Proposal: Uganda Coffee Agronomy Training (UCAT) Impact Evaluation

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1. Background

Scientific evidence on the impact of agronomy training on smallholders' coffee yields is lacking. We aim to fill this important gap in knowledge gap through a large-scale, randomized evaluation of agronomy training conducted by TechnoServe and Hanns R. Neumann Stiftung (HRNS) in Uganda. Both TechnoServe and HRNS use a farmer field school approach and will collectively train 60,000 coffee farmers in Uganda between 2018 and 2022.

In addition, recent evidence on the impact of mobile phone and video-based agricultural extension services indicates that these approaches can be highly cost-effective and easily scaled (Casaburi et al., 2014; Vasilaky et al., 2015; Fabregas et al., 2018; Van Campenhout et al., 2018). ICT-based approaches to strengthening or delivering coffee agronomy training will be evaluated alongside the in-person training. The ICT-based interventions will be designed and implemented by Precision Agriculture for Development (PAD), a non-profit that uses research and technology to deliver agricultural to advice farmers in developing countries.

2. Objective

To evaluate the impact of coffee agronomy training in a farmer field school format on coffee agronomy practices, yields, and potentially livelihoods of coffee-growing households, and to evaluate the impact of ICT-based mobile reinforcement of such programs as well as stand-alone ICT-based extension on coffee agronomy practices.

3. Outcomes

The primary outcomes for the evaluation of in-person training are adoption of good agronomic practices and coffee yield per tree. Net income from coffee and other key crops will also be considered as secondary outcomes. The primary outcome for the evaluation of ICT-based extension components is adoption of good agronomic practices. All outcomes (agronomic practices, coffee yield, net coffee and other crop income) will be measured at the household level.

4. Experimental design

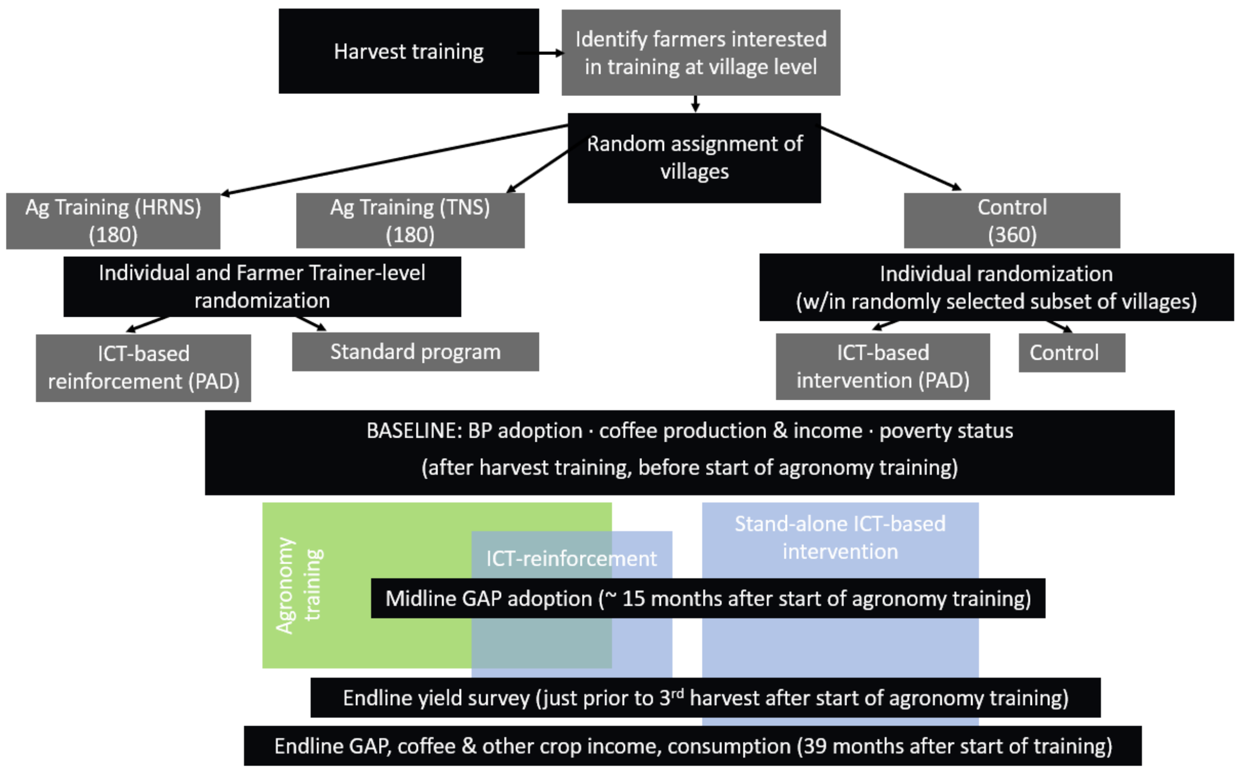
The evaluation of in-person agronomy training will use a cluster-randomized design. Villages in districts where HRNS and TechnoServe plan to train farmers will be randomized to one of two primary treatment arms: Agronomy Training (AgT) and Control (C). One farmer group per village will be included in the study.

The number of farmers included in the sample within Control villages will be higher than in AgT villages. Stand-alone ICT-based training approaches will be piloted in this additional Control sample, subject to an initial evaluation of spillover effects by PAD. The experimental design is illustrated in Figure 1.

The evaluation of agronomy training will measure the overall effect of agronomy training (augmented for a subset of farmers by one or more ICT-based enhancements), compared to no training (pure control). The evaluation of ICT-based extension, to be elaborated in a separate proposal by PAD, will measure the impact of this type of intervention both within the context of farmer field school programs implemented by HRNS and TechnoServe, and as a stand-alone intervention.

The ICT-based reinforcement of implementer-led agronomy training will be added after the HRNS and TechnoServe interventions are well underway, to avoid compromising the implementation of core HRNS and TechnoServe activities.

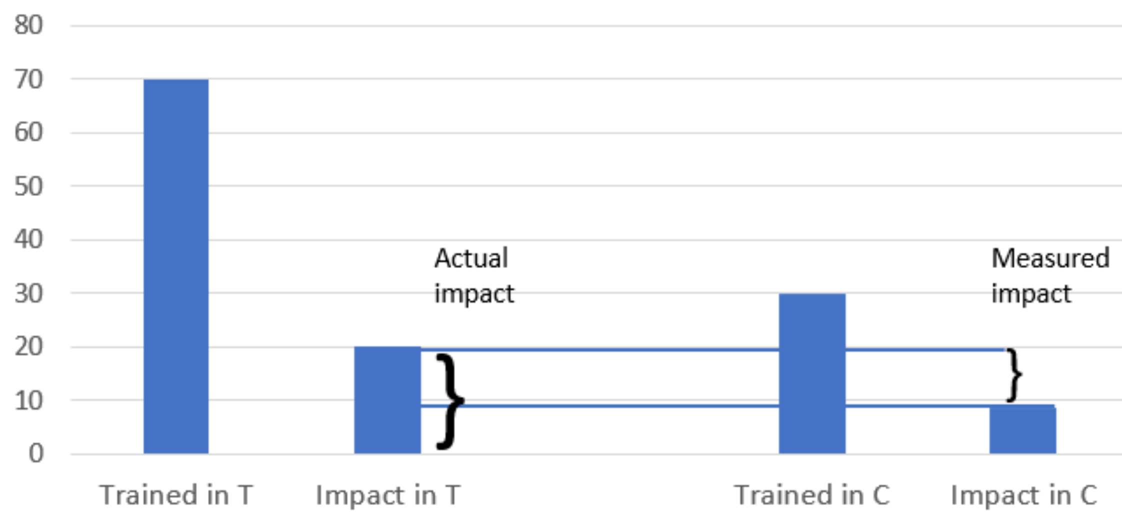
Figure 1. Experimental design



Limiting spillovers

The possibility that farmers in the control group (those living in Control villages, who are not assigned at the individual level to receive ICT-based training) access the randomized interventions is a potential threat to the study design. Such unintended access, termed a "spillover" could occur through attendance of a farmer field school training, accessing ICT-based extension materials, or talking with others who have been trained through either modality. Such spillovers have the potential to increase the adoption of good agronomic practices among control farmers, thus reducing the difference between groups, and so the ability of the study to detect changes due to the intervention. This effect is illustrated in Figure 2. Assume 70% of farmers in the treatment group are trained, and this translates to a 20% increase in coffee yield. If some, presumably lower, proportion of farmers in the control group are also trained, these farmers' yields will also be increased, to a lesser extent than in the treatment group. Since the estimated impact of the intervention is the difference between yield in the treatment and control and groups, spillovers cause the impact to be under-estimated. This could even result in the impact being statistically undetectable.

Figure 2. The impact of spillovers on estimated impact of intervention



Two strategies will be used to limit the negative impact on the study of spillovers through attendance of control group farmers at farmer field school training sessions. First, the distance between villages assigned to the AgT intervention and those that do not receive this intervention will be maximized. Second, information on the location of farmers' residences, and on their social ties to those assigned to other treatment arms, will be collected at baseline. Distance to the nearest AgT village is expected to correlate with attendance of training, and social connection to farmers in AgT villages or assigned to receive ICT-E is expected to correlate with learning from these treated farmers. Adding these variables to the statistical model used to estimate treatment effects will mitigate the effect of spillovers on our ability to detect differences between groups.

To maximize spacing between AgT and C villages, GPS coordinates of coffee-growing villages within a sub-set of the Cohort 2 program area reserved for the RCT will be collected by the training implementers (HRNS and TechnoServe). Of these villages, 360 study villages in the TechnoServe program area, and an additional 360 in the area served by HRNS will be selected by the evaluation team such that the minimum distance between any two villages is maximized. GPS data from the HRNS region indicate that a minimum distance of 1.9 KM between study villages is feasible, and this has been imposed as the minimum. Based on results from a spillover study concluded in the last quarter of 2018, the minimum distance between RCT villages in the TechnoServe region is 1.4 KM.

Half of these study villages (180 in each implementer's region) will be randomly assigned to receive Agronomy Training (AgT) by the implementer operating in that region, the other half (180) will be assigned to a Comparison (C) group. Implementers may organize multiple farmer groups within each village assigned to the AgT group; only one of these groups will be included in data collection for the study. Within the RCT area, training implementers will operate only in the AgT villages; any other villages in the RCT area (those assigned to the comparison group, and those not selected as study villages) will not be eligible for training.

Selection of coffee farmers within study villages

In order to recruit similar farmers in AgT and C villages, it is critical to select these in an identical manner. Comparing farmers who choose to participate in agronomy training in AgT villages to a representative group of farmers in C villages will likely lead to bias, as those who make the effort to attend training are those most interested in improving their coffee practices. Further, in order to detect impacts of agronomy training on adoption of practices and yields, it is important to focus on those farmers with the greatest likelihood of engaging in the offered training. A representative sample of farmers will include many who never attend training and thus dilute the impact of the training on the population, making effects difficult to detect statistically.

Therefore, to identify farmers who are interested in agronomy training for participation in the study, a one-time training meeting on harvest practices will be held in both AgT and C villages at the beginning of the harvest season (September-October 2018 in HRNS region; May 2019 in the TechnoServe region). The following information will be collected from each consenting coffee-growing household represented:

- Name, gender, and phone number of the primary coffee farmer in the household
- Number of coffee trees or acreage under coffee

At harvest training sessions led by HRNS, data collectors employed by the evaluation team will collect this data using tablet computers. In TechnoServe groups, paper forms will be completed by farmer trainers, and provided to the evaluation team for data entry.

In AgT villages, 12 farmers per village will be randomly selected from among those who attend the harvest training and report owning at least 50 coffee trees. In Comparison villages, 18 farmers will be selected from among the harvest training attendees. 12 of these farmers will receive no training at all – these constitute "pure control" farmers, while 6 of them may be assigned to the stand-alone ICT-based training intervention. In villages where fewer than this number of farmers attend, local leaders will be asked to provide names of other coffee farmers who they believe would be interested in the type of training provided.

This design allows the outcomes of farmers who receive in-person training (a subset of whom will also receive ICT-based reinforcement, for example voice call or SMS reminders) to be compared against the outcomes of an equal number of "pure control" farmers who receive neither in-person training nor mobile extension services. Additional farmers included in the Control group may be assigned to the stand-alone ICT-E intervention. Limited baseline data, including eligibility criteria (number of coffee trees), basic socio-economic indicators, and phone numbers will be collected from these additional Control group farmers. Follow-up data collection on these farmers will be limited to observed agronomic practices at endline. Figure 3 illustrates the sample of farmers included in the study.

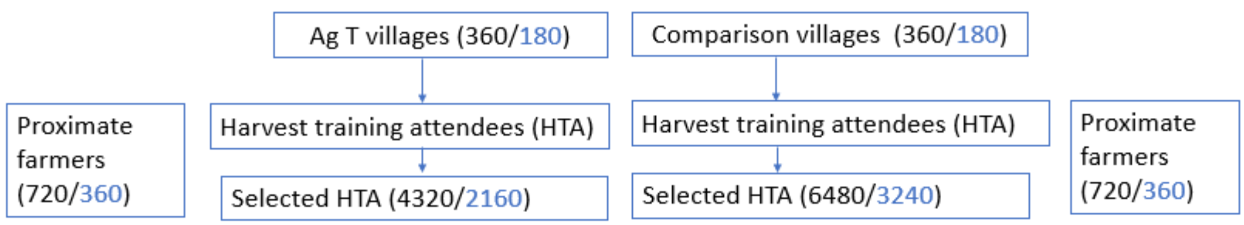
In addition, to allow for analysis of how farmers who attend agronomy training differ from the overall population of coffee-growing households, and to measure spillover effects on coffee agronomy practices to farmers who do not attend training, two additional households with at least 50 coffee trees who did *not* attend the harvest training will be identified based on the suggestion of harvest training attendees.

These two groups (harvest training attendees and proximate coffee farmers) will constitute the study sample for the evaluation of in-person agronomy training (HRNS/TNS evaluation sample).

Midline stock-taking

Based on data collected through the midline survey, to be conducted approximately 15 months after baseline, plans for subsequent data collection and intervention may be adjusted. In particular, if the impact of the intervention on GAP adoption is seen to be very low at midline, collection of endline yield data may be cancelled.

Figure 3: Study sample (numbers in black indicate total sample; blue indicate per-region sample)



Analysis of heterogeneous effects by weather conditions

Coffee yields and quality are highly dependent on favorable weather conditions. Insufficient rainfall can decimate a coffee harvest, and excessive heat can increase pest pressure and reduce quality. Increasing variability in the level and timing of rainfall in East Africa predicted by climate models, and observed in recent years thus constitutes a serious threat to coffee growers in the region. The agronomic practices promoted by HRNS and TechnoServe are expected to mitigate the negative effects of climate change on coffee production through improved water management and increased shade. We will measure the extent to which training on these practices improves the climate resilience of coffee yields using remotely sensed weather data throughout the study area. This weather data will be used to construct an index of coffee growing conditions, and an analysis of heterogeneous treatment effects by weather suitability will be conducted. This analysis will enable us to estimate the cost-effectiveness of the intervention under various climate scenarios.

5. Data collection

Baseline survey

A baseline survey will be conducted after the harvest training and before the start of agronomy training. This survey will cover the following topics:

<u>Coffee production</u>: Farmers will be asked how much land they have under coffee and the proportion of mature coffee trees. Farmers will also be asked about their coffee sales, including any payments taken before harvesting, forms of coffee sold, the coffee quantity harvested, and the revenue received from coffee, over the previous 12 months.

<u>Good agronomic practices (subset)</u>: The survey module on GAPs jointly developed by HRNS, TechnoServe, Laterite, and IFPRI, will be used to collect data on coffee agronomy practices at baseline among a subset

of 2 harvest training attendees per village. The sample size for this module is limited due to the tight timeline for conducting the baseline survey, and because low expected variability in GAP adoption at baseline implies that baseline data on GAPs is not important for the identification of treatment effects. This observational survey will be conducted on the parcel of land under coffee identified by the farmer as the one on which he or she is most likely to implement new practices.

Farmers not included in the GAP sub-sample will also be asked to identify the parcel on which they are most likely to implement new practices, and to show the enumerator this parcel. A GPS reading will be taken at the center of the parcel using a handheld GPS unit so that practices on the same parcel can be observed at endline. In addition, to validate farmers' self-reported coffee acreage, the area of this plot will be measured using via GPS for a subset of two farmers per village.

Coffee agronomy knowledge and perceptions: Questions on farmers' knowledge and perceptions of coffee agronomy will be included that correspond to the GAP module.

Income: Questions on the role of coffee income in the household, and other important sources of income.

Demographics: Composition of the household, educational attainment of the head and spouse.

Poverty status: Standard Poverty Probability Index (PPI) module.

Gender dynamics (subset): Questions on women's income sources, household decision-making, and household labor on coffee.

Social network: Questions on farmers' social ties to other coffee farmers in neighboring villages.

Intervention monitoring

Attendance of training session attendance by male and female members of study households will be tracked by implementers and provided to the evaluation team. This will allow for analysis of the determinants of attendance, as well as analysis of the key training modules leading to impact.

Data collectors employed through the evaluation will observe 60 training sessions per implementer over the course of the two-year training period. Visits will be coordinated with implementer management staff but will not be announced ahead of time to the trainers.

The knowledge and capacity of HRNS field extensionists and TechnoServe farmer trainers will be evaluated through a face-to-face interview during a scheduled training of trainers approximately year after the start of the program.

GAP midline

A survey on GAPs will be conducted approximately 15 months after the baseline survey (April 2020 for HRNS; October 2020 for TechnoServe). This survey will include the same modules as the baseline survey on coffee agronomy knowledge, perceptions, and practices, and will be administered to 4 farmers per village.

Coffee yield endline

Allometric measurement of coffee yields will be conducted prior to the third coffee harvest following the onset of training (August-September 2021 in the HRNS region; March-April 2022 in the TechnoServe region). This method involves counting cherries on randomly selected trees, stems, branches, and clusters, and multiplying the estimated number of cherries per tree by the average weight of ripe cherries harvested later in the season. Use of digital images and machine learning algorithms to count cherries will be explored. If not previously measured, the area of the yield measurement plot will be measured with a GPS unit. Yields will be measured for harvest training attendees within the HRNS/TNS evaluation sample only. Yields will not be measured for proximate farmers within the HRNS/TNS evaluation sample, nor for the additional farmers included for the stand-alone ICT-based intervention. Total land area under coffee will be measured for a randomly selected subset of farmers.

Endline for other outcomes

A survey to capture impacts on GAP adoption, coffee income and production costs, and production of other crops will be conducted approximately 39 months after the onset of agronomy training (April 2022 for HRNS; October 2022 for TechnoServe). The full survey, including modules on GAP adoption, coffee income and production costs, will be administered to the harvest training attendees within the HRNS/TNS evaluation sample. Proximate farmers in the HRNS/TNS evaluation sample and the additional Control group farmers included for the mobile extension intervention will be administered the GAP adoption module only.

Sub-samples

Figure 4 shows the number of farmers, per region, in each sub-sample. Of the 4320 farmers identified through harvest training in each region, 3600 (10 per village) are administered the standard survey. Within the standard survey, the gender dynamic module is administered for 720 per region and the perimeter measurement of the first adoption parcel is administered for 720 per region. An additional 720 per region (2 per village) are administered the GAP survey. Proximate farmers (2 per village; 720 per region), and the 6 additional farmers through the harvest training in Control villages, are administered a very brief, "Limited" survey.

At midline, the GAP survey is re-administered to the same farmers administered this module at baseline. This survey is also administered to two additional Harvest Training Attendees per group so that the total sample size per region at midline is 4 farmers per group (1440 total per region).

At endline, the Yield survey and subsequent endline is administered to Harvest Training Attendees only. All farmers in the sample are administered the GAP module.

Figure 4: Survey rounds and modules by sub-sample per region

	Survey round	**Baseline**			**Midline**	**Endline**		
	Survey type: Sub-sample:	*Standard*	*Standard + GAP*	*Limited*	*GAP*	*Yield*	*GAP*	*Income*
HRNS / TNS Evaluation	Harvest training attendees (non-BP sample)	3600			720	3600	3600	3600
	Harvest training attendees (BP sample)		720		720	720	720	720
	Proximate farmers			720			720	
	Additional C group farmers for eval of ICT-based training			1080			1080	
	Number of observations per region	3600	720	1800	1440	6120	4320	6120

6. Sample size and minimum detectable effects

We propose to include 180 Agronomy Training and 180 Comparison farmer groups per implementer (total of 720 farmer groups), and to include 12 harvest training attendees per group in the TNS/HRNS evaluation sample. The corresponding minimum detectable effect on coffee yield and GAP adoption, and the total number of farmers included in the study are highlighted in the tables below.

Table 1 indicates the detectable percentage increase in coffee yield per tree among the 70% of farmers recruited though the harvest training who are assumed to complete training in AgT groups, compared to those in C groups. The number of farmer groups per treatment and implementer varies by column, and the number of harvest training attendees surveyed per group varies by row. Calculations are based on the mean, standard deviation, and intra-village correlation of log yield, as estimated from the Ssembabule pilot yield study.[1]

In Table 1, we use the mean inter-cluster correlation (ICC) of yield. Table 2 provides the total number of farmers to be surveyed (for both implementers and all treatments) for each combination of group size and farmers per group, including two farmers per group who do not attend harvest training and 50% more harvest training attendees in comparison groups than AgT groups.

[1] Ssembabule data are considered more accurate as yields were measured before most farmers had begun harvesting, whereas the harvest was well underway by the time yields were measured in Kakumiro.

Table 1: Minimum detectable proportional increase in coffee yield among the 70% of harvest training attendees assumed to complete AgTraining. Power=0.9, ICC= mean ICC in Ssembabule pilot data.

Harvest training attendees / AgT group	Harvest training attendees / C group	Proximate farmers / group	Number of groups					
			150	**160**	**170**	**180**	**190**	**200**
5	7.5	2	0.000	0.250	0.242	0.236	0.229	0.223
6	9	2	0.247	0.239	0.232	0.225	0.219	0.214
7	10.5	2	0.239	0.231	0.224	0.218	0.212	0.206
8	12	2	0.232	0.225	0.218	0.212	0.206	0.201
9	13.5	2	0.227	0.220	0.213	0.207	0.202	0.196
10	15	2	0.223	0.216	0.209	0.203	0.198	0.193
11	16.5	2	0.195	0.189	0.183	0.178	0.173	0.169
12	18	2	0.192	0.185	0.180	0.175	0.170	0.166

Table 2: Total sample size (both treatments, both implementers), incl. two proximate farmers/group, and 50% more harvest training attendees in comparison villages.

		Number of groups					
		150	**160**	**170**	**180**	**190**	**200**
Harvest training attendees / AgT group	**5**	4950	5280	5610	5940	6270	6600
	6	5700	6080	6460	6840	7220	7600
	7	6450	6880	7310	7740	8170	8600
	8	7200	7680	8160	8640	9120	9600
	9	7200	7680	8160	8640	9120	9600
	10	8700	9280	9860	10440	11020	11600
	11	9450	10080	10710	11340	11970	12600
	12	10200	10880	11560	12240	12920	13600

Because ICC is critical for determining sample size, we replicate the analysis of minimum detectable effect size in Table 3, using the upper bound of the 95% confidence interval of the ICC instead of the its mean. We propose to set the sample size per implementer based on Table 1. However, the results in Table 3 provide assurance that even if the ICC is higher than expected, we will still be able to detect the selected minimum yield impact in the joint HRNS and TNS sample.

At midline, we propose to interview 4 farmers per group. Within AgT groups, this sample will consist of up to 2 farmers in the ICT-E group and 2 receiving standard training. In the Comparison groups the sample includes 2 farmers in the pure control treatment and 2 assigned to ICT-E, if the group includes such farmers. Table 4 shows the minimum detectable effect (MDE) on GAP adoption for each of the treatment groups against the pure control group. Note that the MDE depends on the adoption rate in the comparison group; this is because the variance of a proportion is lower as the proportion approaches zero or one.

Table 3: Minimum detectable proportional increase in coffee yield among the 70% of harvest training attendees assumed to complete AgTraining. Power=0.9, ICC=95th percentile from Ssembabule pilot data.

Harvest training attendees / AgT group	Harvest training attendees / C group	Proximate farmers / group	Number of groups					
			300	320	340	360	380	400
5	7.5	2	0.210	0.203	0.197	0.191	0.186	0.182
6	9	2	0.204	0.198	0.192	0.186	0.181	0.177
7	10.5	2	0.200	0.193	0.188	0.182	0.177	0.173
8	12	2	0.197	0.190	0.185	0.179	0.175	0.170
9	13.5	2	0.194	0.188	0.182	0.177	0.172	0.168
10	15	2	0.192	0.186	0.180	0.175	0.171	0.166
11	16.5	2	0.190	0.184	0.179	0.174	0.169	0.165
12	18	2	0.189	0.183	0.177	0.172	0.168	0.164

Table 4: Minimum detectable effect on GAPs in midline sample, assuming 2 farmers surveyed per group, and ICC equal to that observed for coffee yields.

	Adoption level in AgT comparison group					
Number of farmer groups per arm		**0.1**	**0.15**	**0.2**	**0.25**	**0.3**
	150	0.086	0.098	0.107	0.113	0.118
	160	0.083	0.095	0.103	0.109	0.114
	170	0.080	0.091	0.100	0.106	0.110
	180	0.077	0.089	0.097	0.103	0.107
	190	0.075	0.086	0.094	0.100	0.104
	200	0.073	0.084	0.092	0.097	0.102

7. RCT Timeline

RCT Timeline. C1 = cohort 1; C2=cohort 2. C1 is the pilot cohort, C2 is RCT cohort

Year	**2018**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
Agronomy training, HRNS/TNS (C1)												
HRNS harvest training (C2)												
Agronomy training for D.C.s (TNS)										10 DC		
HRNS baseline survey (C2)												

Year	**2019**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
HRNS baseline survey (C2)												
HRNS agronomy training (C2)												
TNS harvest training (C2)												
Agronomy training for D.C.s (TNS)					10 DC							
TNS baseline survey (C2)												
TNS agronomy training (C2)												

Year	**2020**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
HRNS agronomy training (C2)												
Agronomy training for D.C.s (TNS)			6 DC						6 DC			
HRNS midline BP survey (C2)												
TNS agronomy training (C2)												
TNS midline BP survey												

Year	**2021**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
HRNS agronomy training (C2)												
TNS agronomy training (C2)												
HRNS yield endline (C2)												

Year	**2022**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
Agronomy training for D.C.s (TNS)	53 DC						53 DC					
HRNS BP, income, & cons endline (C2)												
TNS yield endline (C2)												
TNS BP, income, & cons endline (C2)												
Data analysis												

Year	**2023**											
Month	1	2	3	4	5	6	7	8	9	10	11	12
Preparation of manuscript for publication												
Dissemination of results												

HRNS activity
TNS activity
Evaluation team activity

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