Can SMS-extension increase farmer experimentation? Evidence from Six RCTs in East Africa

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Use of SMS to affect behavior

- Use of SMS to change behavior:
  - Health (Hall et al., 2015; Head et al.,2013)
  - Education (Ksoll et al, 2014; Aker et al. 2012; Berlinski et al. 2016; Cuhna et al, 2017)
  - Governance (Aker et al., 2017; Dustan et al., 2018)
  - Agriculture (Aker et al., 2016; Hildebrandt et al., 2015; Courtois and Subervie, 2014, Camacho and Conover, 2010; Fafchamps and Minten, 2012)
- Concerns around impact: illiteracy, ‘spam’, not reading/understanding
- Even if effect small, potentially very cost-effective
  - The cost to carriers to transmit a marginal message is close to zero
  - E.g. Amazon’s web services SMS: $0.002 in India and $0.006 in US

Role of Meta-analysis

- Failure to reject null hypothesis often interpreted as ineffective program
  - Potentially problematic for low cost interventions
  - Meta-analysis can help

- Heterogeneity of treatment effects?

ICT-based Extension

- Potential to reach farmers at scale at a low-cost, time to the season, personalize, repeat information, etc.
  - Traditional in-person costly and subject to delivery issues (Anderson and Feder, 2007)
- Is information/salience a constraint?
- Agricultural info perhaps too complex to deliver through phone (Aker, 2011)?
- Few evaluations despite wide array of projects (Nakasone et al., 2014) and evidence characterized as ‘mixed’ (Aker et al., 2016)

This Project

- Can SMS-based agricultural information change farmer behavior?
  - Meta-analytic techniques to combine results from multiple experiments and increase power

- Six RCTs of SMS-based programs implemented in Kenya and Rwanda
  - Differences in implementer, message content, farmer population
  - All programs designed to encourage experimentation with inputs
  - Agricultural lime (N=6) & chemical fertilizers (N=4)

- What lessons can we learn about mechanisms and how to optimize messages?
  - Learning vs. salience?
  - Framing
  - Repetition
  - Complementary add-ons: voice calls, call center access, etc.

Outline of Talk

1. Motivation
2. Context
3. The programs
4. Results from six trials
   - Summary of Results
   - Differences by program characteristics
5. Cost-effectiveness
6. Conclusion

Implementing Agencies

- Kenya Agriculture and Livestock Organization (KALRO)
  - Public agency
  - Broad messages covering various agricultural management topics
  - Worked with general population of farmers

- Innovations for Poverty Action (IPA) & Precision Agriculture for Development (PAD)
  - Non-for profit organizations: research focused and interest in determining impact and test alternatives
  - Use of local soil test to target lime recommendations
  - Worked with general farmer population and clients of agrodealers

- One Acre Fund (OAF)
  - Social enterprise providing inputs on credit and agricultural training to farmers (extensive additional in-person extension services)
  - Use of soil tests to target lime recommendations
  - Worked with existing clients

Recommended Inputs

- Lime
  - All programs recommended agricultural lime and input used to reduce soil acidity
  - Estimated returns 35-40% (OAF, 2015)
  - Low baseline adoption of lime in general farmer population (6-12%)
  - Less well known, only recent push to make available to farmers

- Chemical Fertilizers
  - Widely known and available for purchase
  - High baseline adoption of planting fertilizers 85-95%, but lower experimentation with other types (e.g. top-dressing: less than 20% ever used Urea and 60% ever used CAN)

Overview of the programs

	Populations	Number of SMS	Example message	Additional randomization	Baseline / Control use	Surveys	Administrative data
KALRO Kenya	• N= 800 • Randomly selected farmers	• Total: 20 • Lime: 2 • Fertilizer 5:	*''If soil acidic (pH less than 5.5) apply recommended rate of lime"*	---	• Lime: 7% • Fertilizer: 84%	• In person: • Baseline • Endline	Paper coupon
IPA/PAD1 Kenya	• N= 1,900 • Existing IPA database	• Total: 24-28 • Lime: 8 • Fertilizer 9	*"Based on soil test around [landmark] we recommend you buy [kg] lime"*	General or specific Information	• Lime: 12% • Fertilizer: 84%	• Phone: • Baseline • Endline	SMS coupon
IPA/PAD2 Kenya	• N= 5,900 • Agrodealer clients	• Total: 13 • Lime: 6 • Fertilizer 4	*"The soil in your area is [level] acidic. Apply [quantity] bottle top per plant"*	Offer/Follow up to additional phone call	• Lime: 9% • Fertilizer: 84%	• Phone: • Baseline • Endline	SMS coupon
OAF1 - Kenya	• N= 4,900 • OAF clients	• Lime: 6	*"Your soil is [level] acidic. We recommend [quantity] kg lime per acre"*	Broad or Detailed Information	• Lime: 12%	• Phone (1/3 sample) • Baseline • Endline	OAF sales
OAF2 - Kenya	• N= 32,500 • OAF clients	• Total: 1-10 • Lime: 1-5 • Fertilizer 1-5	*"[Name] OAF recommends you to buy [Q] lime. Farmers all over Kenya are getting bigger yields. Keep up with them"*	Behavioral framing repetition, frequency, adding fertilizer information	• Lime: 32% • Fertilizer: 93%	---	OAF sales
OAF3 - Rwanda	• N= 110,500 • OAF clients (randomized at group level)	• Lime: 1-4	*"Do you have fields with poor harvest even when you use fertilizer? You probably have acidity and need lime"*	Behavioral framing repetition, frequency	• Lime: 4%	---	OAF sales

Data

- Administrative:
    - Discount coupon redemption:
        - Paper coupon: 50% discount lime (KALRO)
        - SMS coupon: 10 kg lime or equivalent gift (IPA/PAD1), 15% discount (IPA/PAD2)
    - Direct purchases from OAF

- Survey data:
    - Phone-based survey and home visits (KALRO only)

- Do not have same outcomes across all projects

Estimation

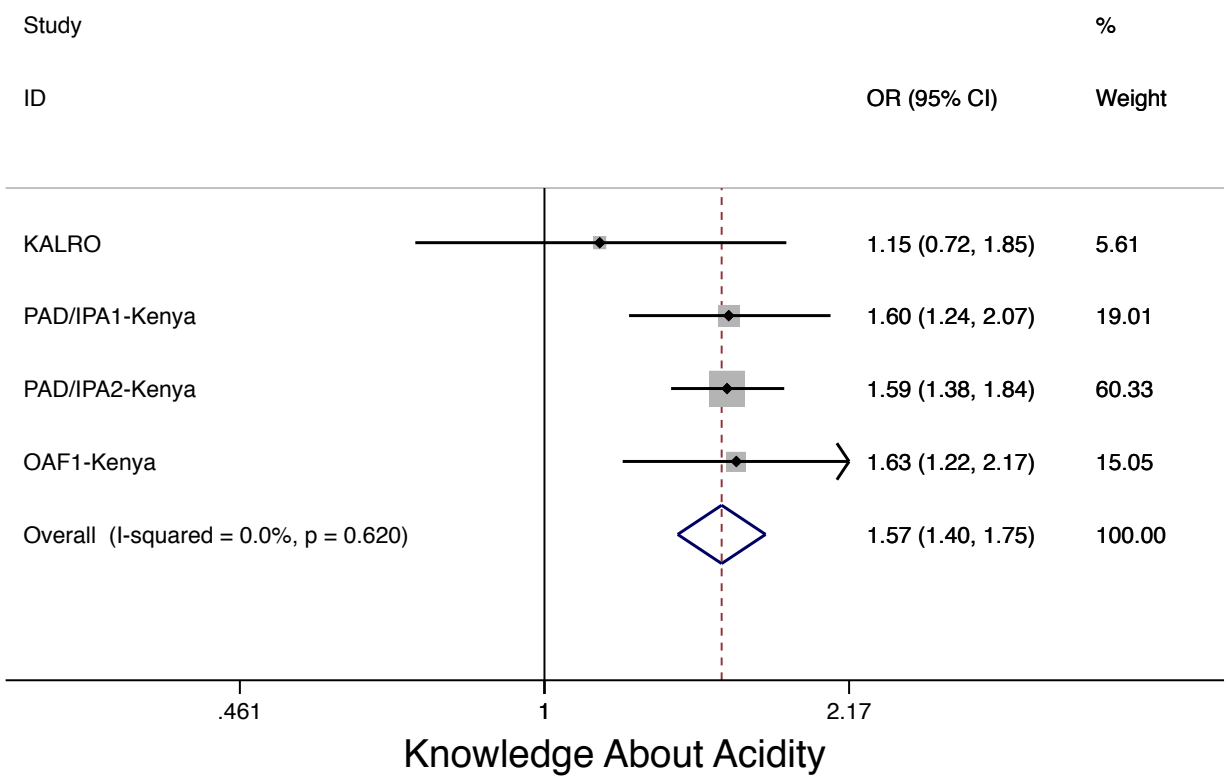
- Logistic regressions ran for each program and results reported as odds ratios
  - Intention to Treat estimates
  - Show effects pool all treatment arms for given study
  - We control for all stratification variables, location fixed effects, demographic characteristics, and previous input use

- All program results synthesized in a meta-analysis:
  - We estimate random effects model that assumes that there is a distribution of true effects across settings (e.g. obtain the mean of a distribution of true effects)
  - Study weights are given by the inverse of variance (within and between-study variance)

- Tests of Heterogeneity:
  - P-value for Q test for homogeneity (null of homogenous treatment effects)
  - I^2 index (% of variance that is attributable to study heterogeneity)

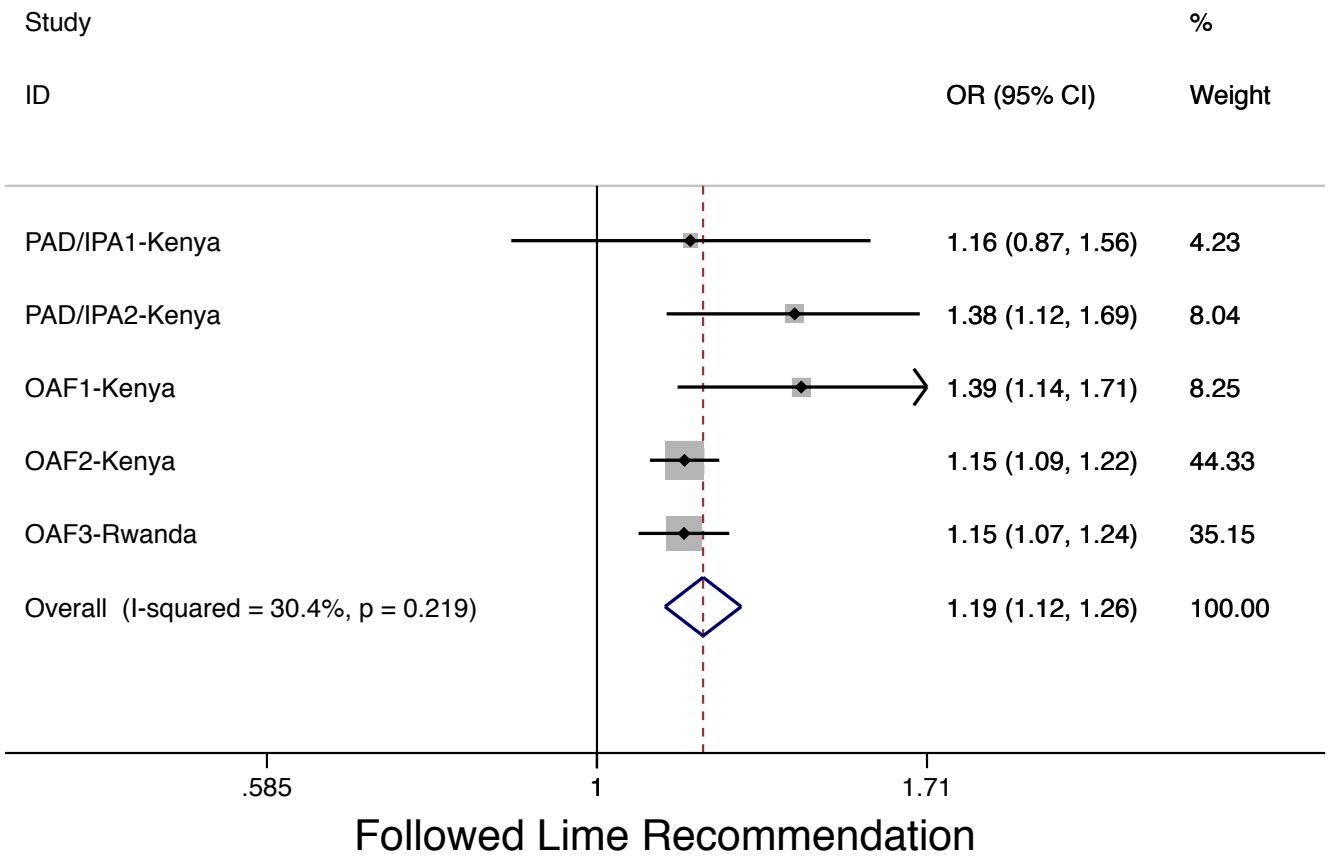
Knowledge gain effect (self-reported): 1.57 (95% CI: 1.40 ,1.75)

- Ex: "*Do you know strategies to deal with soil acidity? (lime=1)*"
- N=4



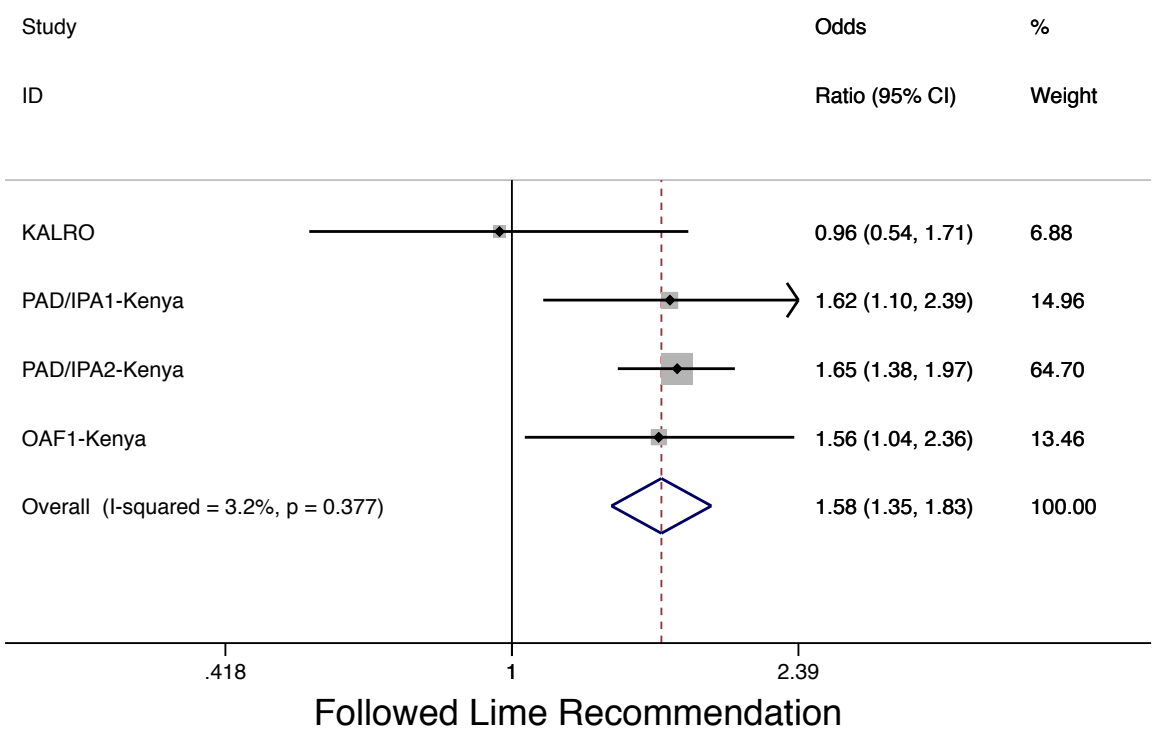
Followed Lime Recommendation (administrative): 1.19 (95% CI 1.12,1.26)

- Effects measured for concurrent agricultural season
- N=5



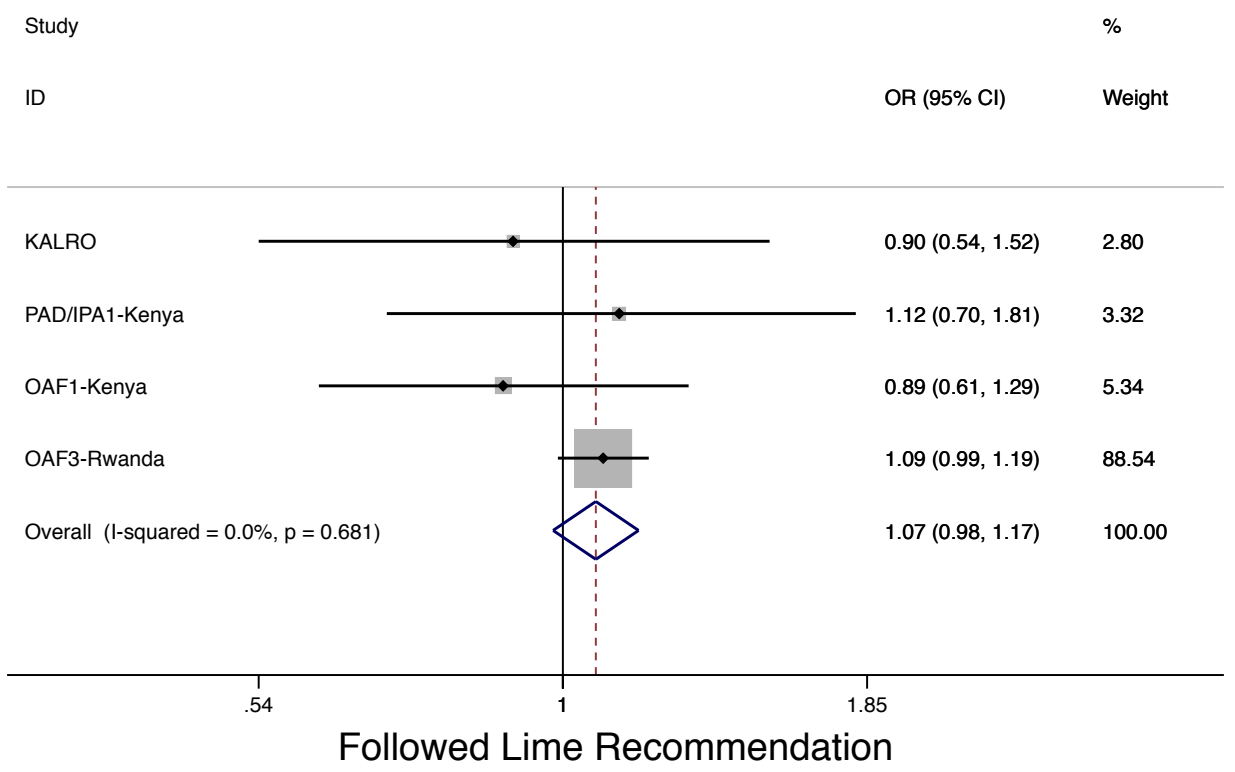
Followed Lime Recommendation (self-reported): 1.58 (95% CI 1.35,1.83)

- Effects measured for concurrent agricultural season
- N=4



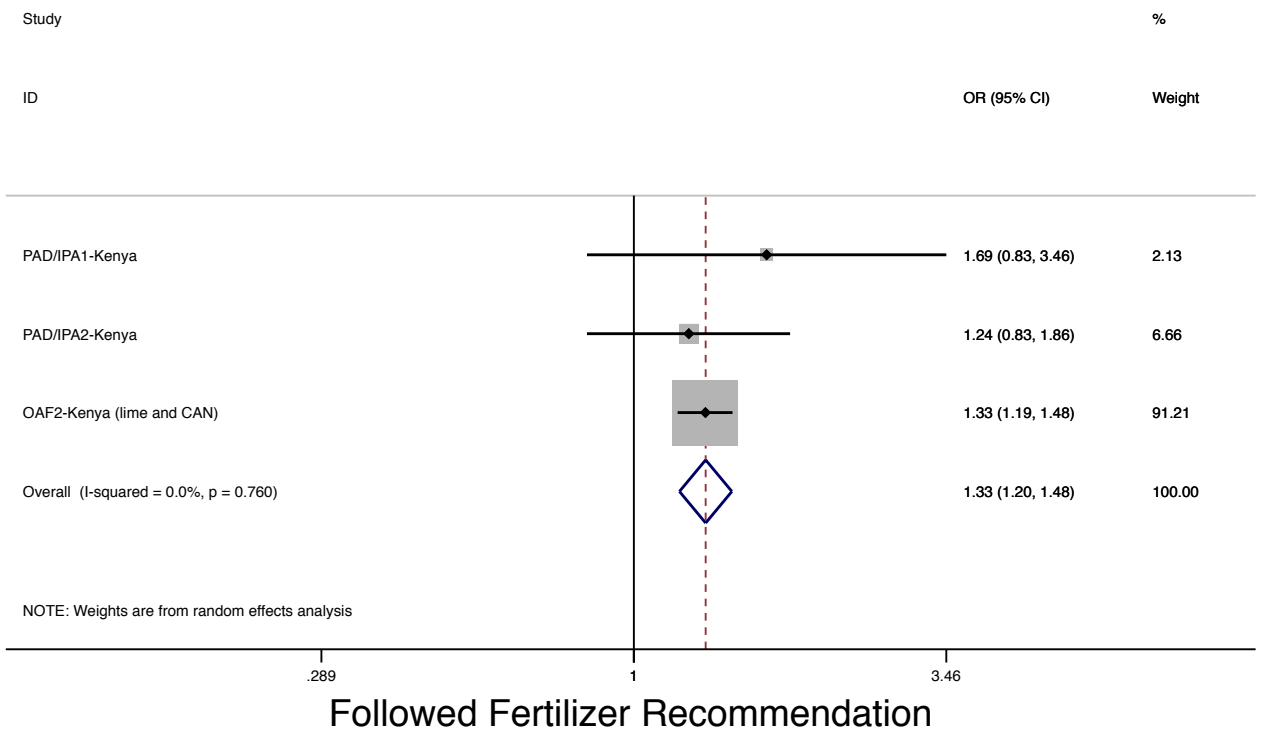
Persistence follow Lime (administrative): 1.07 (95% CI 0.98, 1.17)

- Effects measured for subsequent agricultural season
- N=4



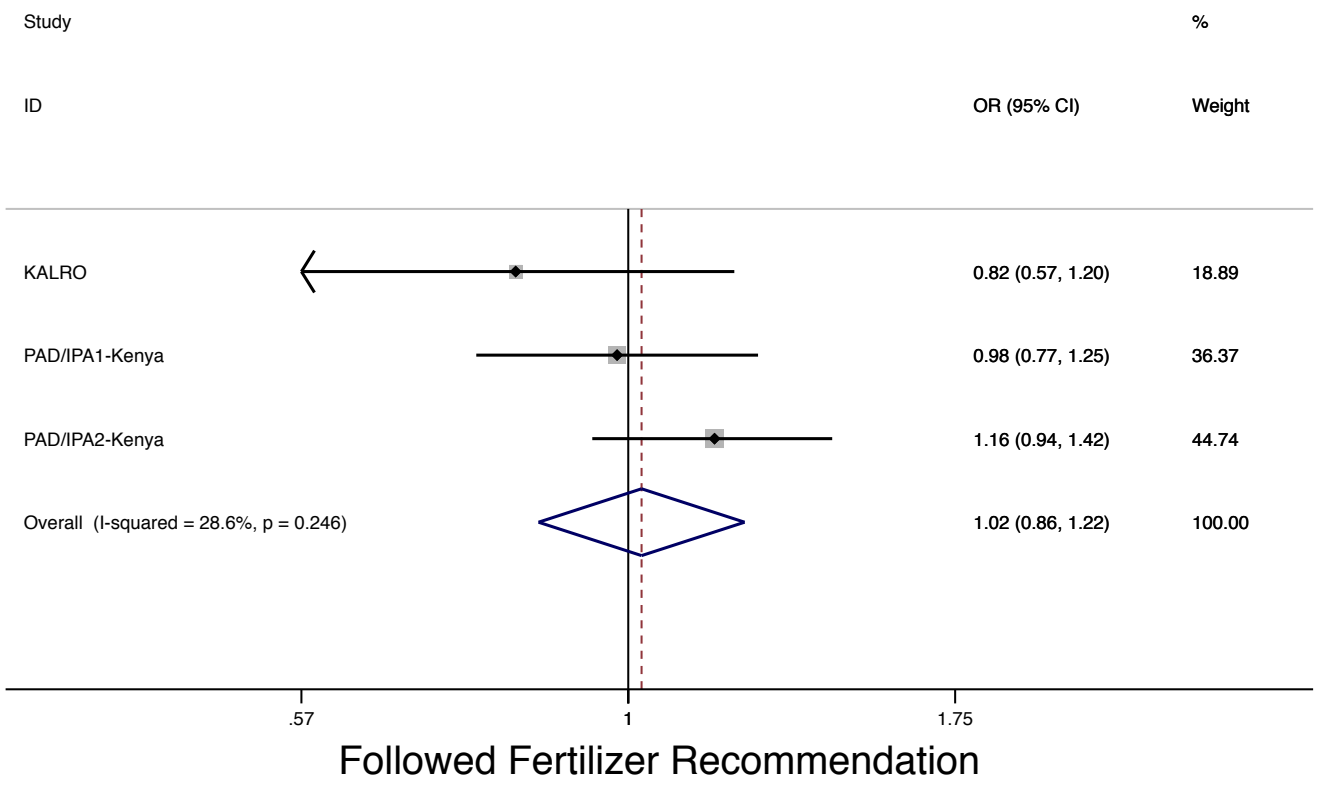
Followed Fert Recommendation (administrative): 1.31 (95% CI: 1.19, 1.45)

- Effects measured for concurrent agricultural season
- N=3 (no admin data for KARLO in concurrent season)



Followed Fert Recommendation (self-reported): 1.02 (95% CI: 0.86, 1.22)

- Effects measured for concurrent agricultural season
- N=3 (no survey data for OAF2-Kenya)



Summary

	Studies (N)	*Effect*	*95% Confidence Interval*	
Odds Ratios				
Heard Lime	4	1.21	0.93	1.57
Knowledge Acidity	4	1.57	1.4	1.75
Lime recommendation (survey, first season)	4	1.58	1.35	1.83
Lime recommendation (admin, first season)	5	1.19	1.12	1.26
Lime recommendation (admin, second season)	4	1.07	0.98	1.17
Fertilizer Recommendation (survey)	3	1.02	0.86	1.22
Fertilizer Recommendation (admin)	3	1.31	1.19	1.45
Index (s.d.)				
Adoption of other inputs	6	0.01	0.00	0.01

- Positive effects on knowledge and experimentation with lime
  - Cannot reject all programs have the same common effects using odds ratio model
  - Can reject for lime using LPM, once OAF3-R is included

- Fertilizer results less clear
  - Only one program had statistically significant results: OAF2-K
  - Lower baseline adoption (the program promoted second top-dressing, a less common practice)

Message Repetition

- OAF2-K and OAF3-R randomized number of repetitions

	Followed lime rec			
	OAF2-K		OAF3-R	
	(1)	(2)	(3)	(4)
N Lime SMS	1.035***		1.057***	
	(0.008)		(0.011)	
N Lime SMS$\geq$ 1		0.983		1.043
		(0.068)		(0.051)
N Lime SMS $\geq$ 2		1.159**		1.131**
		(0.083)		(0.063)
N Lime SMS $\geq$ 3		1.023		1.015
		(0.046)		(0.055)
N Lime SMS $\geq$ 4		1.023		1.022
		(0.045)		(0.056)
N Lime SMS $\geq$ 5		0.973		
		(0.044)		
Mean Control	0.32	0.32	0.05	0.05
Observations	32572	32572	87928	87928

Notes: All regressions include controls. Robust standard errors in parenthesis. For OAF3-R sample standard errors are clustered at the farmer group level * $p < .10$, ** $p < .05$, *** $p < .01$.

Lower Bound on Cost-effectiveness

- Back of the envelope calculation considering only lime adoption as outcome and effects for one season

- Benefits:
  - On average programs increase quantity of lime used by 1.2 kg
  - On farm trials found 2.47 kg of maize increase per kg of lime applied (OAF, 2015)
  - Revenue from one additional kg of maize $0.35 from local market prices minus estimated additional labor and transport cost
  - Cost of lime application $0.15 per kg from local market prices plus estimated additional labor and transport costs

- Costs:
  - Assume marginal cost of 6-message SMS program $0.04
  - Social cost would be even lower

- Estimated cost-benefit ratio: 13.2

Conclusions

- SMS-based programs can change farmer behavior
  - At scale per farmer cost less than $0.01 US
  - Consistent impacts for new input, less clear for well-known ones
  - Repetition important, framing of messages less so

- Future Work:
  - Measure spillovers
  - Predictors of heterogeneity?

Appendix

Estimation: Individual Program Effects

- Intention to Treat Effects

- Logistic regression estimated for each project & pooling results from all treatment arms:
  - Main results reported in terms of odds ratios (OR)

- X vector of demographic characteristics for individual i, randomization strata, baseline practices and are area (γ_A) fixed effects

- Clustering of errors at group level if for OAF3-Rwanda

Estimation: Random Effects Meta-analysis

- Weighted average of study estimates using a random effects (RE) model that allows for the true effect to vary across studies:

$$\widehat{\theta_k^{RE}} = \sum_{j=1}^{s} \frac{w_{j,k}}{\sum_{j=1}^{s} w_{j,k}} \widehat{\theta_{j,k}}$$

Where $\widehat{\theta_{j,k}} \sim N(\theta_{j,k}, \hat{\sigma}_{j,k}{}^2)$ and $\theta_{j,k} \sim N(\mu_k, \tau_k^2)$

j indexes study, k indexes outcome, θ is the true effect and the weights (w) are given by

$$w_{j,k} = 1/(\hat{\tau}_k^2 + \hat{\sigma}_{j,k}^2)$$

- Tests of Heterogeneity:
  - P-value for Q test for homogeneity:
    - Under null of homogeneity, the Q-statistic follows a chi-distribution with s-1 degrees of freedom
  - I^2 index:
    - indicates the percentage of variance in a meta-analysis that is attributable to study heterogeneity