient limitations on primary maize plots of farmers located in 47 villages in Morogoro District, Tanzania. Within a 120 square mile area, fields exhibit eight different combinations of nutrient limitations.

Result: Sub-Regional Soil Variability is Large

How much soil variation do we see? Is the variation agronomically significant?

Nutrient deficiency	Number of farms	Share of farms
N only	35	0.036
NP	5	0.007
NK	2	0.002
NS	638	0.635
NPK	1	0.002
NPS	214	0.214
NKS	56	0.056
NPKS	50	0.050
Total	1001	1.00

Table: Nutrient limitations on farmers' primary maize plots. Government recommended application for maize growers in the region is NP, highlighted in red.

Result: Effects of Information and Liquidity on Fertilizer Purchase (2016)

	Voucher	Recommend.	Recommend. + voucher	Control
Urea & SA	7	0	99	0
Urea & DAP	1	0	0	0
Only Urea	54	0	88	1
n	198	191	203	458

- At baseline (2014), only eight out of 1050 farmers reported applying mineral fertilizer.
- At endline (2016), 249 farmers purchased fertilizer; farmers who received vouchers or recommendations + vouchers purchased mineral fertilizer

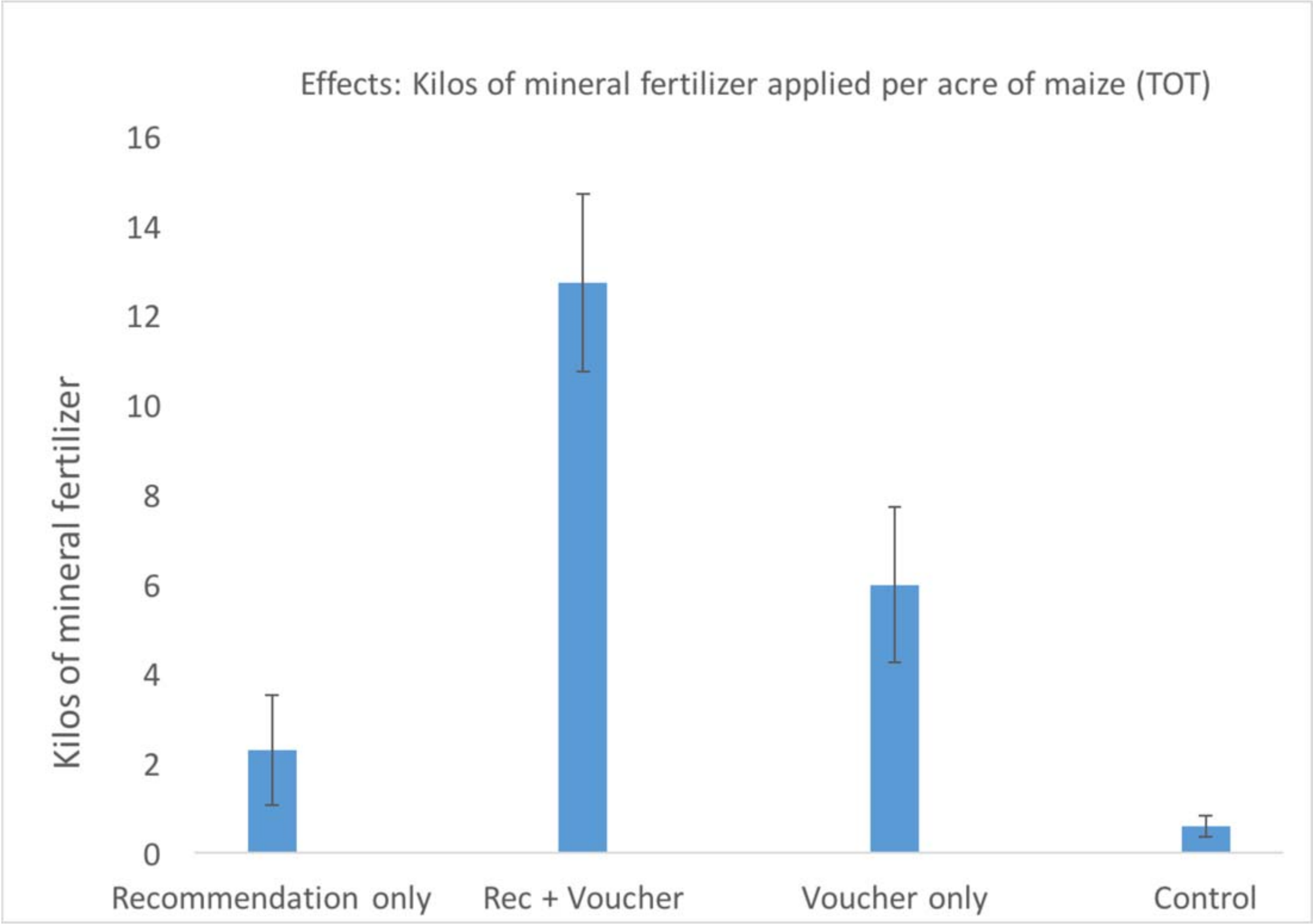
Value of Information

- Farmers who received the vouchers plus information were more likely to buy fertilizers that related to their soil's specific nutrient deficiency than farmers who received vouchers only.
- Voucher only farmers were more likely to just purchase Urea.
- Information can help close farm-specific nutrient deficiency gaps.

	Purchased Ammonium Sulfate Fertilizer (SA)
Sulfur deficient	0.05 (0.09)
Voucher	0.02 (0.11)
Recs	0.001 (0.11)
Voucher & Recs	0.05 (0.11)
Sulfur deficient*Voucher	0.01 (0.12)
Sulfur deficient*Recs	-0.0002 (0.11)
Sulfur deficient*Voucher & Recs	0.46 (0.12) ***
Sulfur deficient*Control	-0.05 (0.12)
Village FE	Y

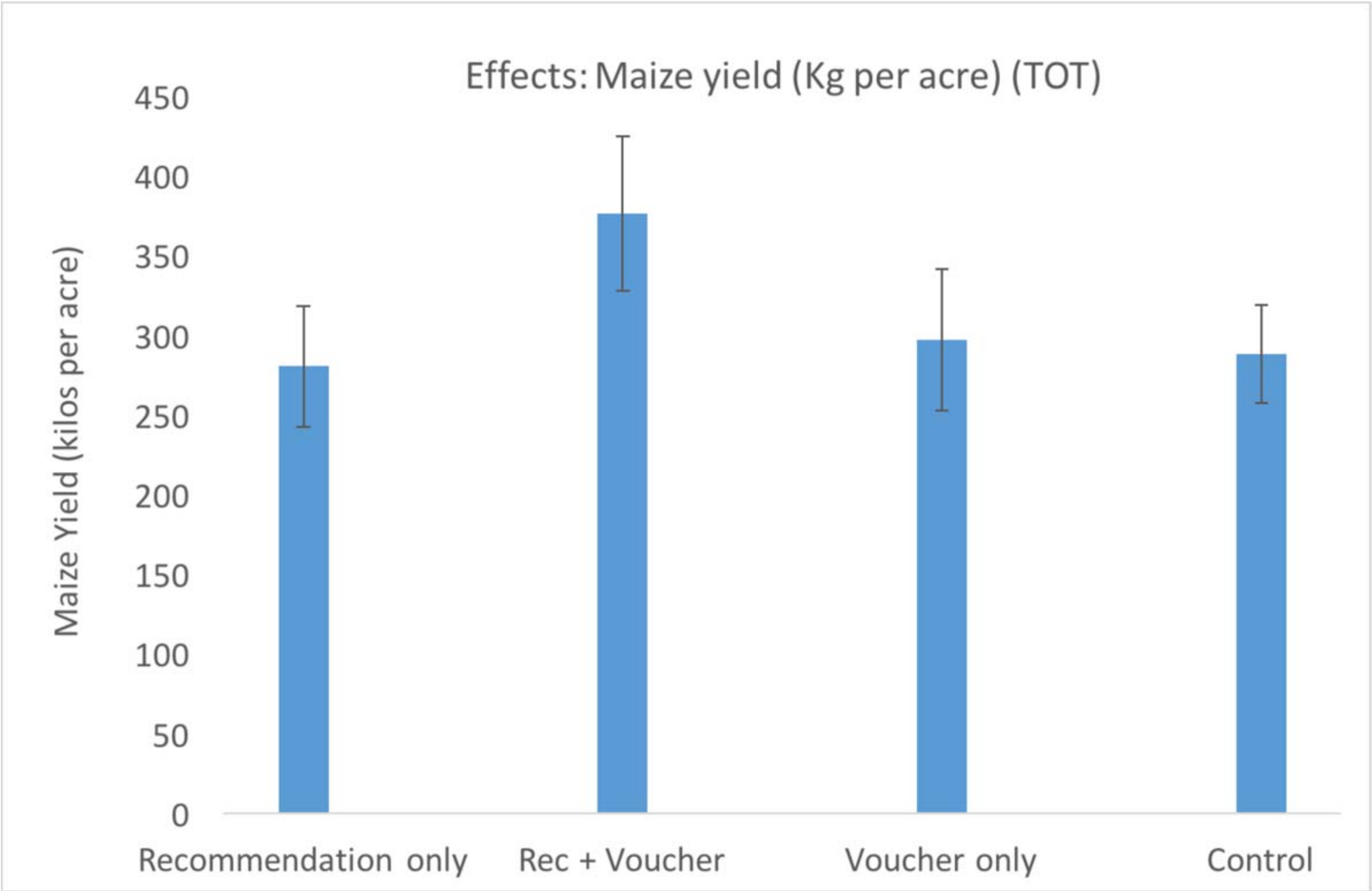
Linear probability model with standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Result: Information + Voucher Affects Investment



- Farmers receiving vouchers only and vouchers + recommendations increased mineral fertilizer application to maize plots. Responses are statistically different from each other (p=.02). Information alone produced no response at endline. Error bars present standard errors.

Result: Information + Voucher Affects Yields (weakly)

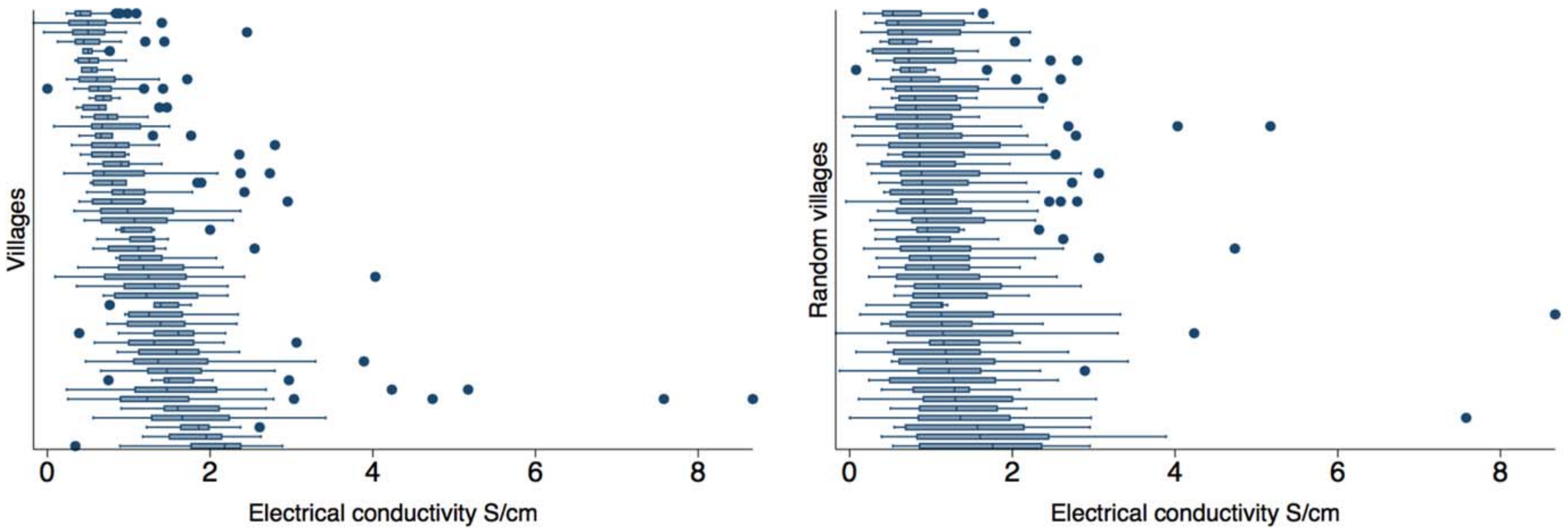


- Small yield increase (relative to control) among farmers receiving vouchers + recommendations. Error bars present standard errors.

Preliminary Conclusions

- Considerable variation in soil nutrient deficiencies in nitrogen, phosphorus, potassium, and sulfur across farms in Morogoro District, TZ.
- National-level fertilizer recommendations may not serve many farmers.
- Vouchers alone move farmers to purchase mineral fertilizer but information plus vouchers can help close farm-specific nutrient gaps.
- Financial constraints are significant: information-provision alone has not changed investment as yet.
- Limited information flow: control farmers living in treatment villages have shown no impact.
- Not much effect on yields at endline; perhaps fertilizing maize is not economical.
- Areas with evidence of agronomically-important variation in soil quality: farm-level soil testing and management recommendations may be significant in improving productivity.
- Future work:
  - Learning over time by farmers? Across farmers? Will effects increase? Attenuate?

Ongoing: What is the optimal scale for soil testing? Plot? Village? Village cluster?



(a) Villages (b) Random villages

Figure: (a) Boxplot distributions of soil electrical conductivity (EC) levels for sampled Morogoro villages. (b) Boxplot distribution of soil electrical conductivity levels in random villages with the same soil sample counts as the measured villages. Though EC is clustered at the village level, we see considerable variability in that clustering.

Thank you.

Improving Yields with Improved Recommendations: Evidence from Mexico

Carolina Corral (Precision Agriculture for Development)
Xavier Giné (World Bank)
Aprajit Mahajan (UC Berkeley)
Enrique Seira (ITAM)

Agrilinks: Soil Variation and Why It Matters

June 29,2017

Improving Small Farmer Productivity

- Improving agricultural productivity often seen as key to reducing poverty.
- Technology adoption an important mechanism for improving productivity.
- However, adoption of technologies remains uneven particularly among small farmers in developing countries (Foster and Rosenzweig (2010) and Jack (2013)).
- One potential reason for low average rates of adoption is heterogeneity in effects of technology.
- Yields in Mexico remain low and variable – comparable to poorer countries – even though fertilizer usage is high on average relative to Sub-Saharan Africa. Yield Summary

This Project

- Better understand (certain kinds of) heterogeneity that could cause variation in yields and adoption of new technologies.
  - Focus on Soil quality. Cited as central to understanding fertilizer adoption (Jayne and Rashid (2013)).
  - Develop interventions based on improved understanding of heterogeneity.
- Variation in soil characteristics.
  - Cation Exchange Capacity: CEC
  - Macronutrients (N, P, K): NPK
  - Variation within and across clusters
- Considerable variation in Soil Quality within and across clusters.
- Var(Soil Quality) $\implies$ Var(Yield Maximizing Inputs)
- Devise interventions based on soil quality.

Experimental Interventions

- Three Interventions
  - Soil analysis and recommendations (Individual and Averaged)
    ▸ SA Document ▸ SA Document 2
  - In-kind grant (Flexible and Inflexible). Work closely with Agro-dealer to provide tailored packages.
  - Agricultural Extension Services.
- Combined these into 4 treatment arms (+ control arm).
- First describe each intervention in detail and then the treatment arms.

Input Recommendations

- Used soil analysis to generate input recommendations for target yield of 4.5 to/ha under normal weather conditions.
  - Recommendations from Fertilab (proprietary) calibrated model based on Leontief (Liebig) production functions.
  - Recommended dosages of (a) Urea (b) Diammonium Phosphate (DAP), (c) Potassium Chloride (KCl) + micro-nutrients.
  - Provided prices, quantities and total costs for each recommended input – "Shopping List". ▸ Costs
- Recommendations:
  - Fertilizer Dosage
    - Quantities and prices
  - Timing of fertilizer application – at sowing and 30 days after depending on plant growth.
    - Dealer mixed fertilizers as per localized recommendations. Provided in two packages.
  - Precision sowing-drill – optimal spacing and fertilizer.
  - Timing of herbicide use (2 and 40 days after sowing)

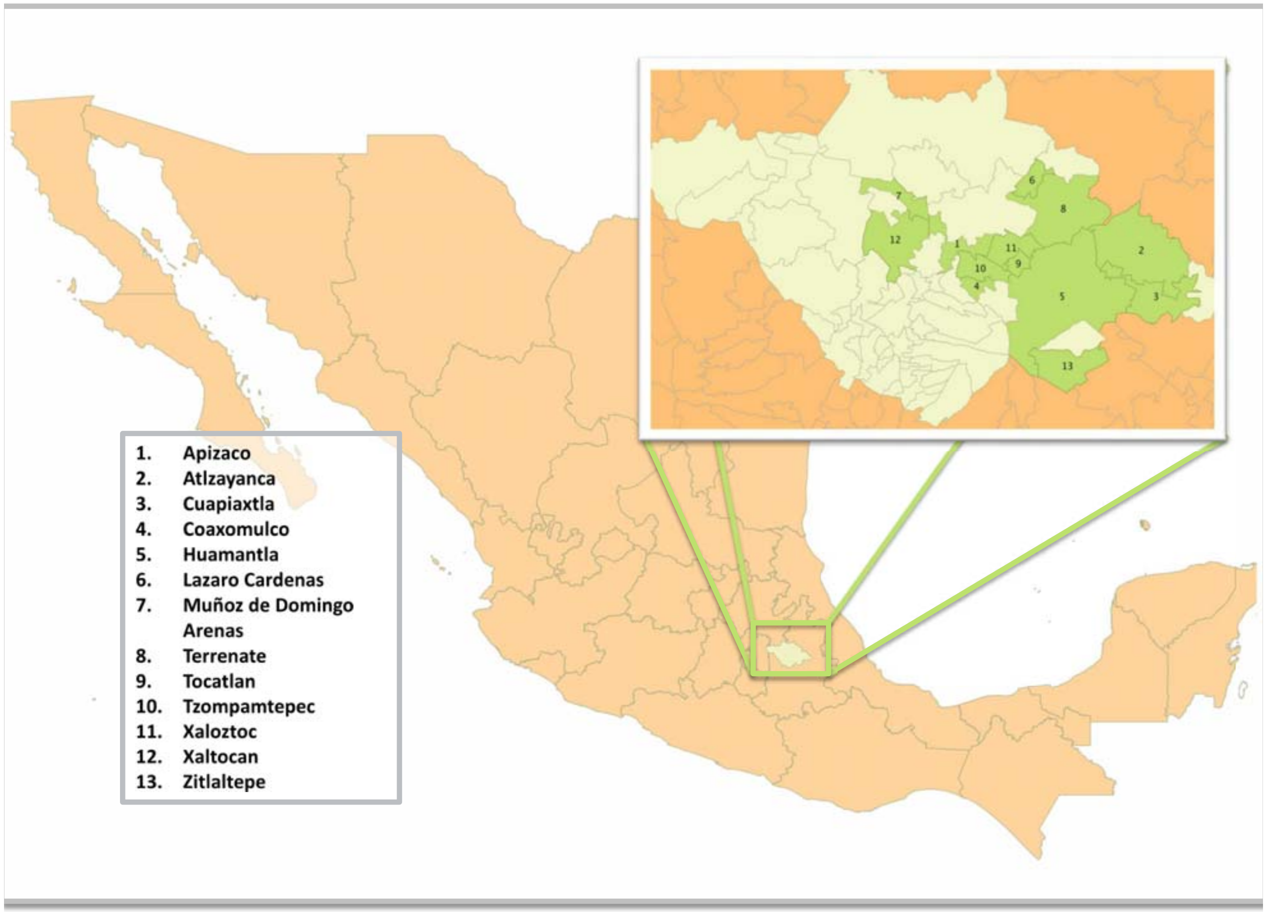
Nutrient and Fertilizer Recommendations

- Nutrient recommendations show substantial variation (corresponding to variation in soil quality).
  - Substantial within and across cluster variation: ANOVA
- Nutrient recommendations were translated into fertilizer recommendations.
- Recommendations differed from usual practices
  - Farmers typically used more fertilizer overall (particularly Urea) and much less KCl and no micro-nutrients.

Average Soil Analysis and Recommendations

- Random subset of farmers received averaged soil analysis and recommendations. Averages were taken over all farmers in the same region.
- Still localized (but not individualized) analyses and recommendations.
- Average recommendations cheaper to generate and blend so (if outcome differences are small) may be more cost-effective.
- Worked with local agro-dealers to generate fertilizer blend packages for recommendations

Tlaxcala (Mexico)



- 13 municipalities of Tlaxcala with large population of small maize farmers.
- One of Mexico's poorest states. 88% of agriculture rain-fall dependent. ▸ Census Comparison
- Sample selection likely different if program were run by other organization. ▸ Summary Statistics

Fertilizer Usage & Yields (2015)

	Urea (kg/ha)	DAP (kg/ha)	KCl (kg/ha)	Total used (kg/ha)	Self-reported Yields (t/ha)
T1	-25.1922**	0.1835	14.1000***	-3.2671	0.473***
	(12.2636)	(5.8961)	(3.6068)	(14.3666)	(0.168)
T2	-34.6799**	-15.4584**	13.9155***	-25.5097*	0.364**
	(13.3004)	(5.9624)	(4.0599)	(15.0860)	(0.162)
T3	-33.0566***	-13.5308**	19.1991***	-17.8228	0.512***
	(12.0266)	(6.4360)	(4.1225)	(15.1384)	(0.159)
T4	3.7682	2.4656	5.2264	9.0950	0.231
	(12.2239)	(5.7112)	(3.7929)	(16.1128)	(0.170)
Constant	195.6280***	38.4331***	13.6592***	256.7331***	2.237***
	(10.3920)	(5.5828)	(2.8609)	(13.7837)	(0.110)
Observations	824	824	824	824	811
R-squared	0.0275	0.0305	0.0485	0.0100	0.014
p-value T1=T2=T3=T4=0	0.0217	0.0006	0.0002	0.0470	0.0105
p-value T1=T2=T3=T4	0.0220	0.0002	0.0091	0.0245	0.3827
p-value T1=T2=T3	0.4731	0.0001	0.0707	0.0167	0.6540
p-value T4=T5	0.7591	0.6677	0.1741	0.5749	0.5309
p-value T2=T3	0.7962	0.5482	0.0239	0.3050	0.3701

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

- T1-T3 less Urea, DAP; More KCl.
- $T1 \approx T2 \approx T3$

Do Improved Practices Stick?

- After study concluded, we followed farmers in 2016
- Collected data on agricultural practices and investments.
- Yield data currently being cleaned

2016 Practices

	Used Sowing Machinery	Used Hybrid Seeds	Fertilizer at Sowing	Used herbicide
T1	-0.0219	-0.0085	0.0024	0.0902**
	(0.0311)	(0.0259)	(0.0297)	(0.0431)
T2	0.0094	-0.0294	0.0319	0.0883**
	(0.0273)	(0.0259)	(0.0329)	(0.0398)
T3	0.0574*	0.0264	0.0847**	0.1350***
	(0.0328)	(0.0325)	(0.0391)	(0.0428)
T4	0.0355	0.0111	0.0477	0.0111
	(0.0290)	(0.0265)	(0.0350)	(0.0293)
Constant	0.1083***	0.0764***	0.1210***	0.0764***
	(0.0273)	(0.0211)	(0.0338)	(0.0259)
Observations	824	824	824	824
R-squared	0.0071	0.0052	0.0076	0.0216
p-value T1=T2=T3=T4=0	0.1795	0.3893	0.1622	0.0462
p-value T1=T2=T3=T4	0.1977	0.2524	0.1312	0.0563
p-value T1=T2=T3	0.1594	0.1984	0.0655	0.1492
p-value T1=T2	0.2604	0.2668	0.3259	0.9585
p-value T2=T3	0.2120	0.0945	0.1331	0.1376

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

- $T3$ shows persistence in 2016

2016 Practices

	Used Fertilizers	Covered the fertilizer	Followed recommendations	Used Yara fertilizers
T1	-0.0755	0.0461	0.0976***	0.0731**
	(0.0656)	(0.0637)	(0.0326)	(0.0280)
T2	-0.0106	-0.0011	0.0912***	0.0976***
	(0.0513)	(0.0726)	(0.0253)	(0.0210)
T3	-0.0344	0.1273**	0.1332***	0.1053***
	(0.0575)	(0.0503)	(0.0305)	(0.0254)
T4	0.0104	0.1117**	0.0680**	-0.0006
	(0.0559)	(0.0542)	(0.0316)	(0.0182)
Constant	0.4459***	0.7070***	0.0382**	0.0318**
	(0.0479)	(0.0492)	(0.0154)	(0.0141)
Observations	824	824	824	824
R-squared	0.0038	0.0165	0.0186	0.0266
p-value T1=T2=T3=T4=0	0.6377	0.0013	0.0003	0.0000
p-value T1=T2=T3=T4	0.4829	0.0468	0.3620	0.0002
p-value T1=T2=T3	0.5508	0.0365	0.3949	0.5434
p-value T1=T2	0.2819	0.3524	0.8573	0.4660
p-value T2=T3	0.6918	0.0106	0.1878	0.7947

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

- $T3$ shows persistence in 2016.

Conclusions

- Provided farmers with localized recommendations and AEW services, agro-dealer coordination and in-kind grants to help implementation.
- High take-up in grant receiving arms. Level of localization seems to not matter for take-up or plant density.
- Variance within higher than variance across clusters.
  - For soil characteristics, input recommendations, plant density.
- Providing in-kind grants appears important.
  - Uncertainty about new recommendations.
- Take-up high and yields 15-22% higher.
- Evidence of some continued practices in 2016.
- Following farmers to see yield improvements.

Soil Analysis: Fertilab Document

Fertilab®
Fertilidad de Suelos S. de R.L.

Análisis que Rinden Frutos

DIAGNOSTICO DE LA FERTILIDAD DEL SUELO

INFORMACIÓN GENERAL

Cliente	Ismael Zacamolpa Cerbani		
No. de Registro	SU-35440	Cultivo Anterior	Ninguno
Fecha de Recepción	09/03/2015	Cultivo a Establecer	Maiz
Fecha de Entrega	11/03/2015	Tipo de Abono Organico	N/A
Rancho o Empresa	Cuaxomulco	Tipo de Agricultura	Temporal
Municipio	Cuaxomulco	Manejo de Residuos	Retirados
Estado	Tlaxcala	Meta de Rendimiento	5 Ton/Ha Ton/Ha
Identificación	.23.01.10.01	Prof. Muestra	0-30 cm

Propiedades Físicas del Suelo

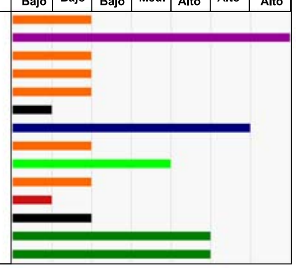
Clase Textural	Franco Arcillo Arenoso		
Punto de Saturación	31.6	%	Mediano
Capacidad de Campo	16.7	%	Mediano
Punto March. Perm.	9.94	%	Mediano
Cond. Hidráulica	6.00	cm/hr	Mod. Alto
Dens. Aparente	1.35	g/cm3	

Reacción del Suelo Necesidades de Yeso y Cal Agrícola

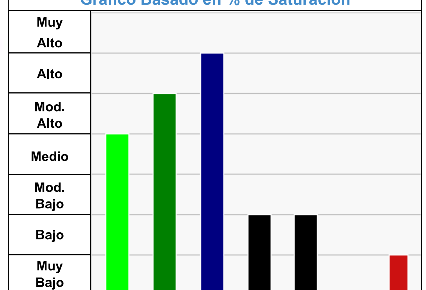
pH (1.2 agua)	5.12		Acido
pH Buffer	6.90		
Carbonatos Totales (%)	0.01	%	Libre
Salinidad (CE Extracto)	0.30	ds/m	Muy Bajo
Requerimientos de Yeso	No Requiere		
Requerimientos de Cal	0.00		

Fertilidad del Suelo

Det	Result	Unid	Muy Bajo	Bajo	Mod. Bajo	Med.	Mod. Alto	Alto	Muy Alto
MO	1.11	%							
P-Bray	61.2	ppm							
K	121	ppm							
Ca	633	ppm							
Mg	90.0	ppm							
Na *	19.5	ppm							
Fe	34.3	ppm							
Zn	0.42	ppm							
Mn	7.70	ppm							
Cu	0.45	ppm							
B	0.13	ppm							
Al *	12.2	ppm							
S	13.8	ppm							
N-NO3	22.7	ppm							



Cationes Intercambiables
Gráfico Basado en % de Saturación



% Sat	71.3	16.7	7.00	1.81	3.16	ND	—
meq/100g	3.16	0.74	0.31	0.08	0.14	0.00	4.43
Catión	Ca	Mg	K	Na*	Al*	H*	CIC

Relacion Entre Cationes (Basadas en me/100g)

Relación	Ca/K	Mg/K	Ca+Mg/K	Ca/Mg
Resultados	10.2	2.39	12.6	4.27
Interpretación	Mediano	Mediano	Bajo	Mediano

* Es deseable que estos elementos tengan un bajo contenido

Interpretación Resumida del Diagnostico de la Fertilidad del Suelo

Suelo con pH acido. Suelo de textura media. Libre de carbonatos. Libre de sales. Bajo nivel de materia organica, es recomendable su aportacion. Bajo nivel de calcio. Muy alto suministro de fosforo disponible.Contenido bajo de potasio. Bajo nivel de magnesio. Suministro moderado en nitratos.

En cuanto a la disponibilidad de micronutrientes: Pobre en zinc. Bajo contenido de cobre. Muy pobre en boro.

Poniente 6. No. 200 Ciudad industrial
Celaya, Gto. C.P. 38010
Tel. (461) 614 5238, 614 7951
www.fertilab.com.mx

Supervisor de Análisis de Suelos
Ing. José Trinidad Guzmán M.

▸ Return to Study Design

Soil Analysis: Farmer Document

Return to Study Design

Fertilab ipampa Qfd

ID. .23.01.09.

RECOMENDACIÓN PARA FEDERICO SERRANO HERNANDEZ

CUAXOMULCO, CUAXOMULCO

Municipio:	CUAXOMULCO
Localidad:	CUAXOMULCO
Parcela:	CUAXILCA
Análisis de suelo:	35455

1. ***Diagnóstico de su PARCELA*** **CUAXILCA**

El laboratorio Fertilab, especialista en suelos analizó la muestra de su parcela y encontró que existen los siguientes niveles de nutrientes:

Propiedades Físicas del Suelo		Reacción del Suelo		
Clase Textural:	Franco Arcillo Arenoso	pH (1:2 agua):	6,69	Neutro
Densidad Aparente	1,1 g/cm3	Materia Orgánica:	0,56	
Punto de Saturación:	30 %	Carbonatos Totales	0,01%	
Cond. Hidráulica:	6,7 cm/hr			

Elementos en el suelo	Ideal para 4.5ton/ha	Cantidad en su parcela (ppm)	
Nitrógeno	**71**	5,44	✗
Fósforo	**30**	4,86	✗
Potasio	**300**	246	✗
Magnesio	**200**	423	✔
Hierro	**9**	10,2	✔
Zinc	**1.2**	0,46	✗
Manganeso	**4**	10,2	✔
Cobre	**.5**	0,99	✔
Boro	**.8**	0,02	✗

ppm = partes por millón

Fertilab Calibration Model

▸ Return to Study Design

Fertilab ipampa Qfd

ID. .23.01.09.

RECOMENDACIÓN PARA FEDERICO SERRANO HERNANDEZ

CUAXOMULCO, CUAXOMULCO

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Parcela:	CUAXILCA
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Cobre	**.5**	0,99	✓
Boro	**.8**	0,02	✗

ppm = partes por millón

ID. .23.01.10.

3. Paquete de fertilización con productividad mayor según los análisis de suelo de su parcela

Según el análisis de suelo de su parcela, Ud. podría alcanzar una productividad de **4.5 toneladas** en su parcela de prueba si en 2015 sigue los siguientes pasos:

1. Fertilizar a la siembra y a los 30 días después de la siembra con un paquete de fertilizantes diversificado.
2. Sembrar 20 kilogramos de semillas criollas o 60,000 de semillas híbridas por hectárea, utilizando una sembradora de precisión para asegurar que las semillas no compiten entre ellas por nutrientes, y que los fertilizantes no quemen sus semillas.
3. Aplicar un herbicida sellador a los 2 días de la siembra y volver a aplicar un herbicida a los 40 días de siembra para que sus plantas no compitan por nutrientes con malezas.

Le proponemos **diversificar el uso de fertilizantes** como se explica abajo para llegar a una productividad de hasta 4.5 toneladas por un costo total de **$2512,04**

Dosis de fertilizantes en kg/ha [2]	MOMENTO DE APLICACIÓN		
	Siembra Kg aplicados por ha	**1era fertilización** Kg aplicados por ha	**Kg totales**
Urea (Blanco)	40,21	163,29	203,5
DAP (Negro)	76,09	0	76,09
Cloruro de Potasio	4,17	4,17	8,33
Minab R	20,41	0	20,41
Costo por aplicación	**$1354,49**	**$1157,55**	**308,33**

PRODUCCION MAXIMA ESPERADA [3]	**4.5 tn por ha**
Precio de Venta promedio (esperado)	2762,45$ por ton
Valor de la producción	**12431,04$ por ha**
1. Gastos en fertilizantes	**2512,04$ por ha**
2. Gastos en otros insumos y actividades	**1,200 $ por ha****
Semillas (20 kg por ha)	0 $ por ha
Sembradora	800 $ por ha
Herbicida sellador (2 días después de la siembra)	200 $ por ha
Herbicidas	200 $ por ha
Costo de la producción	**3712,04$ por ha**

[2] Los precios son establecidos según la casa de fertilizantes YARA HUAMANTLA al 31/3 por kg de producto: Urea Yara: $6.90, DAP Yara $9.70, Cloruro de Potasio YARA: $7.40; Agroquímica Minab-R $15.10

[3] Las metas de producción están basadas en la calidad de su terreno son **aproximadas** y pueden variar dependiendo de factores externos como la cantidad de lluvia y la ocurrencia de eventos adversos como heladas o plagas. Los actividades agrícolas incluyen: sembradora de precisión (1200 pesos), 2 aplicaciones de herbicidas (400 pesos) y 5 jornales de mano de obra para herbicidas, fertilización y otras labores y cosecha (2000 pesos)

Anova Assumptions

- Assumes $\mathbf{Y}_c \equiv \{Y_{ic}\}_{i=1}^{n}$ is i.i.d. across clusters.
- Assumes $Y_{ic} = \mu + \alpha_c + \epsilon_{ic}$ and that $\{\epsilon_{ic}\}_{i=1}^{n}$ are i.i.d across individuals within a cluster.
- Therefore,

$$\text{Corr}(Y_{ic}, Y_{jc}) = \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_\epsilon^2}$$

- Each cluster is about 2.7 km^2 (We sample approx .15 km^2 or about 5%)
- QQ plots indicate non-normality

Return to Individual SA Anova

Comparing Study Farmers to Census

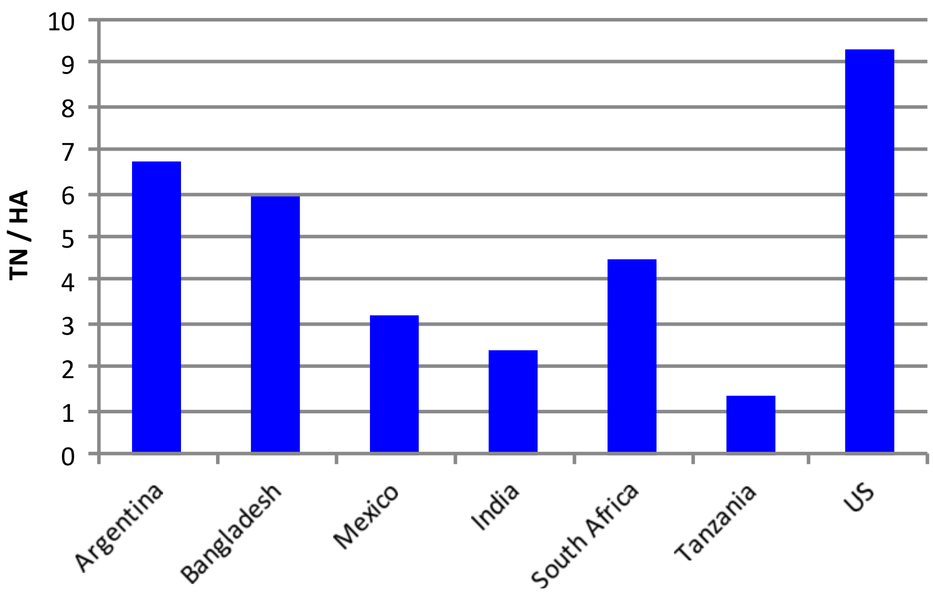
	Mexico		Study sample	
Variable	Mean	Sd	Mean	Sd
Rain-fed agriculture[a]	0.87	0.213	1.000	0.000
Chemical fertilizers[a]	0.74	0.282	0.973	0.160
Organic fertilizers[a]	0.06	0.114	0.390	0.488
Hybrid seeds[a]	0.23	0.265	0.064	0.245
Herbicides[a]	0.34	0.301	0.858	0.348
Insecticides[a]	0.20	0.237	0.116	0.320
Technical assistance[a]	0.03	0.061	0.106	0.308
Maize Yields (ton/ha)	2.73	2.500	1.96	1.118
% pop. working $<$ twice min wages	61.76	19.53	74.9	04.33

Source:INEGI. VIII Agricultural, Livestock and Forestry Census 2007.
[a] Fraction of plots with given characteristic.

Return to Location

[Return to Introduction](#)

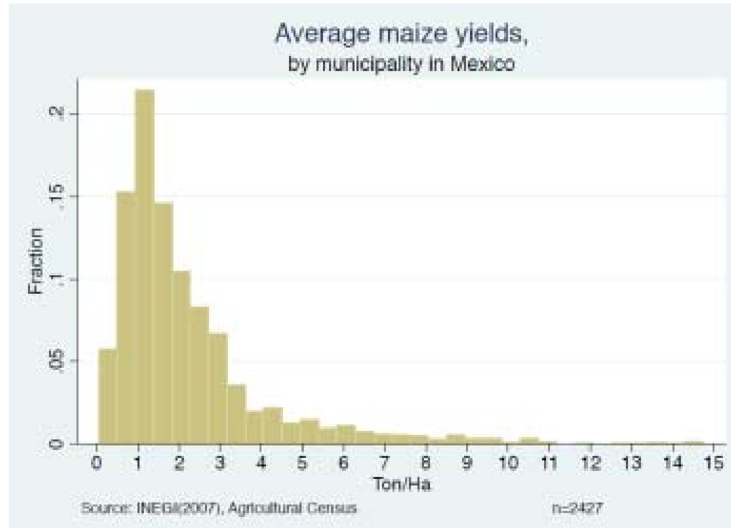
Average Maize Productivity 2008-2012



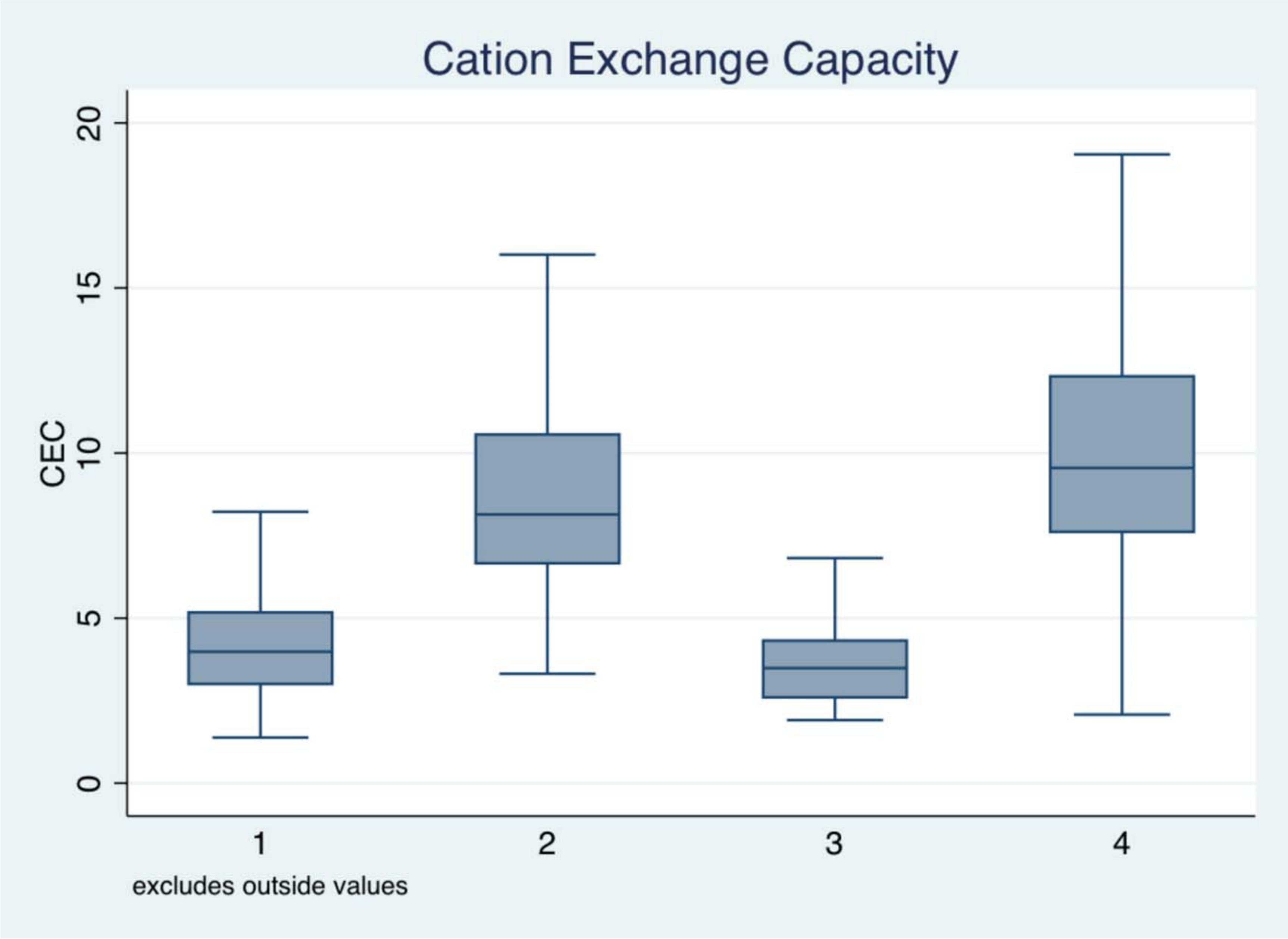
*** Includes irrigated and non irrigated plots**

Source: FAO STATISTICS http://faostat3.fao.org/faostat-gateway/go/to/home/E

Although yields have been improving in Mexico since the 1980's, they are as low as those in much poorer countries, particularly among small land holders.



Return to Project Intro



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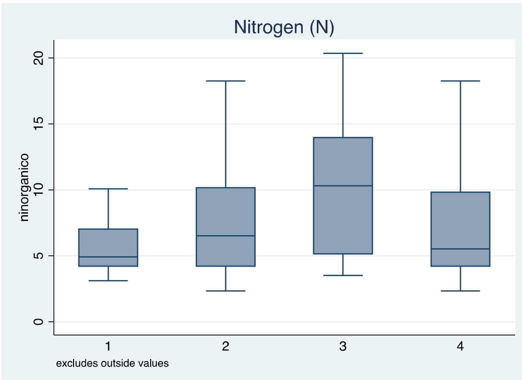
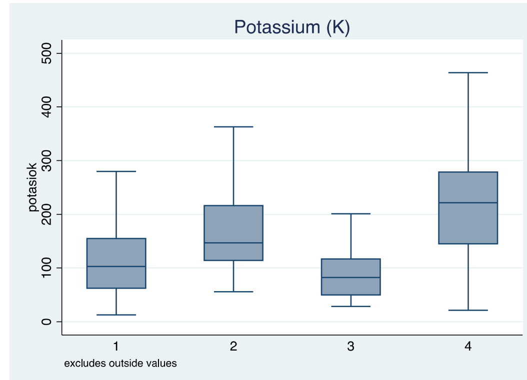
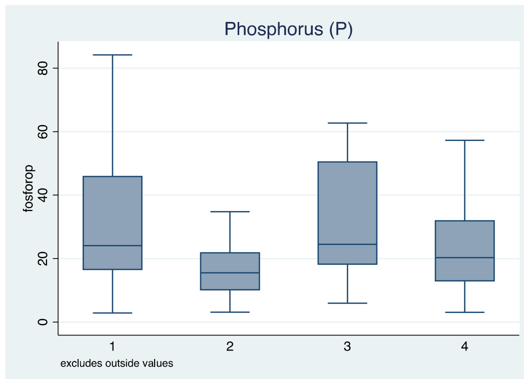
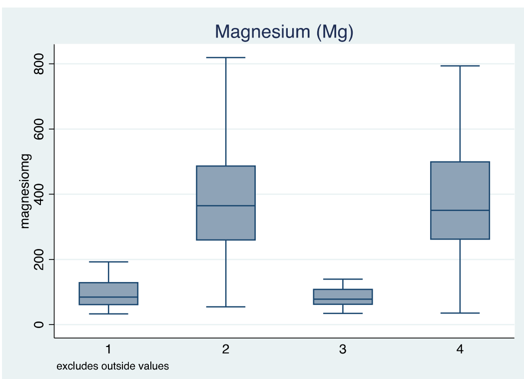
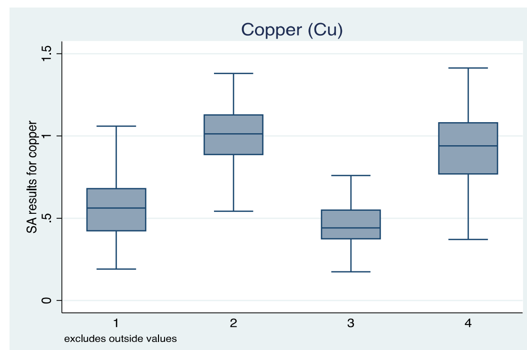
Variation: Macronutrients











Variation in Soil Quality

- Considerable heterogeneity in soil quality.
- ANOVA: Sub-plot i in cluster (localidad) c

$$Y_{ic} = \mu + \alpha_c + \epsilon_{ic}$$

Characteristics	$\frac{\sigma_\alpha^2}{\sigma_\alpha^2+\sigma_\epsilon^2}$	σ_ϵ	σ_α
Sand (%)	0.426272	8.029361	6.921045
Clay (%)	0.326779	4.692272	3.269121
Slit (%)	0.372773	4.939243	3.807766
Nitrogen (N)	0.112593	6.9907	2.490083
Phosphorus (P)	0.188448	23.32174	11.23826
Potassium (K)	0.220409	102.0539	54.26382
Calcium (Ca)	0.143122	1314.204	537.1018
Magnesium (Mg)	0.404289	98.36461	81.0339
Cation Exchange Capacity, CEC	0.186664	6.881082	3.296493
pH (1:2)	0.392394	0.507053	0.407477

$n = 817$.

- Within variation > Across variation. Anova
- Soil Sampling Scheme (Key to Soil Sampling)
- Return to Project Intro

Summary Statistics & Balance

Variable	Mean[a]	p-value[b]
Male	0.8269 (0.3795)	0.4673
Age	56.7179 (14.0192)	0.3432
Years as farmer	35.0449 (16.9482)	0.3491
Finished primary school	0.6218 (0.4865)	0.1168
Self-Reported Yield (t/ha)[c]	1.9657 (1.0782)	0.9959
Total ha worked[c]	5.8899 (5.1306)	0.5193
Used sowing precision machinery[c]	0.1154 (0.3205)	0.8989
Number of fertilizations[c]	1.6 (0.5296)	0.994
Total Fertilizer (Kgs./ha)[c]	333.766 (162.4325)	0.8924
Ever done soil analysis	0.1538 (0.3620)	0.8911
Ever fertilized at sowing	0.1677 (0.3748)	0.6281
Ever had AEW	0.1026 (0.3044)	0.7412
Used hybrid seeds[c]	0.0387 (0.1935)	0.228
Total self-reported income[c]	28271.3462 (32968.9182)	0.3955

[a] $n = 817$. S.E.s in parentheses.
[b] p-value for treatment coefficients jointly equal to zero.
[c] In 2014.

Return to Location

Individual Nutrient Recommendations: ANOVA

- Soil quality Heterogeneity $\implies$ Recommendation Heterogeneity.
- ANOVA: Sub-plot i in cluster (localidad) c

$$Y_{ic} = \mu + \alpha_c + \epsilon_{ic}$$

Nutrient	$\frac{\sigma_\alpha^2}{\sigma_\alpha^2+\sigma_\epsilon^2}$	σ_ϵ	σ_α
Nitrogen (N)	0.133353	15.55322	6.101006
Phosphorus (P)	0.182385	11.62552	5.490764
Potassium (K)	0.249569	14.47331	8.346572
Magnesium (Mg)	0.250801	0.812977	0.470375

$n = 817$.

- Within variation > Across variation

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Questions and Answers

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