Harvesting the rain: The adoption of environmental technologies in the Sahel

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December 2021

Low yields and environmental degradation

Yields in African agriculture have been stagnant over the past decades

- R+D for improved varieties lags behind other parts of the world
- Farmers are poor and inputs are expensive

Dependence on extensification puts farmers at increased risk

- Farming increasingly marginal land; less resilient to shocks

Need for technologies that increase yields and restore degraded land at low cost

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Our focus: Demi-lunes

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- Construction requires labor, few other inputs
- Appropriate for sloped land, *glacis* soil

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Why is adoption low?

On-farm trials show reduced soil erosion, lower risk of crop failure and increased yields and profits (Warren et al. 2001, Vohland and Barry 2009)

- Yet adoption is low
- In Niger: <10 percent of farmers use any RWH

Why? Like other environmental technologies, costs are upfront and (private) benefits are longer term

- Lack of information, cash on hand liquidity constraints, high discount rates

Related literatures

Timing of costs and benefits of environmental and agricultural technologies deters adoption (Magruder 2018, Fowlie and Meeks 2021)

- Cash on hand liquidity constraints matters for upfront costs; credit constraints matter for delayed benefits (Karlan et al. 2014, Beaman et al. 2014, Crepon et al. 2015)

Training and information services can be critical for realizing returns to new technologies (Glennerster and Suri 2017, Emerick and Dar 2017)

- Effectiveness may depend on information content and delivery (Hanna et al. 2014, Ben Yishay and Mobarak 2015, Ben Yishay et al. 2019)

Soil degradation and climate shocks threaten poor farmers, but few studies on tech adoption for resilience (Hansen et al. 2019)

- Some retrospective work (e.g., Michler et al. 2019), fewer prospective RCTs (e.g., Dar et al. 2016)

Investigating low adoption

Question: Why is adoption of a seemingly profitable technology so low?
Approach: Test for the presence of barriers by relaxing them
Design: Village level RCT

Barrier:	–	Information	Liquidity	Discount rates	–
Treatment:	Control	Training only	Training + Unconditional cash transfer (early)	Training + Conditional cash transfer	Training + Unconditional cash transfer (late)

Data: One year of intervention, 3 years of follow up

Sample and data

Study sample

- Sampled 180 villages with degraded soil in Zinder region
- Based on a census, selected a random sample of 16 farmers per village (N=2861), stratified by gender

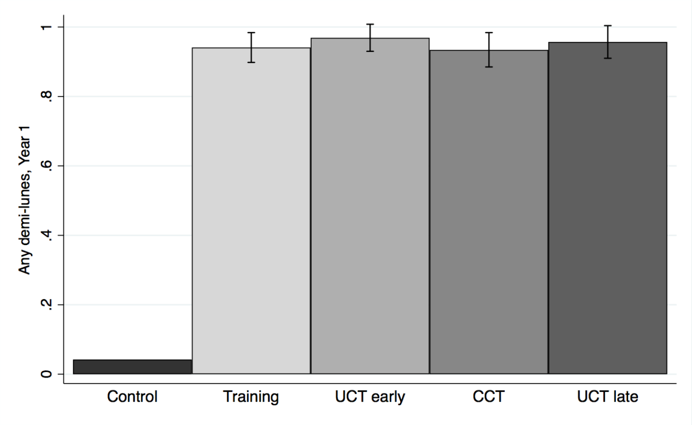
Data

- Household surveys at baseline (year 0), midline (year 1), endline (year 3)
- Demi-lune adoption data (years 1, 2 and 3)
  - Field verification, blind to treatment
  - Basis for CCT payout in Year 1 (2018)
- Spillover sample surveyed at endline

Results I: Adoption

Results: Demi-lune adoption

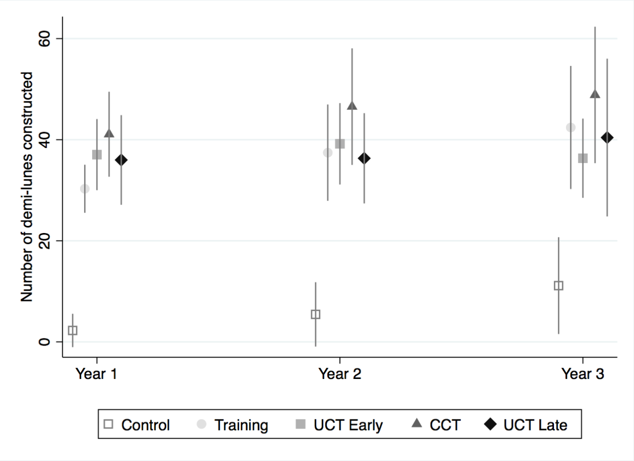
Year 1: Any adoption



>90 increase in likelihood of adoption; indistinguishable across arms

Results: Adoption over time

Total number of demi-lunes, Years 1-3



Year 3: Treatment arms indistinguishable, catch up in control group

Results: Reconciling and interpreting magnitudes

Level of adoption:

- Agronomists recommend 250-300 demi-lunes/hectare of *glacis* land
- Treated farmers adopted an average of 42 demi-lunes, own 0.35 hectares of *glacis* land (~20 percent of all degraded land)
- Around 48 percent of "full adoption"

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Is this under-adoption?

- Agronomic recommendations based on full field coverage not on max profits → likely increasing MC or decreasing MB
- Other frictions could lead to adoption < private optimum
  - Market failures? No evidence that labor, seed or insurance market frictions constrain adoption
  - Behavioral frictions? No evidence that behavioral biases lower adoption (but hard to test!)

Results II: Impacts on production, resilience and soil quality

Results: Agricultural production

	Value of production (z-score)	No. of fields owned/rented	Percentage of crops failed
Panel A: Midline			
Any treatment	0.13*	0.01	-0.02*
	(0.08)	(0.13)	(0.01)
Control mean	-0.00	2.60	0.05
Observations	2,535	2,535	2,535
Panel B: Endline			
Any treatment	0.14**	-0.07	-0.00
	(0.07)	(0.12)	(0.01)
Control mean	-0.00	2.86	0.10
Observations	2,486	2,486	2,486

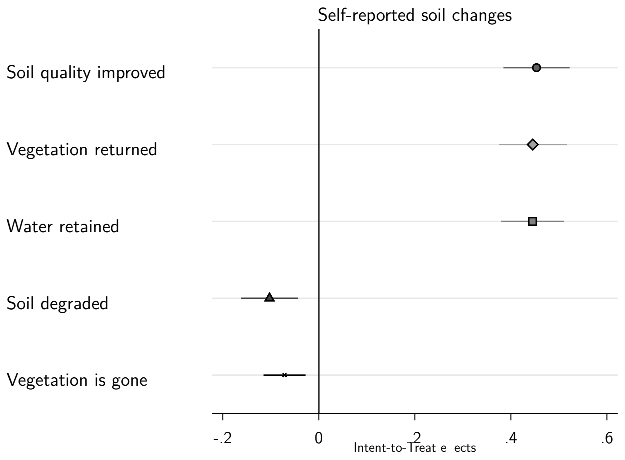
Results: Land use and resilience

Past three years (measured at endline)

	Brought land back into production	Stopped cultivating any land	Affected by drought
Any treatment	0.34***	-0.07**	-0.05*
	(0.04)	(0.03)	(0.03)
Control mean	0.39	0.21	0.30
Observations	2,486	2,486	2,486

Results: Soil quality

Changes in agricultural production over past three years (Endline)



Results: Cost-benefit and cost effectiveness

Private costs and benefits (year 1 only):

- Average payout in the CCT treatment was similar to the UCT arms: 20-25 USD
- Average household expenditure on labor (including foregone family labor income): 20-30 USD
- Average additional crop income, Year 1: 40 USD

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Cost effectiveness:

- Training had similar results to CCT/UCT arms, but without financial transfer
  - If transfer is counted as a cost, then training only is most cost effective
  - USD 1.07 per demi-lune adopted

Results III: Mechanisms

Relaxing constraints on technology adoption

Three potential barriers

1. Households may lack information → **large effect from training alone**
2. Households may be cash-on-hand liquidity constrained → **some additional year 1 adoption in UCT-early**
3. Households may face discount rates that make technology unprofitable → **some additional year 1 adoption in CCT arm**

Impact of training alone dominates any impacts from cash transfers

Why was training so effective?

Trainings provide information, but details may matter

1. Awareness – make farmers aware of a previously unknown technology
2. Technical information – provide the technical knowledge to adopt a known technology
3. Trigger social learning – catalyze further peer learning, information transmission
4. Non-informational channels – motivation, persuasion, ...

Ongoing work and next steps

Evidence on training only is scarce – most programs bundle training with other interventions

- Other studies of information interventions with familiar technologies show big treatment effects (Hanna et al. 2014, Islam et al. 2014)

Ongoing work: Remote sensing to measure adoption; scale up with Ministry of Environment

Thank yous

Financial support from:

- Agricultural Technology Adoption Initiative (ATAI)
- Standing Panel on Impact Assessment (SPIA) of the CGIAR
- Anonymous donor

Implementation and data collection: Ministry of Environment Niger, Concern International, Sahel Consulting