Misperceived Quality: Fertilizer in Tanzania

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Motivation: yields and profits limited by low fertilizer use

• 1 in 4 people are chronically hungry in Sub-Saharan Africa (SSA) (FAO 2014)

• Large staple cereal yield gaps in SSA, relative to what has been found experimentally possible on similar soils.

• Primary contributor to low yields: extremely low use of improved seeds, mineral fertilizer.

• First order assessment suggests mineral fertilizer use IS profitable on average.
Motivation: low fertilizer use is persistent

- Sub-Saharan Africa: 18 kg per hectare (FAO 2013)
- Tanzania’s fertilizer consumption is 9 kg per hectare – below the continental average and well below the Kenyan average
Motivation Why don’t farmers use (more) fertilizer?

- Input and output market inefficiencies (Minten et al. 2013; Croppenstedt 2003; Suri 2011)
- Uninsured risk (Karlan et al. 2014; Dercon and Christiaensen 2007)
- Behavioral constraints (Duflo et al. 2011)
- Knowledge (Foster and Rosenzweig, 2010)

Poorly understood: impact of mineral fertilizer quality affect farmer fertilizer use?
Motivation: Why is fertilizer quality relevant to the problem of under-use?

• Agronomic quality of fertilizer determined by its nutrient content
  • Nutrient content not observable at purchase
  • Low quality fertilizer is less agronomically effective

• Farmer uncertainty about quality could affect use

• Weak regulatory environment – quality unknown
  • Conditions provide opportunity for Akerlof’s (1970) “dishonest sellers”, who “wish to pawn bad wares as good wares and thereby tend to drive the good wares out of the market” …
Motivation

• First generation of papers gathers evidence on quality
  • Herbicide: Ashour et al. (2017) find poor quality herbicide in Uganda
  • Seeds: Tjernstrom (2017) finds 23% of seeds do not germinate in Kenya; Bold et al. (2018) find 50% maize seed fails to germinate in Uganda; Kilip et al. (2017) find hybrids not the claimed variety in Uganda.
  • Ashour et al. (2017) and Bold et al. (2018) measure farmer beliefs about quality and study correlation

• Second generation
  • deBrauw and Kramer (2019)
  • planned work by several teams on market info/market power interventions
Research Questions

• *Is* fertilizer quality a problem?
• What do farmers **believe** about fertilizer quality?
• Can we change beliefs?
Main results of this work:

• Mineral fertilizer quality is good.

• Farmers believe that fertilizer is low quality.

• Farmer Willingness-to-Pay (WTP) for “perfect quality fertilizer” exceeds market price.
  
  • Farmers behave as though operating in a market characterized by asymmetric information

• WTP responds to information on
  
  • Unobservable quality (nitrogen content)
  
  • Physical characteristics
Contribution

• Our results suggests an equilibrium where farmers’ beliefs about fertilizer diverge from the truth.

• Why can such an equilibrium can persist in a competitive input market?
Outline

1. Research setting and data
2. What is the quality of fertilizer?
3. What do farmers believe?
4. How do beliefs affect farmer WTP?
5. Exploring the findings
   - Why don’t agrodealers act to solve the problem?
   - Why do beliefs persist?
6. Can a scalable information campaign change beliefs and increase demand?
Setting: Tanzania

New law to protect public from fake fertilizers

Dodoma. The government is finalising guidelines and regulations for destroying seized fake fertilizers in a move to protect people’s health and the environment.

Tanzania Fertilizer Regulatory Authority (TPRA) in collaboration with National Environment Management Council (NEMC), Tanzania Bureau of Standards (TBS) and the Government Chief Chemist work on final touches on the document.

Deputy Minister for Agriculture, Food Security and Cooperatives, Mr Godfrey Zambi, told the Parliament yesterday that the guideline and regulations would control the destruction of all substandard fertilizers in the country.

Yara Tanzania Ltd refutes counterfeit fertilizer claims

Fertilizer market in the country has been infiltrated by penetration of counterfeits smuggled in by unscrupulous agro dealers and companies.

Speaking at Nane Nane exhibitions in Dodoma yesterday, Chief Executive Officer for Tanzania Fertilizer Regulatory Authority (TFRA) Dr Susan Ikerra said a survey conducted in agrogoods and shops in Mboya, Iringa, Rukwa, Ruvuma, Morogoro regions and recently in Njombe found fake, substandard and adulterated fertiliser being sold to farmers unbeknown to them.

She said the situation has contributed to low productivity among farmers in the country. “Most farmers can hardly tell genuine fertiliser from fake ones,” she said.

Dr Ikerra added that a recent survey conducted in different parts of the country has revealed that some agro dealers are repackaging fertiliser in other companies’ bags and rebranding. “Such a case was noted in Calcium Ammonium Nitrate (CAN) fertiliser. We impounded fake fertiliser branded Sulphate of Ammonium (SA), and CAN which were both substandard and packed in wrong bags.”

She said the case is being handled by responsible authorities.
Setting and data:

- Tanzania imports nearly all the mineral fertilizer it sells; imports through the Dar es Salaam port
- 10 major firms sell own-branded fertilizer in Tanzania; three consistently import (2018)
- In 2010 (Benson et al.):
  - Urea made up 50% of fertilizer used in Tanzania
  - NPK: 20%
  - CAN: 9%
- Extremely limited regulatory enforcement on quality
- Most small farmers purchase mineral fertilizer in small (1-2 kg) quantities from open 50 kg bags
- Lack of (scientific) evidence verifying fertilizer quality
Data: Fertilizer sampling and Agro-dealers

• Census and survey of all agro-dealers in Morogoro Region (2016)
  • 225 agro-dealers
  • Surveyed on business operations, supply chain details, fertilizer quality perceptions
• 636 fertilizer samples collected by enumerator mystery shoppers

Locations of 100 market centers identified in our Morogoro Region agro-dealer census
Mineral fertilizer can contain less nitrogen (N) than the manufactured standard due to

- Adulteration: fertilizer “cut” with table salt, concrete
- Manufacturing impurities or process problems
- Degradation due to poor storage and handling (trivial)

- We confirmed that fertilizer meets nutrient standards at port of entry.
- 42 fertilizer samples at Dar es Salaam warehouses and port (ships on arrival) in 2017-2018
- All passed nutrient standards
Fertilizer quality: importance of careful testing

- ICRAF used Mid-infrared diffuse reflectance spectroscopy (MIR) to measure nitrogen in all samples.
- We double tested randomly selected ~10% at Thornton Labs in Florida; uses traditional organic chemistry methods – Kjeldahl method.
Result – Fertilizer Quality is good: <1% of urea below standards
Our good quality result is consistent with majority of research

- Urea: No evidence of missing nitrogen
  - IFDC studies in five West African countries (2013)
- **One outlier:** Bold et al. (2017) finds that urea in Uganda is missing 30% of its nitrogen on average.
Evidence across studies does not support story of widespread fertilizer adulteration.
It’s hard to adulterate

• Evidence of adulteration requires additional information beyond measured nutrient content to ensure shortages are not due to
  • manufacture deficiencies
  • uncontrolled variability in chemical analysis

• Adulteration is difficult to pull off
  • profitably, especially for urea!
Farmers report persistent concerns about fertilizer adulteration

IFDC notes (2013) farmer beliefs about urea fertilizer are not consistent with evidence of its good nutrient quality:

“...the total N content compliance of urea was good. Yet, there is a perception that urea is being mixed with non-fertilizer materials in the region, which the study results did not confirm. A specific assessment is required to further verify this claim.” (p. 39)
Survey data consistently establishes farmers' suspicions

- We find
  - 36 percent of farmers report adulteration is a problem in their market (2016)
  - Farmers report 40 percent of fertilizer is “bad quality” in local markets (2019)

- Bold et al find that on average farmers think fertilizer in their local shop is missing 38 percent of nitrogen on average

- Ashour et al find farmers believe 41 percent of herbicide is counterfeit or adulterated in their local market

Dealers are suspicious too: 21% report suspecting that they had purchased adulterated fertilizer before from their supplier
A second quality dimension: fertilizer's physical characteristics

- More than half of farmers reported having purchased clumped/caked fertilizer previously

<table>
<thead>
<tr>
<th>% Samples Exhibiting Physical Quality Problems</th>
<th>Percent of fertilizer samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clumping</td>
<td>27.84</td>
</tr>
<tr>
<td>Discoloration</td>
<td>10.38</td>
</tr>
<tr>
<td>Debris/foreign material</td>
<td>4.78</td>
</tr>
<tr>
<td>Powdering</td>
<td>7.91</td>
</tr>
<tr>
<td>obs</td>
<td>636</td>
</tr>
</tbody>
</table>
Farmer data and WTP assessment

- Surveyed 164 farmers in Morogoro Region who provided
  - 217 fertilizer samples
  - Interviews on fertilizer experience, quality perceptions
  - WTP assessment for urea

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farmers (n=164)</strong></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>45.93 (11.34)</td>
</tr>
<tr>
<td>Male (share)</td>
<td>0.61</td>
</tr>
<tr>
<td>Ever purchased mineral fertilizer? (1=Y)</td>
<td>99.39</td>
</tr>
<tr>
<td>Ever purchased fertilizer from an open bag or a repackaged small pack? (1=Y)</td>
<td>75.15</td>
</tr>
<tr>
<td>Able to purchase fertilizer on credit? (1=Y)</td>
<td>90.91</td>
</tr>
<tr>
<td>Ever purchased fertilizer with credit? (1=Y)</td>
<td>16.97</td>
</tr>
</tbody>
</table>
What do farmers believe? WTP Assessment

1. We purchased three 1 kg samples of Urea in the market which met the 46% N content standard (lab tested in US).

   A: Good appearance
     Good quality

   B: Large clumps
     Good quality

   C: Foreign material,
     Good quality

2. All farmers shown each sample, asked how much they would be willing to pay for each; prompted to report what it was worth to them, not what they thought it would cost.

3. All farmers presented with the results of the lab tests and emphasized that all samples met the 46% N content standard

4. Farmers provide a second WTP for each sample
What do farmers believe? WTP Assessment

• Urea is available in local markets and local market price + transactions costs should serve as an upward bound on the farmer WTP

• Second half of the WTP assessment introduces a good NOT currently available: Urea with nutrient quality certified by an independent third party

• Elicited hypothetical responses for logistical reasons – we wanted farmers to be presented with the same products
WTP Result: 1. Farmers pay more for good looking fertilizer
2. WTP for tested fertilizer exceeds market price.

Mean 1kg Urea price: 1500 TZ Sh (04/2016)
What do farmers believe? WTP Assessment

- We find consistent results in our 2019 incentivized BDM with 350 farmers in the same region:
  - 54% increase in WTP for tested urea over untested WTP

<table>
<thead>
<tr>
<th></th>
<th>WTP TZSh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morogoro (market center)</td>
<td>47.99</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
</tr>
<tr>
<td>Tested</td>
<td>535.03***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>Constant (local market)</td>
<td>1,015.24***</td>
</tr>
<tr>
<td></td>
<td>(38.37)</td>
</tr>
</tbody>
</table>

Observations 1,045

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Farmers seem to use these observable characteristics as a signal of unobservable quality.

Are physical quality characteristics of mineral fertilizer a good signal of unobserved quality?

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) WTP TZSh</th>
<th>(2) WTP TZSh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample B (clumps)</td>
<td>-763.1***</td>
<td>-737.7***</td>
</tr>
<tr>
<td></td>
<td>(96.80)</td>
<td>(75.58)</td>
</tr>
<tr>
<td>Sample C (foreign material)</td>
<td>-805.7***</td>
<td>-787.5***</td>
</tr>
<tr>
<td></td>
<td>(100.8)</td>
<td>(79.43)</td>
</tr>
<tr>
<td>post information</td>
<td>712.2***</td>
<td>712.2***</td>
</tr>
<tr>
<td></td>
<td>(93.08)</td>
<td>(71.38)</td>
</tr>
<tr>
<td>Sample B * post information</td>
<td>282.5**</td>
<td>282.5***</td>
</tr>
<tr>
<td></td>
<td>(136.9)</td>
<td>(105.0)</td>
</tr>
<tr>
<td>Sample C * post information</td>
<td>252.9*</td>
<td>251.0**</td>
</tr>
<tr>
<td></td>
<td>(142.4)</td>
<td>(109.2)</td>
</tr>
<tr>
<td>Constant</td>
<td>1,502***</td>
<td>1,044**</td>
</tr>
<tr>
<td></td>
<td>(65.82)</td>
<td>(458.4)</td>
</tr>
<tr>
<td>Farmer FE</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>855</td>
<td>855</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.296</td>
<td>0.666</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
But: Observables do not correlate with N

Regression of the fractional deviation of nitrogen from the manufacturer standard on observable mineral fertilizer quality characteristics (seller samples).

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) N standardized (percentage points)</th>
<th>(2) N standardized (percentage points)</th>
<th>(3) N standardized (percentage points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clumping</td>
<td>0.0309 (0.0561)</td>
<td>0.0936 (0.0735)</td>
<td>0.125 (0.154)</td>
</tr>
<tr>
<td>Powdering</td>
<td>-0.566 (0.861)</td>
<td>0.146 (0.963)</td>
<td>-0.534 (1.072)</td>
</tr>
<tr>
<td>Discoloration</td>
<td>-0.489 (1.025)</td>
<td>-0.282 (1.256)</td>
<td>-0.512 (1.145)</td>
</tr>
<tr>
<td>Debris/foreign material</td>
<td>-0.0467 (0.470)</td>
<td>0.0352 (0.543)</td>
<td>0.763 (0.986)</td>
</tr>
<tr>
<td>DAP</td>
<td>2.812*** (0.670)</td>
<td>2.949*** (0.700)</td>
<td>3.037*** (0.749)</td>
</tr>
<tr>
<td>urea</td>
<td>5.393*** (0.399)</td>
<td>5.539*** (0.402)</td>
<td>5.561*** (0.367)</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.715*** (0.310)</td>
<td>-5.394*** (1.439)</td>
<td>-6.340*** (0.367)</td>
</tr>
<tr>
<td>Observations</td>
<td>606</td>
<td>606</td>
<td>606</td>
</tr>
<tr>
<td>Market location FE</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller FE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.229</td>
<td>0.322</td>
<td>0.578</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
WTP Results Summary and Interpretation

• Farmer pre-information WTP for fertilizer in good physical condition approximates the prevailing market price

• Credible information works. Post-information, mean price for all samples exceed the market price
  • good condition fertilizer increases 47%
  • suggests what farmers would pay for fertilizer without uncertainty about nitrogen

• Farmer WTP responds to observables. Farmers use these as a signal of unobservable quality.

• Hypothesis: Price should relate to observable fertilizer quality
Prices not related to nitrogen (trivial) or observed characteristics

<table>
<thead>
<tr>
<th></th>
<th>price per kg (TZ Sh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (standardized)</td>
<td>-2.643 (215.0)</td>
</tr>
<tr>
<td>Clumps</td>
<td>8.757 (5.749)</td>
</tr>
<tr>
<td>Powdering</td>
<td>-3.714 (29.54)</td>
</tr>
<tr>
<td>Discoloration</td>
<td>-25.99 (34.50)</td>
</tr>
<tr>
<td>Foreign material</td>
<td>34.25 (38.37)</td>
</tr>
<tr>
<td>Market location FE</td>
<td>Y</td>
</tr>
<tr>
<td>Fertilizer type</td>
<td>Y</td>
</tr>
<tr>
<td>Manufacturer controls</td>
<td>Y</td>
</tr>
<tr>
<td>Constant</td>
<td>1,620*** (65.43)</td>
</tr>
<tr>
<td>Observations</td>
<td>603</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.715</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
Why don’t agro-dealers solve the problem?

If farmers infer nutrient quality from bad looking fertilizer **why not improve observable characteristics?**

- Market provides little incentive to invest in supply chain logistics that could plausibly improve fertilizer’s physical characteristics:
  - physical condition of fertilizer NOT explained by shop infrastructure such as use of pallets for storage
  - initial degradation happening close to the port
  - physical characteristics cannot be changed and are random shocks to suppliers

Why don’t dealers test fertilizer quality?

- Fixed cost for testing/certification is high
- Lack of coordination mechanism
CAN fertilizer in the arriving ship’s hatch exhibiting large and hard agglomerations, Dar es Salaam, March 3 2018.
Why do farmer beliefs persist?

- **Difficult to learn** about true quality given considerable stochasticity in agricultural production.
- **Complementary underinvestment** in labor and other critical inputs if farmer believes the fertilizer is poor.
- **Farmer error** in application quantity, method, or timing
- Farmers may **not be purchasing and applying the right types** of fertilizer (Harou et al., 2019).
Can we – by changing beliefs – alter demand?

Given:
• Farmer suspicions about adverse selection
• Farmer willingness-to-pay responds to credible information about unobservable nitrogen content

Could a credible information campaign about tested fertilizer quality resolve information problems in this market?
Can we – by changing beliefs – alter demand?

With Magomba and Maertens, designed an implemented RCT in these 100 markets to test the effects of a scalable information campaign on:

1. farmer beliefs about fertilizer quality
2. fertilizer demand
   - leading some farmers to adopt fertiliser
   - others to use “more” for a given price
3. fertilizer supply
   - sales and stocks
4. prices and new entrants
Can we – by changing beliefs – alter demand?

• All 100 markets in Morogoro region; and within these all 300 agro-dealers

• Random assignment into:
  • **50 Treatment**: Pamphlets were distributed to costumers and passer-by's and posters were hung in public locations and at the stores; then conducted interviews with all agrodealers. Text from poster:

    “Attention farmers! UREA TESTED IN THIS MARKET IN 2016 HAD EXCELLENT QUALITY. Tests were conducted by the International Institute of Tropical Agriculture and Sokoine University. All urea tested contained 46% Nitrogen, which is as required.”

  • **50 Control**: conducted interviews
A ‘strong’ intervention in markets

Upimaji uliratibiwa na shirika la IITA NA Chuo Kikuu cha Sokoini cha Kilimo (SUA)
Sampuli zote za Urea zilizofanyiwa vipimo vya ubora mwaka 2016 zilikiwa na kirutubisho cha Naitrojeni kwa asilimia 46. Hii ina maana kuwa mbolea ya Urea ilikidhi viwango vya ubora vya kitaifa na kimataifa. Mbolea ya Urea ilionekana ni bora.
Village treatment and interviews

• Randomly selected 150 villages (75 treatment and 75 control) within 3-8km of the 100 markets, randomly selected 10 farming households per village

• We interviewed these 10 households (1500 households total)

• In 75 treatment villages: followed interview with an information meeting for the whole village where we inform the village about the good quality of urea fertilizer in the nearby (matched) market

Personal interviews in villages
Data collected to date

- **Dealer survey**: Characteristics of owner, shop, assets, stocks and sales, supply chain, employees, customers, observables
- **Farmer survey**: Household characteristics, risk aversion, assets, fertilizer purchases and use, beliefs about fertiliser
- **Dealer weekly calls**: Number of customers, fertiliser sales, fertiliser prices in the market
- **Endline visits to agrodealers and farmers (ongoing)**: providing information about 2016 tests to all agrodealers and farmers and randomly sampling fertilizer
First results from baseline farmer survey: farmers suspect the quality of fertilizer in their markets

If 10 FARMERS, LIKE YOU, PURCHASE ONE 1 kilogram bag of fertilizer at

_______
(Market 1)

THIS WEEK, HOW MANY WOULD BE bad quality, HOW MANY WOULD BE good quality?

• Farmers believe about 30% of fertilizer for sale in their proximate market is “bad quality” on average
First results from dealer calls: sales are higher in treatment markets

- More to come
Conclusions

• Mineral fertilizer quality is good. Proper nutrient testing by researchers is essential.
• Farmers believe that fertilizer is adulterated/low quality.
• Farmer WTP for “perfect quality fertilizer” exceeds market price.
• WTP responds to information about unobserved quality
• Results suggests an equilibrium where farmers’ beliefs about fertilizer diverge from the truth.

The important questions:
• Why do beliefs persist?
• How do we change beliefs?
• Will changing beliefs about fertilizer quality change behavior?
Thanks

- Funded by DFID PEDL ERG, UIUC ACES OIP, UIUC ACE
Motivation

• Anecdotal reports from farmers suggest quality problems:
  • EX: “...The fertilizer that can be purchased in the village is of poor quality because sellers can sell expired or illegal fertilizer that has not allowed by Tanzania Bureau Service (TBS).” (2015, Morogoro TZ)