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Are Gender Differences in Performance Innate or Socially Mediated?

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Abstract

To explain persistent gender gaps in market outcomes, a lab experimental literature explores whether women and men have innate differences in ability (or attitudes or preferences), and a separate field-based literature studies discrimination against women in market settings. This paper posits that even if women have comparable innate ability, their relative performance may suffer in the market if the task requires them to interact with others in society, and they are subject to discrimination in those interactions. The paper tests these ideas using a large-scale field experiment in 142 Malawian villages where men or women were randomly assigned the task of learning about a new agricultural technology, and then communicating it to others to convince them to adopt it. Although female communicators learn and retain the new information just as well, and those taught by women experience higher farm yields, the women are not as successful at teaching or convincing others to adopt the new technology. Micro-data on individual interactions from 4,000 farmers in these villages suggest that other farmers perceive female communicators to be less able, and are less receptive to the women's messages. Relatively small incentives for rewards undo the disparity in performance by encouraging added interactions, improving farmers' accuracy about female communicators' relative skill.

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Produced by the Research Support Team

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1. Introduction

Gender gaps in earnings and in other economic outcomes have been documented extensively by economists (Blau and Kahn 2000). While gaps favoring men exist in virtually every country, disparities in income, health, education, and decision-making power are more pronounced in developing countries (Jayachandran 2015). Understanding the causes of these gaps has received a lot of attention in the literature, with most of the empirical work focused in developed countries.[2] The early literature documented cases of discrimination against women in the market as a source of disparity in outcomes (Altonji and Blank 1999), while a more recent literature has increasingly focused on gender differences in innate preferences, attitudes and ability as underlying causes, inspired by insights from psychology and experimental research (Bertrand 2011).

Research documenting innate gender differences in risk preferences or attitudes towards competition relies heavily on lab experimental approaches (e.g. Gneezy et al 2003, Niederle and Vesterlund 2007), with very few field experiments (e.g. Flory et al 2015). The literature on discrimination has developed in parallel, and somewhat independently, using observational and experimental data in field settings, employing methods such as audit studies (Neumark 1996), blinded natural experiments (Goldin and Rouse 1996, Moss-Racusin et al 2012), and field experiments with fictitious resumes or emails (Bertrand and Mullainathan 2004; Riach and Rich 2006; Petit 2007; Milkman et al 2012).

The central thesis of this paper is that the two literatures and classes of explanations may be intricately tied to each other: even if women have innate characteristics (raw ability and attitudes) that are comparable to those of men, they may perform differently in the market if the task requires them to interact with others in society, and they are subject to discrimination in those societal interactions. We set up a field experiment and data collection strategy to explore this thesis, and then add a cross-cutting experiment to explore whether the provision of small incentives to promote interactions between women and men helps eliminate such differences between male and female actors.

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[2] See Bertrand (2011) and Niederle (2015) for reviews of the literature.

We set up a field experiment motivated by this thesis, in which we randomly assign male or female farmers in Malawi the task of learning about a new agricultural technique, communicating about it to other villagers, and convincing them to adopt. To measure these communicators' performance in the field, we collect two years of follow-up data on a random sample of other nearby farmers to track how well these other farmers learned and retained information about the technology from their assigned communicator, and whether they adopted it. In addition, we administer knowledge tests to the communicators to measure how well they themselves learned about the technology and retained that information. The latter allows us to compare male and female communicators in terms of their raw innate ability to learn, while the former allows us to track how that ability translates into performance in the field when those communicators have to interact with society at large to complete the assigned task. Comparing across the two stages allows us to infer whether women under-perform on the field task due to a raw ability gap, or because of issues related to social interactions, norms and attitudes.

To shed light on the mechanisms underlying gender discrimination, we provide performance-based incentives to a randomly assigned subset of communicators. These inducements generate additional interactions with both male and female farmers, improving the accuracy of farmers' perception of the communicators' skills. We can thus compare whether performance on the socially mediated task continues to lag among women when the individuals they interact with are better informed about their relative knowledge.

Most real-world labor market tasks are characterized by situations where a woman has to rely on or interact with male (or female) colleagues to be successful in her job. This is true for any job that requires managing or supervising teams of workers, teaching or training others, or interacting with customers. Labor markets in the modern economy rarely offer opportunities for individuals to work and succeed in isolation. In such situations, equally able women may under-perform relative to men because of overt discrimination and lack of cooperation from colleagues (Bagues and Esteve-Volart 2010; Delfgaauw et al 2013), because of social norms and attitudes (Gneezy et al 2009, Bertrand, Kamenica and Pan 2013), or because gender identities require women to behave differently when interacting with male colleagues (Akerlof and Kranton 2000).[3]

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[3] Hoff and Pandey (2014) provide field experimental evidence on how low-caste children in India perform worse on cognitive tasks in the presence of high-caste children, especially when caste identity is made salient.

Perceptions of women's performance may also not accurately reflect their actual performance (Beaman et al 2009).

A lab experimental literature presents some related evidence that women either perform worse, or display some different innate attitudes when they are in mixed-gender environments compared to single-gender environments (Booth and Nolen 2012a, 2012b). In contrast, testing our hypotheses required us to set up a large-scale field experiment, because our core idea is that women's relative performance may change when they move from single-gender or isolated environments (where true innate ability is expressed in private tasks), to a field environment where they have to interact with others to complete the task successfully.

We find that women's performance drops in relative terms when they are reliant on others in the field. We use micro data on individual interactions collected from around 4,000 farmers to explore alternative hypotheses and underlying mechanisms. It is not simply the case that learning and teaching are different skills and women are better learners than they are teachers. Direct measures of teaching performance indicate that women put more effort into teaching, and farmers they teach experience better yields compared to those in male communicator villages. This does not seem to be about cross-gender frictions in communication either: Nearly half of all maize plots in our sample villages are farmed by women, and the gender gaps remain regardless of whether we examine the responses of other male or female maize farmers.

We do observe that both male and female maize farmers perceive male communicators to be more knowledgeable about agriculture, although by our objective measures those men are no more knowledgeable about the new technology introduced through the experiment. Accordingly, other farmers do not pay as much attention to female communicators. Biases in perception and attention appear to be the most likely underlying causes of the patterns we document.

We also find that adding performance-based incentives encourage communicators to intensify their interactions with both male and female farmers, and eliminates the gap in the socially mediated task. This is not because the incentives lead women to exert differentially more effort in the private task of learning about the technology. In fact, the incentives improve the relative performance of male communicators in the learning task, leaving their knowledge indistinguishable from that of female communicators, and erasing the yield gap. The resulting similarity in performance on the socially mediated task across genders is thus parallel to that of the private learning task when added incentives are provided. These results indicate that providing a small incentive to communicators is extremely cost-effective at both improving farm profitability and eliminating discrimination against women in productive social tasks.

We conduct this experiment in an important setting for policy. Agricultural yields have remained low and flat in Sub-Saharan Africa over the last 40 years, and low adoption of productive technologies is thought to be a major cause (World Bank 2008, Conley and Udry 2010, Duflo et al 2011). Lack of persuasive sources of information may make farmers reticent about new technologies, which makes the communication task we assign to men and women in our field experiment extremely important. Yield and other outcome data collected from over 4,000 farmers living in our study villages suggest that success in the assigned tasks has large welfare implications. Use of the new technology increases yields by over 30% in arid areas (BenYishay and Mobarak 2014; Beaman et al 2015).

More broadly, gender disparities in the United States and other developed countries have been studied extensively, and we add to that literature by investigating the sources of disparities in developing countries where gender inequality is more pronounced (Jayachandran 2015). Gender discrimination also has more devastating consequences in developing countries, where 6 million women are reportedly "missing" at birth, and many do not survive into adulthood (World Bank 2011; Duflo 2012).

The rest of the paper is organized as follows: In section 2, we describe the context and our experimental design. Section 3 discusses the data, while results on communicators' unmediated and mediated tasks are presented in sections 4 and 5. Mechanisms are discussed in section 6. We offer a brief conclusion along with implications for policy in section 7.

2. Context and Experiment

2.1 Extension Network

Malawi is predominantly agricultural, and 85% of the population lives in rural areas (Malawi Integrated Household Survey 3, 2011). 56.6% of the rural population was classified as poor in 2011 (MIHS3). Maize is the primary staple food in Malawi. With one rainy season, there is typically one maize harvest per year. The Ministry of Agriculture communicates with maize farmers through a national public, decentralized agricultural extension system. All agrarian areas are in principle staffed by an Agricultural Extension Development Officer (AEDO), but in practice, these frontline positions are chronically understaffed. Each AEDO is responsible for providing extension services to 1,465 households on average, and moreover, many AEDO vacancies remain unfilled. At the outset of our study in 2009, only 56% of all AEDO positions were filled across our study districts, according to Ministry records. As a result, only 18% of farmers participated in extension activity according to the 2006/2007 National Agricultural and Livestock Census. Informational deficiencies remain a key challenge that hinders adoption of yield-enhancing technologies.

In addition, the traditional extension network is male-dominated: the average ratio of male to female AEDOs from 2005-2010 was 8:1 (Masango and Mthinda 2012). The Ministry had adopted a ‘lead farmer’ approach to extend the reach of extension, in which a few farmers are chosen to act as extension partners to communicate with their neighbors. These positions are typically filled by men. These gender imbalances suggest that involving more women to communicate with farmers about new technologies may be a promising way to address informational deficiencies, especially since 48% of maize farms in our study area are cultivated by women. This creates a rich setting to study the role of innate ability vs. social norms and attitudes in the relative performance of men versus women in a field-based task, by involving women in the delivery of extension advice through experimental manipulation.

2.2 Experimental Design

We partner with the Ministry of Agriculture and Food Security (MoAFS) in Malawi to conduct a large-scale field experiment with 142 maize farming communities in 8 districts across the country. In 2009, the MoAFS was preparing to roll out a new extension activity[4] in these eight districts, and we convinced them to incorporate ideas from social network theory to improve delivery. Under this approach, a few village residents are chosen as extension partners or *communicators*, and are asked to serve as the interlocutor between the AEDO assigned to the

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[4] A decentralized T&V model of extension is set up such that information on new technologies flows from researchers to extension workers and on to producers via farmer communicators, points of contact between extension agents and other farmers (Kondylis et al. 2014).

area and the rest of the village farming community. A communicator has two main categories of tasks:

> *Task A:* receive training on a new technology, and acquire, retain and use this knowledge on her own farm.
>
> *Task B:* communicate about the new technology to other (non-communicator) farmers in her village, and convince them to acquire, retain and use this knowledge on their farms.

The reform carried a gender inclusion mandate, to give women more central roles in extension delivery. We exploit this policy interest to experiment with the gender dimensions of communication, and randomly assign the gender of the communicator at the village level. Measuring the relative performance of men and women in Tasks A allows us to isolate gender differences in innate ability, while the comparison to Task B allows us to gauge relative changes in performance across these men and women, when success is contingent on communicating with others and persuading them to accept their message.

In a second, cross-cutting treatment arm, we examine gender-specific constraints to participating in extension tasks by dispensing performance-based incentives to communicators. This makes up four treatment arms (male-assigned without incentives, male-assigned with incentives, female-assigned without incentives, and female-assigned with incentives), in addition to a fifth pure control arm.

Each extension officer (AEDO) is responsible for a group of villages, which is called a "section". Our sampling frame is restricted to the 457 sections (out of 822) actually staffed by an AEDO in our study districts. Within this set, we randomly select 121 sections where we conduct the project. We first randomly assign 26 sections to "pure control" and the 95 other sections to one of the four treatment arms. 76 of those 95 are randomly selected to serve as a "pure treatment" section, in which only one randomly chosen village per section receives the treatment. In the other 19 sections we label "mixed treatment and control", one village is randomly selected to be treatment, and we select one additional village as control.[5]

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[5] This assignment is stratified within each treatment assignment to ensure balance across arms. In three mixed-treatment sections we selected 2 control villages.

We chose to collect data in these 19 additional control villages in treated sections in order to track whether enhanced AEDO attention to the treatment leads to a displacement of effort away from other control villages he is responsible for. Such effort displacement is unlikely, because AEDOs are instructed to assist at most one treatment village in addition to his normal workload for this project. His normal workload requires him to serve 25 villages in the average section, so this project represents a small percentage increase in effort requirement.[6] The project therefore should not significantly deplete the AEDO's attention. Robustness checks, excluding these mixed control villages, and introducing an indicator for mixed section as a regressor do not affect our main results in any significant way. This allows us to plausibly rule out concerns about SUTVA violations. Appendix A provides a detailed timeline.

2.3 AEDO Training

At the outset (August 2009), prior to launching any intervention, AEDOs serving our 95 treatment sections received a three-day training on (a) the new technologies we were introducing for this project, and (b) how to transfer knowledge about those technologies to a village-based communicator. The training materials were prepared and delivered by the two agencies most relevant to the two technologies we introduced (Departments of Agricultural Research Services and Land Resources Conservation). The Department of Agricultural Extension Services (DAES) coordinated the trainings. The sessions were attended by all AEDOs and their direct supervisors (Agricultural Extension Development Coordinators, AEDCs). Each AEDO and AEDC was trained only on the one technology relevant to their assigned districts.

The first day of the training was devoted to familiarizing AEDOs and their supervisors with the aims of the project. The concept of *communicator* was discussed, as well as the motivations for a gender reservation mechanism. This part of the training was key in ensuring good compliance to the study protocols, since the AEDO played a central role in the identification of communicators. The second and third days of training were allocated to classroom and hands-on training on the new technology that the AEDO would then disseminate to communicators. Classroom discussions took place at the training center, while hands-on modules were held in adjacent demonstration plots. The training closed with an explanation of

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[6] All other, non-selected villages continued to receive extension services as per the *status quo* modality, as did our sampled control villages.

each AEDO's specific village assignment, including any gender requirements for the extension partner or "communicator" they had to help identify.

2.4 Communicator Identification and Gender Assignment

The first village visit was designed to identify the communicators in all treatment villages. The AEDO assigned to that village convoked and led a half-day meeting that was open to anyone in the community (including local leaders). Turnout was usually substantial. The concept of "communicator" was first discussed, and the eligibility criterion laid out was that communicators should be willing to learn and disseminate a new technology to others. The specific (random) gender assignment was shared in this first meeting.[7] To reduce gender stereotyping of the communicator role, AEDOs told the meeting attendees that men and women could be equally successful at this task.

After this first discussion, leaders worked with the assembled community members to produce a short list. In a second step, the AEDO selected the communicator from the short list, and verified the assignment and/or the good faith attempt of complying with the assignment. Third, AEDOs and leaders went back to the larger assembly to share their final choice of communicator. This last step ensured that the community endorsed the pick. These meetings were completed during August-September 2009.

While we essentially find perfect gender compliance in our male-communicator arm at baseline, this is not the case of our female assignment: in that arm, only 58% of communities actually had a woman communicator by midline. We therefore conservatively report *intent-to-treat* (ITT) estimates throughout the paper, which tracks the effect of the village getting *assigned* a female communicator.[8] Different *types* of women or men may have chosen to comply with the treatment assignment, especially across the incentive and no-incentive arms, and this makes the local average treatment effect of gender across incentive arms difficult to interpret.

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[7] In all communities, we asked community leaders to designate 5 "peer farmers" and 1 "lead farmer". However, the specific communicator type is not the focus of this paper and, in the interest of statistical power, we pool these groups and focus on the gender assignment. In both *lead farmer* and *peer farmer* villages, our gender treatment implied that one woman should be designated as communicator. Again, we pool these two treatment arms into one general *communicator* treatment and split the effects along the (random) gender assignment.

[8] We do not present 2SLS results of actual compliance on assignment, since round-to-round compliance is likely endogenous to our gender and incentive assignments through actual communicators performance.

2.5 Shadow Communicators and Training

We follow the same communicator identification process in control villages, to designate "shadow communicators" who *would have* played the communicator role, had that village been treated.[9] These shadow communicators are useful for research purposes, because they represent the correct counterfactual against which to compare the actions of the actual communicators in treatment villages. Identifying and surveying the shadow communicators allows us to report experimental results on what actions and activities the communicators participate in as a result of the project, holding constant the social identity and other unobserved characteristics of the communicator. These regressions will prove to be useful to understand the mechanisms underlying the effects that we will observe.

This design implies that the only difference between treatment and control communities is that communicators in treatment villages receive subsequent visits and trainings from the AEDOs on a new technology, while shadow communicators don't. AEDOs trained the communicators soon after identification, and ahead of the main planting season. These trainings lasted for half a day. It involved explaining the merits and demonstrating the application of the new technology. The AEDOs then made follow-up visits to treatment communicators over the course of the next two years.

2.6 Incentives

In a cross-cutting experiment, we randomly assign performance-based incentive payments to half of the male and female communicators. We informed only the selected communicators about the incentives during individual meetings in October-November 2009, after the selection and training of communicators was completed, so that the assignment of incentives does not influence the identities of communicators.

The scheme consists of two payouts, one after the first agricultural season, and the associated midline data collection was completed, and the other after the second agricultural season and completion of endline data collection. The first payout was based on gains in knowledge score in their community, because we mostly expected information about the new

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[9] In control communities, the process ended after the community endorsed the choice of communicator. Unlike communicators in treatment communities, shadow communicators were not trained nor contacted beyond the second step of the identification process.

agricultural technologies to spread during the first year. The threshold for the incentive payment is set at 20 percentage point increase in knowledge scores among interviewed farmers, as measured by an exam administered during the midline that tested farmer knowledge of the details of how to implement the technology (see Appendix B). Communicators are given no prior information about the nature of the exam or the sampling frame for the survey, and therefore have no opportunity to teach others to the test. Furthermore, we rotated the set of households who were sampled in each round, so that there is not a perfect overlap of households across survey rounds. Not surveying the same households across rounds is costly because it creates imperfect panels, but we did it to make it more difficult for the communicators to target a minority of households in order to win the incentive payment.

Endline payouts are indexed on gains in adoption within the community. In order to avoid relying solely on respondent self-reports, we monitor adoption through an on-farm monitoring (OFM) survey administered between planting and harvest. Enumerators trained in the maize farming process visited the farms of 1,400 households to directly observe any evidence of technology use. These farm visits were timed to the agricultural cycle when that evidence would be visible. Gains in adoption of 20 percentage points and higher trigger a payment. The OFM surveys were also conducted on a rolling sample of farmers to ensure that communicators could not easily target effort on a narrow set.

Payouts were given in kind, in the form of demonstration kits and production inputs. The incentives are gender-neutral in nature since maize farms are equally cultivated by men and women in our sample. MoAFS financed the intervention and legislated their value, and project staff ensured that payouts across all villages were roughly equal in value (KW 12,000, or USD 80 per community per year).

2.7 Technology

We promoted one yield-enhancing conservation farming technology in each village. AEDOs in four arid districts were trained on “pit planting”.[10] “Changu composting” was promoted in villages in the other four districts.[11] These conservation agriculture technologies

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[10] These are Rumphi, Neno, Chikwawa, and Balaka districts.

[11] There are Zomba, Mchinji, Dedza, and Mzimba districts.

have proven yield benefits and overall positive returns, as documented experimentally for Malawi (BenYishay and Mobarak, 2014; Beaman et al., 2015), and observationally for the sub-region (Thierfelder et al., 2015). These techniques do not confer any added benefit to one gender over another, and there is no gender gap in knowledge of these techniques in our control villages at baseline. We will briefly describe the two technologies here, and Appendix C provides the detailed training manuals.

Pit planting increases a soil's capacity for storing water while minimizing soil disturbance and, thus, nutrient runoff. In practice, rectangular pits are excavated in a field. Seeds are planted inside the pits, rather than on ridges, which is the status quo practice in Malawi. The pits conserve moisture and allow farmers to use small quantities of inputs more efficiently. Once prepared, pits can be used for at least two consecutive seasons, after which farmers have to reshape the pits. Pit planting was virtually non-existent at baseline in our study area. Only 1 percent reported ever practicing it, and only 12 percent of farmers had ever heard of the technology.

The main benefits of "Changu composting" over other types of compost are (i) reduced heap maturity and (ii) use of easily accessible materials. At baseline, we record that only 7 percent of farmers in control villages had heard of this particular type of compost (overall, 53% had heard of compost in general), and only about 25 percent of those who had heard of Changu composting were able to correctly answer questions on preparation, properties and application methods.

The data analysis will pool all eight districts together and use district fixed-effects to absorb any unobserved technique-specific and geographic heterogeneity.

3. Data and Descriptive Statistics

3.1 Data Sources

We first conduct a full listing of all households in each of the 142 villages. We randomly select households to survey from this sampling frame. We chose all communicators (treated or shadow), plus 25 other randomly selected households for the surveys. We rotate the sample of households participating in each survey round and create imperfect panels to both minimize survey fatigue for each household and prevent communicators from focusing on just a few households, after observing who we survey. This yields samples of 3,685, 3,496 and 3,314 households of ‘regular’ (non-communicator) farmers and 467, 474, and 329 communicators at baseline, midline and endline, respectively. The baseline was conducted in August-September 2009, a midline in July – September 2010 at the end of the first agricultural season, and an endline in July – September 2011 after the second agricultural season. We augmented our midline and endline instruments with a spouse/additional farmer module, increasing the total number of respondents to 6,006 and 4,693 at midline and endline, respectively.

These surveys capture a rich set of measures of knowledge and adoption of the promoted techniques, along with agricultural production, household demographics, individual characteristics, perception, and social network relationships. To test respondents’ knowledge about the technology introduced in their village, we ask seven questions regarding the details of how to apply the technology. The questions are based on the material used by AEDOs to train communicators in treatment villages.[12] We use these questions to construct a [0,1] knowledge index where 0 indicates a respondent could not correctly answer any question, and 1 that a respondent answered all questions correctly. Adoption of the technology is self-reported in the survey, and validated through direct observations during the on-farm monitoring.

The social network module records farmers’ interactions with and perceptions of (shadow or actual) communicators and other farmers in their village. Social network relationships with other non-communicator farmers were recorded as follows. For each respondent, we drew a list of six randomly-picked farmers in the community from our baseline listing. We then asked questions about the nature of the respondent’s interactions with each of these farmers, as well as their perceptions about those farmers. Appendix B details the construction of all main outcome variables.

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[12] See Appendices B and C for a detailed record of the knowledge exam, and training manuals, respectively.

3.2 Descriptive Statistics and Balance

Table 1 displays sample characteristics of the communicators chosen for the experiment, and compares them to both shadow communicators and other non-communicators who were randomly selected to respond to our survey. Communicators are similar to regular farmers on most dimensions, with no significant differences by gender (cols 8, 9, 10). Reassuringly, shadow and actual communicators share similar characteristics (col 11). Randomly varying the gender of chosen communicators does not lead to statistical differences in the observable characteristics of the communicators (col 7). This is important to note for the proper interpretation of the statistical differences in post-treatment outcomes across arms that we will report later. Those outcome differences will be attributable to randomly assigning a task to either men or women who are similar along observable dimensions.

Table 2 tests for balance in randomization by comparing non-communicator respondents across treatment assignments. We achieve balance on individual observable characteristics across all treatment arms (cols 3, 6, 9), and reject joint significance of these characteristics in determining treatment status. Farmers in our study area are about 40 years old, work mainly in agriculture and cultivate just under 1 hectare of land, own one head of cattle and about 4.75 other assets. The farmers are quite poor on average: they live in dwellings made out of local material, with only 23 percent owning a tin roof. Their diet consists mainly of maize. Only 5% had taken any loan in the year prior to baseline.

4. Regression Results

4.1 Communicators' Performance in the Private Task *(Task A – Learning about the New Technology)*

To explore whether there are any innate differences between genders in their ability to perform assigned tasks, we first compare communicators' relative performance in a task that did not require them to interact with other farmers in society: acquiring, retaining and adopting the new technology themselves. We use the performance of shadow communicators in control villages as the omitted category. This implies that we are holding constant all socioeconomic characteristics, network positions and other unobservables associated with identity, and identifying this relationship on the basis of random assignment of the task (or not). We estimate the following specification:

$$y_{ivdt} = \beta_1 NonIncentMale_{vd} + \beta_2 NonIncentFemale_{vd} + \beta_3 IncentMale_{vd} + \beta_4 IncentFemale_{vd} + \Gamma\, X_{ivdt} + D_t + D_d + \epsilon_{ivdt} \quad (1)$$

y_{ivdt} is the outcome (such as performance on the technology knowledge test) for communicator *i* in village *v* in district *d* in year *t*. We estimate this specification using OLS regression and include some control variables measured at baseline,[13] district fixed effects, and survey year fixed effects.[14] We cluster standard errors at the village level, which was the unit of randomization. In addition to displaying regression coefficients β_1- β_4 in the table, we also report statistical tests of gender difference in performance within each incentive arm (i.e., $\beta_1 = \beta_2$ and $\beta_3 = \beta_4$), as well as the effect of incentives for each gender (i.e., $\beta_1 = \beta_3$ and $\beta_2 = \beta_4$). We also report the overall gender difference pooling across incentive arms. These coefficients and tests are identified off the random assignment of both the gender and the incentives of communicators through the field experiment.

Given imperfect compliance to our gender assignment, we report intent-to-treat (ITT) estimates of the effect of being assigned to the male or female communicator arm. Treatment-on-Treated or IV specifications would be more complicated to interpret in our setting because: (a) men or women of different types or abilities may choose to comply with the assignment of tasks, and the gender assignment may affect the quality of their replacement, and (b) we report results on many downstream outcomes, such as agricultural yields or crop failure among other farmers who are trained by the either the male or female assigned communicators. We will show that male and female communicators are differentially able to persuade other farmers to adopt, and given the selection of who chooses to adopt, only ITT estimates are interpretable for many specifications we report.

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[13] Controls include a constant, communicator-level characteristics (mean landholdings, mean number of plots worked, proportion of HH heads that are male, proportion of HH heads that have completed primary education) and village characteristics (matrilineal dummy, dummies for religion, dummies for language, dummies for village primary economic activity, percentage of HHs in village growing maize, dummies for type of staple food), and district and survey-year indicators.

[14] We pool both survey rounds for parsimony, with no effect on our central conclusions. For reference, we run the same model on the split survey rounds and find qualitatively similar results (not reported).

Table 3 reports results on four measures of communicator effort in "private" tasks that do not require any interaction with other farmers in his/her society: extensive and intensive margins of participation in trainings on the promoted technology (cols 1, 2), post-training measures of knowledge about the technology to track how well the information was learnt and retained (col 3), and the propensity to adopt the technology on the communicator's own farm (col 4).

Communicators in treated communities are 36-43 percentage points more likely to have been trained by AEDOs than shadow communicators, and we do not detect any significant gender difference in training participation.

Column 3 reports on how well communicators retained the information that they were trained on. Shadow communicators (the omitted category) obtain average knowledge scores of 0.15 across the two survey rounds, which can be interpreted as correctly answering 15 percent of the questions about the technology that they are tested on, or one of the seven questions on average. Trained communicators in treated villages acquire and retain significantly more knowledge about the technology than their shadow counterparts. Their test scores are about double or triple of shadows' scores. Female communicators score slightly higher than men in the knowledge test, but the difference is not statistically significant.

Column 4 shows that only 2% of shadow communicators adopt the new technology, and that there is a sharp increase in adoption among treated communicators, especially with incentives. Communicators use own adoption as a strategy to teach and persuade others to adopt. There is a statistically significant female advantage: across the entire sample (pooling incentive and non-incentive arms), female-assigned communicators are 8 percentage points more likely than male communicators to adopt the technology themselves. The gender contrast is especially stark when incentives are not offered: only half as many male communicators adopt the technology as females (p-value = 0.06).

The promise of incentive payments has much greater impact on male communicators. Incentives significantly boost knowledge retention among male communicators, while female performance is almost equally strong with or without incentives. This pattern of more pronounced gender differences in the non-incentive arm will be repeated in subsequent tables, as performance-based incentives appear to mitigate the gender gaps we report on in this paper.

4.2 Communicators' Performance in the Socially Mediated Task (Task B – Teaching and Convincing Others about the Technology)

Table 3 focused on tasks that do not require much social interaction with, or dependence on, the rest of the villagers. Table 4, in contrast, focuses on tracking performance in tasks that are *social*: convincing others in the community to acquire and retain information and, ultimately, use the technology. We now use the sample of non-communicator farmers in all villages (randomly chosen, excluding the communicators) to evaluate how well information and adoption traveled from the communicators to others.[15] We present the same statistical tests as in Table 3, comparing the male and female-assigned villages and the effects of incentives. Table 4 report results for three different samples: separately for female and male respondents, and a pooled sample.

The change in the relative performance of women when we compare across Tables 3 and 4 is striking. While in the absence of incentives, female-assigned communicators were outperforming their male counterparts in adoption of the technology (Table 3, col. 4), they are systematically less successful at convincing others to accept their message without incentives (Table 4, col. 1, 2, 3). Without incentives, recipient farmers' knowledge scores in female-communicator villages is 4 percentage points lower than that of recipient farmers in male-communicator villages, and this gap is statistically significant. The size of the gap is equivalent to 0.20 standard deviations, or 50% of the average knowledge scores in the control group. Non-incentivized female communicators under-perform in transferring knowledge to both male and female recipients in the village, challenging the idea of cross-gender frictions in teaching.

Coefficient estimates in columns 4-6 indicate that female communicators also under-perform in convincing others to adopt. Interestingly, there is a larger and more significant drop (of 4 percentage points) when they try to convince other women, casting further doubt on frictions in communication across genders as the underlying mechanism.

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[15] In these regressions, controls (coefficients not reported) include a constant, total landholdings, number of plots cultivated, baseline HH characteristics (HH head male dummy, dummy if respondent is HH head, HH head completed primary school education dummy, improved water source dummy, dummy for dwelling with improved roof, dummy for dwelling with improved walls, dummy for whether any HH member took a loan) and village characteristics (matrilineal dummy, dummies for primary religion, dummies for primary language, dummies for primary economic activity, percentage of maize growers in the village, dummies for type of staple food), and district and survey-year indicators.

In the row that reports the gender difference in performance pooling across both incentive arms, estimated coefficients are negative in Table 4 (suggesting a male advantage in transferring knowledge and convincing others to adopt), whereas all coefficients in the equivalent row in Table 3 were estimated to be positive (suggesting a female advantage in acquiring, retaining and using the new technology). This reversal in the female advantage is a key result in this paper. Without incentives, communicators in female-assigned villages are as knowledgeable and adopt more, but this relative zeal does not translate into other farmers accepting their message.

These gender differences are again more pronounced in the non-incentive arm, and in Table 4, female communicators catch up to their male counterparts in the incentive arm. For example, recipient farmers' knowledge improves by 5 percentage points with the introduction of incentives in female-assigned villages (p-value = 0.04). Across villages with male and female communicators facing incentives, there is virtually identical knowledge (p-value = 0.88) and adoption (p-value = 0.78). This similarity parallels the similarity in the communicator's own performance on the private learning task (p-value = 0.84). Thus, performance-based incentives appear to lead to socially mediated outcomes that more closely reflect the underlying skill of men and women.

4.3 Are Women Simply Worse at Teaching than at Learning?

The results we have reported thus far are consistent with women under-performing in relative terms when they move from a private task that requires little social interaction to more public tasks that do. This may be evidence of discrimination against women in societal interactions, but it also may simply be the case that women are better learners than they are teachers. Differences in teaching performance could also arise due to gender disparities in human capital investment early in life. To explore these possibilities, in Table 5 we study crop yields and crop failures amongst a random sample of recipient farmers in each village.

Columns 1-3 report the effect of our treatments on a measure of maize yield on the farm captured at endline, after the second agricultural season post intervention. The technologies are productive on average, so maize yields are significantly greater across all treatment villages compared to control. In the absence of incentives, the yield increase is significantly higher in female communicator villages (p-value = 0.03). In this arm, yields are 17% greater when women teach. The female communicator advantage persists for both male and female recipient farmers, so it does not appear to be the case that female communicators are only better at teaching other women.

In line with our results on the "private task" (technology adoption by the communicators), male communicator villages gain more with incentives, erasing female communicators' advantage in producing higher yields. While female communicator villages retain an advantage overall in the full sample, the difference is no longer significant.

Columns 4-6 show that the likelihood of crop failure is smaller (but statistically indistinguishable) in the female communicator villages. Crop failure is a relatively rare event that year (5% in control villages), and there is no evidence that female communicators cause more disasters or are less able to transfer skills to other farmers.

We are reporting results on yields and failure on a random sample of all recipient farmers, not conditioning on adoption, to avoid any selection issue regarding who the male or female communicators choose to target. The fact that yields are the same or greater in female communicator villages suggests that when women manage to teach and convince others to adopts, the recipients do just as well with the technology. It does not appear to be the case that women are worse than men at teaching. Even if women are less confident as teachers, or in terms of the beliefs they express about the new technology, it does not undermine their performance as teachers. The differential gender performance in the private versus public tasks therefore does appear to be related to something else: social frictions, or perceptions of women, or willingness to accept messages when equally able or more able women are asked to complete a task that requires them to interact with and persuade others in society.

5. Mechanisms

In this section we explore what types of communication inefficiency can explain why female communicators, despite being as knowledgeable and achieving better command of a new technology, are not as convincing as men in getting others to learn and adopt a new technology. First, women may be worse as teachers. The yield data strongly suggest otherwise. Second, there may be some "gender frictions" if farmers learn more from others of the same gender. Then our results could stem from a gender composition effect: there are more male farmers in our sample, who are more receptive to male communicators, and women would be mechanically less effective. As previously reported, this hypothesis is not borne out by the data when we separately estimate effects for male and female controlled plots. This is in line with other findings in the literature, showing that discrimination against women is not solely perpetrated by men (Bagues and Esteve-Volart 2010; Jayachandran 2015).

Third, women may find it more costly to communicate with others. For instance, getting others in the community to pay attention to their message and trainings may be harder for female than male communicators, especially in the presence of gender bias on the demand side. We might observe lower attendance at the trainings women organize, should this be the issue. Fourth, other farmers may perceive women to not be as good at farming, and may not want to receive advice from them, or give as much credence to the advice they impart. Finally, other farmers may be less inclined to engage in discussions with female communicators due to social norms and attitudes about women's place in society (e.g., "we do not want to talk to women, they should not teach").

We combine our random assignment to performance-based incentives with rich data on all farmers' and communicators' social networks, perceptions and communication patterns to shed light on the relative merits of each of these mechanisms.

5.1 Interactions with Communicators

Our treatment encouraged communicators to hold *formal* training activities on the plots in which they adopted the new technology. We start by examining communicators' self-reported provision of trainings for other farmers (col 1, Table 6). Male and female communicators are equally likely to organize trainings for others. Again, in the non-incentive arm female communicators put in more effort, but there is no statistical gap in the overall sample. However, other farmers report that they are significantly more likely (by 11 percentage points, p-value < 0.05) to participate in trainings organized by male communicators (cols 2-4). In summary, although the supply of trainings is comparable across men and women, the demand for that training is not. [16]

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[16] We note that female communicators are 7 percentage points less likely to provide training than males in the incentive arm (35% for men, 28% for women, difference not significant). A simple back-of-the-envelope calculation shows that this gap in training provision is unlikely to explain a 50% (7pp) drop in attendance (from 13% for men to 6% for women, significant at the 10% level). For men in the incentive treatment, a 1% increase in training provision

We also collected data on more informal interactions between communicators and other farmers. We asked all farmers in the sample whether they have ever *discussed the new technology with a communicator*, and columns 5-7 show that these informal discussions are significantly less likely to occur in female communicator assigned villages. The treatment evidently induces a lot of informal discussion across all treatment villages relative to control, but both male and female plot owners are 11 percentage points less likely to have those discussions with female communicators. Providing a small performance-based incentives significantly augments farmers' interactions with communicators in both female and male communicator villages.

Columns 8-10 examine whether maize farmers report interacting with women less *in general*, not necessarily about this new technology. 77% of all households in all villages report talking to the communicators, and this is equally true for shadow communicators in the control villages. Within treatment villages, the female communicators appear no less "visible" than male communicators in their respective networks.

In summary, farmers interact with females in general, and women do not suffer from differentially less visibility or greater introversion in this context. Farmers just appear to pay relatively less attention to messages about a new agricultural technology coming from a female communicator, both in informal and formal settings. As Table 5 shows, female communicators transmit the message effectively, despite getting less face time. All of this suggests that either women are not perceived to be good at farming, or that there are differentials in male and female "identity" in agricultural occupations (Akerlof and Kranton 2000), and the role of women in agriculture and training. Providing a small inducement intensifies interactions between farmers and communicators (Table 6), and reduces the gender gap on socially-mediated outcomes (Table 5). Hence, one possibility is that these gaps in perception may be driving female-assigned communicators' relative lack of success in convincing others, rather than a more generalized gender communication gap: by increasing exposure to women communicators, incentives improve the accuracy of farmers' perceptions. We explore these ideas using two further sources of data and

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leads to a 0.37% increase in attendance. For women in the incentive treatment, a 1% increase in training causes attendance to go up by 0.22%. Assuming constant attendance rates across trainings (linear training-attendance relationship), incentivized women would need to provide: (0.13-0.06)/0.22 = 0.32, 32pp, more trainings to close the gap.

outcome variables: (a) rich social network data on who in the community talks to whom about what, and (b) data on villagers' subjective perceptions of the farming ability of men and women.

5.2 Social Network Relationships

We included a social network module in all surveys at midline, which asks the respondent about her interactions with 6 randomly selected other farmers in the village. Table 7 reports the gender dimension of these interactions, by estimating the following model using data in which respondent farmer i is asked about his/her interactions with other farmers j of a given gender residing in the same village:

$$y_{ijvd} = \delta_{FF} FemaleComm_{vd} \,.\, F_j + \delta_{FM} FemaleComm_{vd} \,.\, M_j + \delta_{MF} MaleComm_{vd} \,.\, F_j + \delta_{MM} MaleComm_{vd} \,.\, M_j + \lambda F_j + \Gamma\, X_{ivd} + D_t + D_d + \epsilon_{ivd.j} \qquad (2)$$

$FemaleComm_{vd}$ *and* $MaleComm_{vd}$ are indicators for the village level random assignment of female or male communicators, and M_j and F_j denote whether the other farmer that the respondent is asked about is male and female, respectively. We control for some respondent characteristics in X_{ivd}, including the respondent's own gender. λF_j captures the direct effect of gender of the farmer who the respondent is asked about. The sample size is large in these regressions (up to 29,811) because the unit of observation is now an *(i,j)* pair, and there are up to 6 *j*'s (other farmers) for every *i* (respondent). The excluded category is a male farmer's interaction with a male farmer in a control village.

The regressions in Table 7 explore three types of interactions: talk to other farmers (cols 1-3); discuss farming (cols 4-6); and, discuss the new technology introduced through the field experiment (cols 7-9). We make three central observations. First, people are no less likely to talk to females in the community (cols 1-3), which confirms our earlier observation that females are generally no less visible or isolated in rural Malawi. Females are 3p.p. less likely to talk to others (col. 3), and yet just as likely as male respondents to discuss farming and the new technology (cols 6 and 9). Second, our interventions create more buzz in the village, especially about the new technology. In all treatment villages, regardless of gender assignment, there are significantly more conversations between all farmers about agriculture and about the new technology, relative to control villages. Third, relatively more conversation and buzz occur in male-communicator villages.

6. Perceptions of Male and Female Communicators

Farmers engaging less with female communicators may be related to biased perceptions of women's farming and training abilities (Beaman et al 2009). To investigate, we collect data on other farmers' perceptions of the diligence, skills, and knowledge of communicators in their village. Each question elicits a subjective rating on a {1,2,3,4} scale on different dimensions of perception (cf. Appendix B). At midline, perception questions capture how hardworking and skillful a respondent considers the communicator to be, with no reference point. At endline, we ask whether the assigned communicator is (a) knowledgeable and (b) a good farmer, relative to the respondent herself. We construct two separate indices of these measures, and normalize them to be [0, 1].

Table 8 shows that farmers perceive male communicators to be more hardworking, skillful and knowledgeable than female communicators. This difference is imprecisely measured at midline, but significant at the 1% level at endline. This perception gap exists regardless of the gender of the respondent. Both men and women think that male communicators are better at agriculture. We consider these beliefs and perceptions to be biased against women, because the results in Table 3 and 5 indicate that women are just as knowledgeable about the new technologies introduced through the experiment, and farmers that women teach experience better yields. Again, this is particularly striking in the no-incentive arm, where female communicators are more zealous and induce higher yield increases. In that arm, female communicators are perceived to be as knowledgeable as the shadow communicators designated in our experiment, who did not acquire and teach a new technology, and less knowledgeable than their male counterparts (p-value = 0.07). In line with our thesis, incentives successfully combat this perception gap (p-value = 0.15).

7. Conclusions

This study contributes to the large literature investigating the sources of gender disparities in market outcomes by setting up a large-scale field experiment to test whether women perform differentially worse at a 'social task' that requires them to interact with others to succeed, relative to a 'private task' that does not. Women are comparable to men (or even slightly out-perform men) when innate ability is measured through the private task, but this does not translate into greater success at teaching or persuading others.

We explore underlying mechanisms using a cross-cutting experiment with performance-based incentives for the women and men, detailed micro data on social interactions, perceptions, effort expended, and finally, farm yields to obtain an objective measure of success in the field. We find that women teach better and expend more effort, but others do not perceive them to be as good at farming and teaching, and pay less attention to their message and trainings.

These gender gaps are more pronounced in the no-incentive arm, and assigning a performance-based incentive helps to mitigate these issues. Both male and female-assigned communicators exert more effort with incentives, making gains on different margins. Male communicators do relatively better in the private task with incentives, closing the gap with women. Conversely, incentives allow women to close the gap with men in terms of teaching and convincing others. Both males and females intensify their interactions with other farmers in their village.

Our data do not support a generalized gender communication gap in our study setting (e.g. "nobody talks to women"), nor is it consistent with gender frictions in communication (e.g. "women prefer talking to women, men to men"). Instead, our findings support the notion that farmers in general are less likely to pay attention to and accept a message from a female communicator. Incentives appear to close the gender gap by improving the accuracy of farmers' perception of the communicator's skills. This is further validated by a significant gender perception gap against female communicators that disappears when incentives are provided.

Our results illustrate the cost that gender discrimination imposes to society. Women transmit information about a productive new technology more successfully, and others taught by women experience greater farming yields in a poor, rural society where increases in productivity hold large welfare consequences. Yet, gender-based discrimination leads to inefficiencies in their transfer of this information to others. Talent is wasted, as communication and perception barriers prevent relatively more zealous and accomplished female communicators from efficiently spreading their knowledge.

Can a policy of assigning female farmers to teach others help overcome such inefficiencies? We show that a small in-kind incentive can induce female communicators to expend more effort and overcome demand-side biases. Differences in performance in the field stem from gaps in perceptions, so a class of policy actions where women are empowered to take a leading role in acquiring and passing a message to others in their community, has the potential to change perceptions, narrow the gender performance gap, and make better use of the available talent. The welfare implications of this transition are large, as we show using adoption of a new technology which greatly enhances agricultural yields in a poor agrarian society.

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Table 1: Profile of communicator-type farmers

	Mean						Mean Difference				
	Communicators			Shadow Communicators	Non-Communicators		(1) - (2)	(5) - (6)	(1) - (5)	(2) - (6)	(3) - (4)
	Male	Female	Pooled		Male	Female					
	1	2	3	4	5	6	7	8	9	10	11
Respondent is household head	0.96	0.90	0.93	0.91	0.94	0.94	0.06	0.00	0.02	-0.05	0.02
Respondent is primary agricultural decision maker	0.95	0.99	0.97	0.96	0.91	0.96	-0.04	-0.05	0.03	0.03	0.01
Household head is male	0.82	0.76	0.79	0.79	0.69	0.74	0.06	-0.05	0.14	0.02	0.00
Household head age	40.01	42.02	40.98	39.71	41.42	40.54	-2.01	0.87	-1.41	1.48	1.27
HH head has completed primary education	0.62	0.61	0.61	0.56	0.41	0.49	0.01	-0.09	0.21	0.12	0.05
Total cultivated land area in 2008/09 (hectare)	1.16	1.08	1.12	1.08	0.98	0.91	0.07	0.08	0.17	0.18	0.04
Maize yield (kgs/hectare)	812	605	714	1093	714	788	207	-74	98	-182	-378
HH cultivated cash crops	0.99	0.98	0.99	1.00	0.99	0.99	0.01	0.01	0.00	-0.01	-0.01
Majority of agricultural labor done by women	0.25	0.26	0.25	0.29	0.35	0.23	0.00	0.12	-0.10	0.02	-0.04
Dwelling has improved roof	0.26	0.41	0.33	0.33	0.18	0.24	-0.15	-0.06	0.08	0.17	0.00
Dwelling has improved walls	0.39	0.51	0.45	0.52	0.35	0.44	-0.12	-0.09	0.04	0.07	-0.07
HH uses improved water source in dry season	0.80	0.82	0.81	0.92	0.86	0.81	-0.02	0.05	-0.06	0.01	-0.11
HH uses improved water source in rainy season	0.83	0.82	0.82	0.92	0.86	0.80	0.01	0.06	-0.04	0.02	-0.10
Primary staple food is maize	0.94	0.97	0.95	0.98	0.94	0.97	-0.03	-0.03	0.00	0.00	-0.03
Primary staple food is sorghum	0.03	0.00	0.02	0.00	0.05	0.01	0.03	0.03	-0.01	-0.01	0.01
Primary staple food is cassava	0.00	0.02	0.01	0.00	0.00	0.01	-0.02	-0.01	0.00	0.01	0.01
Number of animals owned by the household	1.58	1.65	1.61	1.66	1.22	1.33	-0.07	-0.11	0.36	0.32	-0.04
Number of assets owned by the household	5.57	5.37	5.48	5.50	4.43	4.79	0.20	-0.36	1.15	0.58	-0.03
Primary source of income is the household farm	0.90	0.85	0.87	0.85	0.79	0.84	0.05	-0.05	0.11	0.01	0.02
Primary source of income is casual labor (ganyu)	0.45	0.31	0.39	0.39	0.48	0.48	0.14	0.00	-0.03	-0.17	0.00
Primary source of income is a business	0.30	0.53	0.41	0.41	0.38	0.44	-0.23	-0.06	-0.07	0.10	0.01
At least one HH member took a loan in past year	0.08	0.14	0.11	0.08	0.04	0.05	-0.06	-0.01	0.04	0.09	0.03
Number of farmers	115	105	220	248	1,206	1,260	220	2,466	1,321	1,365	268

Data source: Baseline household survey. Notes: T test inferences are based on standard errors clustered at the village level. Critical values adjusted using Bonferroni correction for number of tests performed. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 2: Balance Test (non-communicator farmers)

	By Communication Method			By Gender			By Incentive		
	Communicator Vlg	Control Vlg	(1) - (2)	Male Comm Vlg	Female Comm Vlg	(4) - (5)	Incentivized Comm Vlg	Non-incentivized Comm Vlg	(7) - (8)
	1	2	3	4	5	6	7	8	9
Respondent is household head	0.94	0.93	0.01	0.94	0.94	0.00	0.93	0.95	-0.02
Respondent is primary agricultural decision maker	0.94	0.94	-0.01	0.91	0.96	-0.05	0.95	0.92	0.02
Household head is male	0.71	0.70	0.01	0.69	0.74	-0.05	0.71	0.72	-0.01
Household head age	40.97	40.81	0.16	41.42	40.54	0.87	40.73	41.22	-0.49
HH head has completed primary education	0.45	0.46	-0.01	0.41	0.49	-0.09	0.46	0.44	0.02
Total cultivated land area in 2008/09 (hectare)	0.94	0.87	0.08	0.98	0.91	0.08	0.90	0.98	-0.08
Maize yield (kgs/hectare)	752	898	-145	714	788	-74	571	939	-368
HH cultivated cash crops	0.99	1.00	-0.01	0.99	0.99	0.01	0.99	0.99	0.00
Majority of agricultural labor done by women	0.29	0.34	-0.05	0.35	0.23	0.12	0.28	0.30	-0.02
Dwelling has improved roof	0.21	0.24	-0.03	0.18	0.24	-0.06	0.23	0.19	0
Dwelling has improved walls	0.40	0.41	-0.01	0.35	0.44	-0.09	0.43	0.36	0
HH uses improved water source in dry season	0.84	0.93	-0.09	0.86	0.81	0.05	0.86	0.81	0.04
HH uses improved water source in rainy season	0.83	0.93	-0.09	0.86	0.80	0.06	0.86	0.80	0.06
Primary staple food is maize	0.95	0.96	-0.01	0.94	0.97	-0.03	0.97	0.94	0.03
Primary staple food is sorghum	0.03	0.01	0.02	0.05	0.01	0.03	0.02	0.04	-0.03
Primary staple food is cassava	0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.01	0
Number of animals owned by the household	1.27	1.25	0.02	1.22	1.33	-0.11	1.31	1.24	0.06
Number of assets owned by the household	4.61	4.63	-0.02	4.43	4.79	-0.37	4.56	4.67	-0.1
Primary source of income is the household farm	0.81	0.81	0.00	0.79	0.84	-0.05	0.85	0.78	0.07
Primary source of income is casual labor (*ganyu*)	0.48	0.47	0.01	0.48	0.48	0.00	0.51	0.45	0.06
Primary source of income is a business	0.41	0.39	0.02	0.38	0.44	-0.06	0.43	0.38	0.05
At least one HH member took a loan in past year	0.05	0.04	0.01	0.04	0.05	-0.01	0.04	0.05	-0.01
F - stat, test of joint significance			1.83			2.33			2.53
Number of farmers	2,467	1,219	3,686	1,207	1,260	2,467	1,261	1,206	2,467

Notes: See Table 1

Table 3: Communicators' effort & performance

	Attended training	# Trainings attended	Knowledge	Adoption
Village assigned to:	1	2	3	4
Male Communicator, no incentives	0.35***	1.78**	0.15***	0.12***
	(0.06)	(0.70)	(0.04)	(0.04)
Female Communicator, no incentives	0.37***	1.82**	0.19***	0.23***
	(0.08)	(0.58)	(0.05)	(0.07)
Male Communicator, with incentives	0.41***	1.59***	0.25***	0.32***
	(0.07)	(0.43)	(0.04)	(0.06)
Female Communicator, with incentives	0.42***	3.09***	0.27***	0.28***
	(0.08)	(0.96)	(0.06)	(0.08)
Endline Dummy	-0.10**	0.83**	-0.03	-0.07***
	(0.04)	(0.34)	(0.02)	(0.02)
Constant	0.23**	-0.06	0.27***	0.27***
	(0.11)	(0.56)	(0.09)	(0.10)
N	795	795	795	795
Adjusted R2	0.14	0.07	0.38	0.36
Control Group Mean	0.24	0.02	0.14	0.03
	(0.43)	(0.23)	(0.27)	(0.18)
Gender Difference (pooled incentives)				
Coefficient for [female comm. – male comm.]	0.03	1.53	0.05	0.07
	(0.13)	(1.29)	(0.08)	(0.10)
Incentive Ttest: Non-incentivized=Incentivized				
p-values, male communicators	0.53	0.81	0.04	0.01
p-values, female communicators	0.59	0.18	0.22	0.55
Gender Ttest: Male=Female				
p-values, non-incentivized communicators	0.83	0.96	0.48	0.08
p-values, incentivized communicators	0.89	0.11	0.84	0.71

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, gender of the HH head, education level of the HH head) and village characteristics (matrilineal dummy, dummies for religion, dummies for language), and district and survey-year indicators. Crop fail effect not included as a dependent because crop failure experienced by only 10 of the communicators. Columns (1)-(4) are estimated on midline and endline samples, while columns (5-6) are restricted to the endline sample for which yield was captured at the individual level. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 4: Other farmers’ knowledge and adoption

	Knowledge Score			Adoption		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
Male Communicator, no incentives	0.09***	0.10***	0.09***	0.02**	0.03	0.02*
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Female Communicator, no incentives	0.04**	0.05**	0.05**	0.01	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Male Communicator, with incentives	0.10***	0.09***	0.10***	0.06***	0.04**	0.05***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Female Communicator, with incentives	0.08***	0.12***	0.10***	0.03**	0.06***	0.04***
	(0.02)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)
Endline Dummy	-0.04***	-0.05***	-0.05***	-0.02**	-0.03***	-0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.14***	0.24***	0.21***	0.06***	0.06**	0.06***
	(0.03)	(0.04)	(0.03)	(0.02)	(0.03)	(0.02)
N	3924	4235	8159	3924	4235	8159
Adjusted R2	0.17	0.22	0.20	0.05	0.06	0.06
Mean of Control Group	0.06	0.09	0.08	0.01	0.02	0.01
	(0.17)	(0.22)	(0.20)	(0.10)	(0.13)	(0.12)
Gender Difference (pooled incentives)						
Coefficient for [female comm. – Male communicator]	-0.06*	-0.02	-0.04	-0.04*	0.01	-0.01
(std. error)	(0.04)	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, male communicators	0.51	0.86	0.83	0.05	0.36	0.12
p-values, female communicators	0.09	0.04	0.04	0.19	0.08	0.08
Gender Ttest: Male=Female						
p-values, non-incentivized communicators	0.05	0.07	0.03	0.25	0.85	0.53
p-values, incentivized communicators	0.46	0.45	0.88	0.19	0.50	0.78

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, gender of the HH head, education level of the HH head) and village characteristics (matrilineal dummy, dummies for religion, dummies for language), and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 5: Other farmers' maize production

	Log Maize Yield			Likelihood of crop failure		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
Male Communicator, no incentives	-0.12	0.13	0.01	-0.01	0.00	0.00
	(0.09)	(0.08)	(0.07)	(0.02)	(0.03)	(0.02)
Female Communicator, no incentives	0.04	0.27***	0.17**	-0.01	-0.02	-0.01
	(0.10)	(0.08)	(0.08)	(0.02)	(0.02)	(0.02)
Male Communicator, with incentives	0.12	0.25***	0.19**	0.00	-0.01	0.00
	(0.11)	(0.09)	(0.09)	(0.01)	(0.02)	(0.01)
Female Communicator, with incentives	-0.04	0.22**	0.09	-0.02	-0.02	-0.02
	(0.10)	(0.08)	(0.07)	(0.02)	(0.02)	(0.01)
Constant	5.62***	5.84***	5.75***			
	(0.14)	(0.16)	(0.12)			
N	1392	1441	2833	1763	1623	3820
Adjusted R2	0.28	0.34	0.31	.	.	.
Mean of Control Group	6.49	6.66	6.57	0.05	0.06	0.05
	(0.99)	(0.99)	(0.99)	(0.21)	(0.23)	(0.21)
Gender Difference (pooled incentives)						
Coefficient for [female comm. – Male comm.]	0.00	0.10	0.06	-0.02	-0.03	-0.03
	(0.14)	(0.13)	(0.11)	(0.03)	(0.03)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, male communicators	0.02	0.16	0.03	0.53	0.68	0.96
p-values, female communicators	0.41	0.56	0.32	0.66	0.95	0.91
Gender Ttest: Male=Female						
p-values, non-incentivized communicators	0.07	0.07	0.03	0.89	0.39	0.51
p-values, incentivized communicators	0.15	0.71	0.24	0.21	0.55	0.25

Data sources: Endline HH Survey. Notes: Likelihood of crop failure (1-3) is probit; sample size varies when included controls perfectly predit failure. Maize yield (4-6) is OLS. Regressions include the same controls as in Table 4. Maize yield calculated for all farmers that reported growing maize on at least one plot. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 6: Other farmers' interactions with communicators

	Communicator led trainings	Farmers interactions with communicators								
		Farmers participated in trainings			Discussed Technology			Talked to Communicator		
		Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6	7	8	9	10
Male Communicator, no incentives	0.12	0.03	0.01	0.02	0.08***	0.10**	0.09**	-0.03	-0.05	-0.04
	(0.08)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)
Female Communicator, no incentives	0.24***	-0.01	-0.03	-0.02	0.03	0.04	0.04	-0.04	-0.06	-0.05
	(0.08)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
Male Communicator, with incentives	0.35***	0.14***	0.13***	0.13***	0.22***	0.23***	0.23***	0.00	0.06	0.04
	(0.10)	(0.03)	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.02)	(0.04)	(0.03)
Female Communicator, with incentives	0.28***	0.07**	0.05	0.06**	0.18***	0.16***	0.17***	-0.01	0.07	0.04
	(0.08)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)	(0.03)
Endline Dummy					-0.10***	-0.07***	-0.08***	0.28***	0.34***	0.31***
					(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	-0.08	0.11***	0.18***	0.18***	0.10**	-0.03	0.04	0.69***	0.47***	0.58***
	(0.11)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)	(0.05)
N	325	2663	2000	4663	3550	4970	8520	3730	6571	10,301
Adjusted R2	0.12	0.02	0.04	0.03	0.07	0.07	0.07	0.16	0.17	0.18
Mean of Control Group	0.13	0.12	0.20	0.15	0.09	0.13	0.11	0.87	0.72	0.77
	(0.34)	(0.33)	(0.40)	(0.36)	(0.29)	(0.33)	(0.32)	(0.34)	(0.45)	(0.42)
Gender Difference (pooled incentives)										
Coefficient for [female comm. – male comm.]	0.05	-0.10**	-0.12*	-0.11**	-0.10**	-0.13*	-0.11**	-0.02	0.01	0.00
	(0.15)	(0.05)	(0.07)	(0.05)	(0.05)	(0.07)	(0.06)	(0.05)	(0.07)	(0.06)
Incentive Ttest: Non-incentivized=Incentivized										
p-values, male communicators	0.05	0.01	0.03	0.01	0.00	0.1	0.00	0.34	0.02	0.04
p-values, female communicators	0.71	0.02	0.08	0.01	0.00	0.01	0.00	0.37	0.02	0.04
Gender Ttest: Male=Female										
p-values, non-incentivized communicators	0.76	0.31	0.36	0.26	0.08	0.18	0.13	0.76	0.94	0.87
p-values, incentivized communicators	0.19	0.08	0.12	0.06	0.24	0.20	0.19	0.76	0.85	0.90

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the same controls as in Table 4. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 7: Farmers' Interaction with Each Other, by Gender

Midline Only	Talks			Discusses farming			Discusses technology		
	female	male	pooled	female	male	pooled	female	male	pooled
Respondent refers to a:	1	2	3	4	5	6	7	8	9
Female farmer	0.01	-0.01	0.00	0.00	-0.02	-0.02	0.02*	0.01	0.01
	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Male farmer in male communicator village	0.02	0.00	0.01	0.11***	0.08**	0.08**	0.15***	0.11***	0.12***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Male farmer in female communicator village	-0.02	0.00	0.00	0.01	0.05	0.05	0.08**	0.09***	0.09***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Female farmer in male communicator village	0.05	0.02	0.03	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***
	(0.03)	(0.03)	(0.02)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Female farmer in female communicator village	0.06*	-0.01	0.00	0.06	0.07**	0.07**	0.08	0.07**	0.08**
	(0.03)	(0.03)	(0.02)	(0.06)	(0.03)	(0.03)	(0.06)	(0.03)	(0.03)
Respondent is female			-0.03**			-0.02			-0.01
			(0.01)			(0.02)			(0.01)
Constant	0.72***	0.84***	0.84***	-0.01	0.03	0.00	-0.03	-0.05	-0.04
	(0.06)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)	(0.03)
N	4162	13,982	13,982	4120	13,874	17,994	4,130	13,925	18,055
Adjusted R2	0.07	0.03	0.03	0.10	0.07	0.08	0.10	0.09	0.09
Mean of Control Group	0.80	0.84	0.84	0.11	0.13	0.13	0.03	0.05	0.04
	(0.40)	(0.37)	(0.37)	(0.31)	(0.34)	(0.33)	(0.16)	(0.22)	(0.20)
By treatment village: interaction w/ other farmer									
female communicator vlg: female farmer = male farmer	0.00	0.11	0.11	0.30	0.55	0.94	0.52	0.59	0.95
male communicator vlg: female farmer = male farmer	0.03	0.77	0.77	0.47	0.15	0.11	0.97	0.14	0.20
By farmer referred to: interaction w/ other farmer									
female farmer: female comm. vlg = male comm. vlg	0.63	0.18	0.18	0.30	0.07	0.08	0.46	0.08	0.14
male farmer: female comm. vlg = male comm. vlg	0.12	0.83	0.83	0.00	0.48	0.19	0.01	0.34	0.14

Data sources: midline household questionnaire. Sample: All "regular" farmers (excludes actual and shadow communicators) in treatment and control villages. Farmers were asked about their interactions with 6 randomly selected "regular" farmers from their village. Each respondent-random farmer pair form one observation in this dataset; dependent variables refer to interactions of the respondent farmer with the randomly selected farmer.
Notes: Regressions include the same controls as in Table 4. Sample size varies across columns due because "do not know" and "no opinion" responses are coded as “missing”. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 8: Other farmers’ perceptions of communicators

	Midline			Endline		
	Index: hardwork + skillful			Index: knowledgeable + good farmer		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
Male Communicator, no incentives	0.04*	0.04**	0.04**	0.03**	0.05***	0.04***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Female Communicator, no incentives	-0.01	0.03	0.02	0.02	-0.02	0.00
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Male Communicator, with incentives	0.07***	0.09***	0.08***	0.04***	0.05***	0.04***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Female Communicator, with incentives	0.07***	0.07***	0.07***	0.02***	0.02	0.02*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Constant	0.78***	0.73***	0.75***	0.80***	0.78***	0.76***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
N	909	3052	3961	2396	1832	4228
Adjusted R2	0.07	0.08	0.07	0.04	0.06	0.06
Mean of Control Group	0.80	0.79	0.79	0.78	0.73	0.76
	(0.18)	(0.18)	(0.18)	(0.14)	(0.16)	(0.15)
Gender Difference (pooled incentives)						
Coefficient for [female comm. – male comm.]	-0.05	-0.03	-0.03	-0.03	-0.09***	-0.06***
	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, male communicators	0.31	0.05	0.06	0.42	0.85	0.66
p-values, female communicators	0.01	0.08	0.03	0.85	0.07	0.25
Gender Ttest: Male=Female						
p-values, non-incentivized communicators	0.03	0.58	0.32	0.58	0.00	0.07
p-values, incentivized communicators	0.98	0.45	0.55	0.20	0.17	0.15

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the same controls as in Table 4. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Appendix A: Project Timeline

Activity	Timing	Responsibility
District-level briefings on impact evaluation with regional and district officials	July 2009	Extension, Land Resources, Research, Planning
AEDOs trained on the new technologies	August 2009	Extension, Land Resources, Research, Planning
AEDOs identify and train village Communicators	August – September 2009	AEDOs
Communicators train other farmers and demonstrate the new technologies	Starting September 2009	Communicators, assisted by AEDOs
Incentivized Communicators are briefed on performance-based rewards program	October-November 2009	Research team collaborating with Planning Department
Recipients of first year performance-based reward identified	November-December 2010	Research team
Incentives delivered	Starting January 2011	Planning Department

Survey Field Work

Baseline: August - October 2009
- Household questionnaire

Agricultural season: November/December 2009 – May/July 2010

Midline: July - October 2010
- Household questionnaire
- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

Agricultural season: November/December 2010 – May/July 2011

Endline: July - October 2011
- Household questionnaire
- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

Appendix B: Construction of the main variables

Communicators' Effort (Communicator questionnaire, midline and endline)

- *Attended training*: A binary variable that indicates whether a Communicator reports working with an AEDO over the last farming season.
- *# Trainings attended*: A discrete variable that indicates the number of times a Communicator reports working with an AEDO over the last farming season.
- *Communicator led training:* A binary variable that indicates whether a Communicator led any training involving other farmers in his village during the 12 months prior to the interview.

Knowledge and Adoption (Communicators and Other Farmers)

- *Knowledge*: A [0;1] continuous variable that measures a respondent's understanding of the technology. The score is the fraction of correct answers a respondent provides to seven technology-specific questions for pit planting, and six for Changu composting. The percentage of correct answers is the knowledge score.
- *Adoption*: A binary variable that indicates whether a respondent adopted the promoted technology (pit planting or Changu composting) in the last farming season.

Other farmer Interactions with Communicator (Other farmers ML and EL; both main and additional respondent)

- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with the communicator during the 12 months prior to the interview.
- *Participated in trainings*: A binary variable indicating whether the farmer participated in a group training held by the communicator during the past 12 (asked at endline only).
- *Talked to communicator*: A binary variable indicating whether a farmer talked to their assigned communicator about anything over the past 12 months.

Other Farmers' Perception of Communicators (household & spouse/additional respondent questionnaire, Social Network module)

- *Midline perception index (hardworking + skillful):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.

  - Perception of how hardworking the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not hardworking" and 1 is "very hardworking"
  - Perception of how skillful the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not skillful" and 1 is "very skillful".
- *Endline perception index (knowledgeable + good farmer):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.
  - Perception of how knowledgeable the communicator is, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is much less knowledgeable than me" and 1 is "communicator is much more knowledgeable than me"
  - Perception of how good the communicator is at farming, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is a much worse farmer than me" and 1 is "communicator is a much better farmer than me."

Other farmers' Interaction with Each Other (Midline Social Network Module)

- *Discussed farming*: A binary variable that indicates whether the respondent reports discussing farming with another randomly drawn farmer from the community during the 12 months prior to the interview.
- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with another randomly drawn farmer from the community during the 12 months prior to the interview.

Knowledge Exam

Knowledge Question	Correct answer	Accepted answers
Pit Planting		
How far apart should the planting pits be?	70 cms	52.5 – 87.5
How deep should planting pits be?	20 cms	15 – 25
How wide should planting pits be?	30 cms	22.5 – 37.5
How long should planting pits be?	30 cms	22.5 – 37.5
How many maize seeds should be planted in each pit?	4	4
Should manure be applied?	YES	YES
How much manure should be applied?	2 double handfuls	2 double handfuls
After harvest what should be done with the stovers?	Maize plants cut off at base, leave roots to decompose in pit, stems and leaves used to cover the soil.	Correct multiple choice option selected.
Changu Composting		
What materials should be used for Changu composting?	Leguminous crop residues (most commonly soybeans and groundnuts), fresh leaves of leguminous trees, maize stoves, chicken or livestock manure	At least 1 correct material listed
How much time should Changu compost be let mature?	60 days	6 weeks – 2 months
How should Changu compost be kept while it is maturing?	In a covered heap	In a covered heap
Should it be kept in the sun or the shade?	Shade	Shade
Should it be kept moist or dry?	Moist	Moist
When should Changu compost be applied to the field?	At least 2 weeks before planting	At least 2 weeks before planting

Appendix C: AEDO Training Program – Conservation Farming

Training Schedule -- Monday, 10th August to Friday, 14th August 2009

Day	Time	Topic	Facilitators
Monday		Arrival of participants	
Tuesday	Morning	Introductory Activities: welcome remarks, norms, introductions	DAPS
		Overview of ADP, ADP-SP, and ADP-SP Impact evaluation	DAPS
	Afternoon	Guidelines for Conservation Farming	DLRC
Wednesday	Morning	Field visit to Conservation Farming site	DLRC
	Afternoon	Discussion of observations from Conservation Farming site	DLRC
Thursday	Morning	Concept of Lead Farmer	DAES
		Concept of Peer Farmer	DAES
		Distinction between Lead Farmer and Peer Farmer	DAES
		Selection of Peer and Lead Farmers	DAES
		Random assignment of gender to Peer and Lead Farmers	DAES
		Monitoring strategy: outcomes of interest and Monitoring instruments	DAPS
	Afternoon	Review of the topics covered and feed back	DAPS

Friday		Departure	

Technical Guidelines for Pit Planting

Pit planting is a conservation farming technology that increases a soil's capacity for storing water while at the same time allowing for minimum soil disturbance. This is because when planting pits are excavated in a field, they may be used for at least two seasons before farmers have to reshape the pits. Planting pits enable farmers to use small quantities of water and manure very efficiently, and are cost and time efficient (although labor to construct the pits can be a constraint). Pits are ideal in areas where rainfall is limited.

The following are the guidelines for pit planting that the project will employ. These guidelines were developed by the MoAFS Department of Land Resources Conservation Conservation.

Step 1: Site Selection

Identify a plot with relatively moderate slopes. If possible the site should be secure from livestock to protect the crop residues.

Step 2: Land Preparation

Mark out the pit position using a rope, and excavate the pits following the recommended dimensions (as shown in the table below). These should be dug along the contour. The soil should be placed on the down slope side. Stones may be placed on the upslope side of the pit to help control run off, but this is optional. If available, crop residues from the previous harvest should be retained in the field so there is maximum ground cover.

Pit dimension and spacing:

Spacing between pits	70cm
Spacing between rows	90cm
Depth	20cm
Length	30cm
Width	30cm

At this spacing, there will be 15,850 pits per hectare (158 pits per 0.1ha). Where rainfall is limited, pits can be made deeper and wider to make maximum use of rainwater.

Step 3: Planting, Manure and Fertilizer Application

The pit can be planted to maize crop at the spacing below:

Crop	Seeds/pit	Plants/ha
Maize	4	63,492

It is recommended that farmers apply 2 handfuls of manure in each pit. Two weeks before rainfall, apply manure and cover the pit with earth. If basal fertilizer is available, it can also be applied at the same time. When manure has been applied, the pits should be covered with soil. A shallow depression should still remain on top. If top dressing is available, it should be applied when the maize is knee high. In some areas, it may be after 21 days.

Step 4: Weed Control and Pest Management

The pits must be kept free of weeds at all times. Weed as soon as the weeds appear and just before harvesting. This will reduce the amount of weeds in the following season. Use of herbicides to control weeds is optional.

Step 5: Harvesting

Remove the crop. Cut plants at base, leaving stems and leaves on the soil. The roots should not be uprooted; they should be left to decompose within the pit.

Increasing the Efficiency of the Pits

It is important to realize that the use of these pits alone will not produce the highest yields. For best results:

- Always incorporate crop residues, leaving a minimum of 30% of crop residue on the field.
- Apply manure generously.
- Protect crops from weeds, pests, and diseases.
- Always plant with the first productive rains.
- Grow crops in rotation; at least 30% of the cropped land should be planted to legumes.
- Using a cover crop / ground cover in conjunction with pits will give best results

Monitoring and Evaluation Indicators

The following indicators will be used to monitor adoption of pit planting:

1. Number of seeds planted per pit
2. Proper spacing of the pits (measured by the number of pits / size of the plot)
3. Quantity of fertilizer applied
4. Use of crop residues
5. Use of a ground cover / cover crop

Training Plan for Pit Planting

1.0 Objectives

By the end of the session, participants should be able to:

- Understand the concept of conservation agriculture
- Distinguish between conservation agriculture and conservation farming
- Understand the options available in conservation agriculture
- Understand the technical recommendations for pit planting
- Demonstrate pit planting

2.0 Steps and Sequence

- Prepare a climate setter
- Outline the objectives on a flip chart
- Outline the concept of conservation agriculture on a flip chart
- Explain the differences between conservation agriculture and conservation farming on a flip chart
- Outline the options in conservation agriculture on a flip chart
- List advantages of conservation farming on a flip chart
- Prepare demonstration set up on pit planting

3.0 Procedure

- Start by setting the climate
- Outline the objectives
- Present the content
    - Brainstorm on the concept of conservation agriculture
    - Explain the concept of conservation agriculture
    - Brainstorm on differences between conservation agriculture and conservation farming
    - Explain differences between conservation agriculture and conservation farming
    - Explain options in conservation agriculture
    - Explain advantages of conservation farming
- Make a summary of session presentation
- Teach technical guidelines for pit planting
- Demonstrate on pit planting

4.0 Methodology

- Lecturette
- Demonstration

5.0 List of Training Materials

- Chalk board/Flip chart
- Chalk / Pental pen
- Previously made compost manure
- Equipment and tools

- Stone for hammering
- Pegs
- Hoes
- Measuring stick
- Measuring string
- Pail/bucket

Guidelines for Nutrient Management

The following are the guidelines to the nutrient management strategy the project will employ. These guidelines were developed by the MoAFS Department of Agricultural Research.

Step 1: Materials for compost

The following materials are appropriate for making compost: leguminous crop residues (Groundnuts and Soyabean), fresh leaves of leguminous trees, chopped maize stover (about 6 inches long), animal or chicken manure (optional)

Step 2: Preparation of compost

Mix three parts of leguminous biomass (crop residues and/or fresh leaves) to two parts maize stover.

Put a layer of legume crop residue followed by a layer of stover then a layer of green leaves of legume tree repeat making the layers until the heap is 120 cm high. After constructing a set of three layers add 5 liters of water to moisten the materials.

After constructing the heap smear the wet earth around the heap covering the biomass. The materials should be kept moist throughout the composting period. After 60 days the manure is ready, remove the manure and keep them under shade.

Step 3: Application method

Apply the manure at least two weeks before planting. Apply 3 kg of manure applied per 10 m ridge. Split open the ridge about 4 cm deep, spread the manure on the open ridge then bury the manure thus reconstituting the ridge.

Step 4: Planting

At the rain onset plant maize, one maize seed per planting hole on the ridge at a distance of 25 cm between planting holes.

Step 5: Use of Inorganic Fertilizer (optional, depends on availability)

Use 23:21:0+4S for basal dressing. Apply fertilizer as dollop; make a hole about 3 cm deep between the maize planting hills.

- Apply 23 kg N/ha of 23:21:0+4S at a rate 2.5g per hole (cups to be calibrated to measure 2.5 g fertilizer).
- Apply 37 kg N/ha of Urea at a rate of 2g per hole (cups to be calibrated to measure 2g fertilizer)

Apply the inorganic fertilizer one (1) week after maize germination. Note that cups must be carefully calibrated; using a bottle cap will result in fertilizer overdose.

Monitoring and Evaluation Indicators:

The following indicators will be used to determine farmer's adoption of NM technology:

- Compost materials used (should exclude grass)
- Time and method of manure application
- Quantity of inorganic fertilizer applied
- Number of compost heaps per farmer (should increase in the second season)
- Expansion of area of land planted using the intervention (land area should increase in the second season)

HANDOUT: MAKING CHANGU COMPOST OR *CHANGU*

This is the type of compost where the organic materials decompose relatively fast hence the name "Changu."

Making of this type of manure undergoes several steps which are outlined as follows:

- Site selection

  The best site for the Changu compost is

  - Near the garden where the compost is to applied, to minimize labour and time in transportation, preferably on the edge of the garden to avoid disrupting cultivation operations in the garden.
  - This should be under shade, on a fairly flat ground.
  - Near the source of materials and water
  - Away from dwelling houses with chickens and goats

- Materials required

  Composting materials

  - Grass
  - Crop residues
  - Maize stover
  - Leaves of various plants

- Booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil)
- Water
- Equipment and tools
  - Bricks
  - Stone/logs
  - Poles
  - Hoes
  - Measuring stick
  - Pail/bucket

Procedure for Construction

The process for construction of Changu compost heap is as follows:

- Clear the surface of the ground in at least 2m diameter for easy marking
- Measure a 1.5m to 2m diameter circle by using a peg and a string
- Heap 20 – 30 cm thick layer of composting material over the area marked, which will form as the base of the compost heap
- Water the heap adequately until it just oozes out when materials are squeezed to induce decomposition.
- Add a booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil) on top to a height of 3 – 5 cm thick
- Water the booster layer adequately
- Repeat the above process with the diameter of each subsequent layer reducing until the heap is 1.5m high, thereby achieving a conical shape
- Cover the heap with grass to reduce evaporation

Procedure for turning

After two to three days the heap will have formed three distinctive layers.

- Insert a stick into the compost heap to check if decomposition has started
- If the stick is warm, it shows that there is microbial activity and decomposition has started.
- Where decomposition has started turn the heap after 3 to 4 days and there after every 4 to 5 days to speed up decomposition.
- During the turning process remove the outer layer (A) from the heap and separate the middle layer (B) from the inner layer (C).
- In the process of rebuilding the heap
  - Put layer A at the bottom
  - Water adequately
  - Put layer C in the middle
  - Water adequately
  - Lastly, put layer B on top/outside the heap.
  - Water and cover the heap with grass

The process of noted undecomposing heap

This is determined if the stick inserted into the heap is not felt to be warm.

This could be solved by dismantling the heap and remaking the compost, using a different booster, adding more water if the material looks dry.

Duration of composting for this method

The heap will mature after 30 to 40 days depending on the nature of composting material used.