Understanding Technology Adoption: Fertilizer in Western Kenya
Evidence from Field Experiments
(PRELIMINARY AND INCOMPLETE)

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Abstract

The question of the determinants of the adoption of new technology in agriculture is of central interest to both academics and policy makers. In this paper, we report the results from a unique set of field experiments conducted in Western Kenya over five years, which were designed to investigate a range of hypotheses on the determinants and barriers to the adoption of a profitable technology. In the experiments, meaningful programs expected to have an effect on the adoption of fertilizer under alternative hypotheses were proposed to randomly selected groups of farmers. We find that while know-how plays a role and can partly be overcome, other factors, such as the inability to save over even short periods of time may be even stronger impediments.

1. Introduction

Maize is the staple food in most of Eastern and Southern Africa. Although a relatively new crop, the production of maize has expanded so fast that maize has become the dominant food crop in that region. In Kenya, maize accounts for 80% of the national production of cereals (Hassan 1998, p.164) and provides 40% of calorie consumption for Kenyans who consume more than 125 kilograms of maize per person each year (Byerlee, 1997 p.16).

Maize is also a crop which has been subject to relatively successful technological improvements such as the use of fertilizer and new hybrid seeds. In developing countries outside of Africa, the use of fertilizer accounted for 50-75% increase in the crop yields from the mid 1960s (Viyas, 1983). Many believed that this new technology in maize production with its high-yield potential would lead Africa to replicate the success of Asia's Green Revolution. However, this hope did not materialize. Fertilizer use in Africa is still very low and has been stagnating since the 1980s.

Meanwhile, with rapid population growth, Africa can no longer be viewed as a land-abundant region where food crop supply could be increased by the expansion of land used in agriculture (Byerlee, 1997). Large areas in Africa are marginal for agriculture and arable land is scarce in many African countries. One of those countries is Kenya, which surpasses major Asian countries in intensity of land use (Binswanger and Pingali, 1988). This makes the need for intensification of land use through the use of land-saving technologies such as fertilizer critical for achieving food security. Yet, the rate of increase in fertilizer use has been substantially lower than in Asia and Latin America (Byerlee, 1997).

In rural Western Kenya, the Ministry of Agriculture recommends the use of hybrid seeds and fertilizer to increase maize yields. This recommendation is based on evidence from experimental farms that fertilizer substantially increases yield. However, according to surveys we have conducted over several years with a random sample of farmers, just 31.1% of farmers had ever used fertilizer, and just 17.4% had used fertilizer in the year prior to the survey. This paper seeks to understand why so many people do not use fertilizer even though it appears to have the potential to improve yields considerably, thus improving poor farmers' lives as well as improving food security in the country.

Models of technology adoption in agriculture suggest three broad categories of explanations. First, fertilizer may not be appropriate in this region. Second, it may be appropriate, but farmers either do not know it, or do not know how to use fertilizer. There may be an inefficiently low level of experimentation if there are externalities in learning. Finally, there is the issue of financing profitable investments. As technology adoption, information acquisition and diffusion, and the financing of investments are all fundamental questions in development economics, the lessons from this project have the potential to extend far beyond the specific example of fertilizer.

In this project, we employ a series of randomized field trials to investigate several hypotheses that might explain why farmers do not use fertilizer: fertilizer is not profitable given the conditions on real farms; it is profitable but farmers do not know how to use it, or do not know how profitable it is; or, farmers have difficulty financing the investment, perhaps because they are unable to save.

In a series of randomized field experiments, we have explored these three hypotheses. Our main results suggest that: (1) fertilizer is profitable; (2) providing information goes part of the way towards increasing fertilizer adoption, and part of the low fertilizer adoption may be explained by the complete absence of diffusion of technological innovation; but (3) programs that help the farmers commit at the point where they have money to use fertilizer later in the season also have a large impact on future fertilizer adoption.

This project has taken place in Busia, a relatively poor rural district in Western Kenya. The majority of Busia district is classified as a moist mid-altitude agro-ecological zone and maize is the main staple food. Soil fertility is low and the Kenyan Agricultural Research Institute and Ministry of Agriculture recommend use of fertilizer.

Since the summer of 2000, International Child Support (ICS), a Dutch Non-Governmental Organization which has been working in Busia District for ten years, has conducted a series of small-scale pilot programs in order to understand the barriers to fertilizer adoption for farmers growing maize. In order to evaluate the impact of these programs, beneficiaries were randomly selected and data was collected. While the experiments and the data collection have already been completed, the data analysis is currently ongoing; this paper presents the experiments and the results that have been obtained so far, as well as some open questions.

A. Fertilizer is profitable

A natural hypothesis to explain the low level of adoption of fertilizer is that it is not a profitable investment for the average farmer. While agricultural experts have found that fertilizer greatly increases yields in test plots, it may not be profitable if it requires substantial investment in complementary inputs, is difficult to use in real-world situations, or cannot easily be used by typical farmers. For example, Foster and Rosenzweig (1995) found that uneducated farmers have negative profits in the first year they adopted HYV seeds. Beginning in the July, 2000, a series of 6 pilot projects (over 3 years) were designed to ascertain the profitability of fertilizer on real farms facing the same conditions as those experienced by local farmers.

ICS first randomly selected 30 farmers from a list of parents of students enrolled at local schools.[1] On each farm, an ICS field officer measured 3 adjacent 30 square meter plots (this is a very small fraction of a typical farm). One plot was randomly assigned to receive Calcium Ammonium Nitrate (CAN) fertilizer to be applied as top dressing (when the plant is knee high). On the second plot, hybrid seeds were used in place of traditional varieties and Di-Ammonium Phosphate (DAP) fertilizer was supplied for planting along with CAN for top dressing. The latter combination is the full treatment recommended by the Ministry of Agriculture. The third plot was a comparison plot on which farmers farmed as usual with traditional seeds and with no fertilizer. ICS paid for the cost of the extra inputs (fertilizer and hybrid seed) and ICS field workers applied fertilizer and seeds with the farmers, followed the farmers throughout the growing season, harvested with them, and weighed the maize yield from each plot. Aside from these visits, the farmers were instructed to farm their plots just as they would have otherwise. Interviews with the farmers and field observation suggest that they did this.

At the end of a growing season, the maize was harvested, dried, and weighed with the farmer. In order to calculate the value of the extra maize from the treatment plot, it was necessary to take some care in measuring the yield. After maize is harvested, it must be dried and shelled, and the kernels must be left to dry for several days before it is ready for consumption or for sale in the marketplace. In later pilots, we attempted to determine the amount of weight that is lost as the maize dries by offering farmers incentives to carefully dry their harvested maize at their home. We then returned to measure the weight of the dried kernels and the ratio of the weight of the dry kernels to the weight at harvest and used these figures to calculate estimates for the earlier pilots.

The program was continued for a total of six growing seasons, with small differences from season to season. After the second pilot, ICS stopped using full treatment, and the amount of top dressing fertilizer used per hole varied from season to season. Most notably, some pilots used ½ teaspoon per hole, and others used 1 teaspoon, since the Kenya Agricultural Research Institute recommends 1 teaspoon per hole (KARI, 2000), while other authorities recommend ½ teaspoons or even less (Salasya, et al., 1998; Ouma, et al., 2002). In the fifth and sixth pilots, different quantities of fertilizer were used on different plots. The size of the demonstration plots also varied from pilot to pilot.

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[1] Comprehensive lists of households of this area are not available but fertility and primary school enrollment rates in this area are both high, so while this is not a representative sample it should not be that atypical either.

In total, six pilot projects were conducted over three years (Kenya has two growing seasons per year), with sample sizes ranging from 29 to 97 farmers. Surveys suggest that there were no differences in farmer-provided inputs, including labor inputs, such as time spent weeding, between the plots.

Table 1 presents the mean and median rate of return obtained for each farmer by taking the difference between the value of the output of the treated plot and the value of the output for the comparison plot, and dividing by the cost of the inputs. Because the price of maize fluctuates considerably during the season and the price of fertilizer does not seem to, the calculations below are done for two prices, 25 Kenyan shilling (Ksh) per goro/goro (a volume measurement which is used for measuring maize at the market), which is the price at harvest, and 40 Ksh per goro/goro which is the price of maize at its maximum price over the season. These figures are based on local prices during the three years ICS has been collecting data, but these numbers are consistent with a much longer historical time series of prices in Nairobi and in cities closer to Busia.

Even at the conservative estimate of 25 Ksh per goro-goro fertilizer yields an average return of 39.6% to ½ teaspoon of top dressing fertilizer per hole over a 4-month period (280% annualized). The valuation of 40 Ksh per goro-goro yields an average return of 123.4% for a 13-month investment (110% annualized). These preliminary results suggest that using the correct amount of top dressing fertilizer is quite profitable, so that low rates of usage cannot be explained purely by unsuitability to African soils, as suggested by Voortman et al. (2000).

In contrast, the official full package recommended by the Ministry of Agriculture is actually unprofitable on average, largely because the seeds may not germinate, causing a complete failure (in contrast, recall that top dressing is applied only after seeds have germinated). Moreover, the rate of return to 1 teaspoon of top dressing fertilizer is consistently less profitable than ½ teaspoon, which suggests that an important part of the learning process is the amount of fertilizer to be used. This suggests that Jovanovic and Nyarko's (1996) target input model of technology adoption, which is also the model employed by Foster and Rosenzweig (1995) is a good framework to model learning and adoption. This is an environment in which learning *how* to use fertilizer may be as important as learning about rates of return, and therefore an environment where we could see learning by doing as well as learning from others. There is also considerable variability in the rate of returns to fertilizer.

B. Learning

The extent to which people learn from each other is a central question in development economics. In particular, the diffusion of new technologies through social networks (neighbors, friends, etc.) has been and continues to be intensively studied (see Munshi (2005) for a recent review of the work in the area). The impact of learning on technology adoption in agriculture has been studied particularly extensively. Besley and Case (1994) show that in India, adoption of HYV seeds by an individual is correlated with adoption among their neighbors. While this could be due to social learning, it could also be the case that common unobservable variables affect adoption of both the neighbors. To partially address this problem, Foster and Rosenzweig (1995) focus on profitability. During the early years of the green revolution, returns to HYV were uncertain and dependent on adequate use of fertilizer. In this context, the paper shows that profitability of HYV seeds increased with past experimentation, by either the farmers or others in the village. Farmers do not fully take this externality into account, and there is therefore underinvestment. In this environment, the diffusion of a new technology will be slow if one neighbors' outcomes are not informative about an individual's own conditions. Indeed, Munshi (2003) shows that in India, HYV rice, which is characterized by much more varied conditions, displayed much less social learning than HYV wheat.

All these results could still be biased in the presence of spatially correlated profitability shocks. Using detailed information about social interactions, Conley and Udry (2005) distinguish geographical neighbors from “information neighbors”, the set of individuals from whom an individual neighbor may learn about agriculture. They show that pineapple farmers in Ghana imitate the choices (of fertilizer quantity) of their information neighbors when these neighbors have a good shock, and move further away from these decisions when they have a bad shock. Conley and Udry try to rule out that this pattern is due to correlated shocks by observing that the choices made on an established crop (maize-cassava intercropping), for which there should be no learning, do not exhibit the same pattern.

All these papers try to solve what Manski (1993) has called the “reflection problem”: outcomes of neighbors may be correlated because they face common (unobserved) shocks, rather than because they imitate each other. This problem can be solved, however, with an experimental design in which part of a population is subject to a program that changes their behavior. The ideal experiment to identify social learning is to exogenously affect the choice of technology of a group of farmers and to follow subsequent adoption by themselves and their neighbors, or agricultural contacts.

The current setup is well-suited to test the proposition that lack of information about either the rate of return to fertilizer, or its proper use, discouraged the farmers from using fertilizer, as well as the strength of network effects: since the farmers participating in each pilot were randomly selected from the parents of a school list, participating in the trials is randomly assigned within a school, and parents from the same schools that were not selected form a control group. Moreover, by comparing those with whom the treatment farmers report talking to about agriculture to those with whom the comparison farmers report talking to, we can experimentally investigate whether knowledge is transmitted within networks.

B1. The trials as agricultural extension

The trials can be thought of as a particularly intense form of agricultural extension. After the harvest, and ICS field officer discussed the results of the experiment in detail with each farmer, and helped him to work through a calculation of costs and benefits of using fertilizer, using his own data as well as the data for all the farmers who participated in the trials. If the farmers lacked information either about costs or about the proper way to use fertilizer, this intervention should have provided that to them.[2]

After each pilot, we have been following each farmer to see if he chose to use fertilizer or any other inputs on his own in subsequent seasons. Table 2 presents the results. Panel A presents the adoption results for all the farmers involved in the six trials, the season immediately after and in the next seasons. The data is pooled across all pilots, and all the regressions control for a dummy for the school the farmer belong to (since randomization was stratified within school). The samples varies across columns, since the number of times a farmer was observed after the initial trial depends on when the trial was conducted. The results are presented for up to 5 seasons following the pilot (although the set of farmers for whom we have data is different for different duration after the trial). Adoption is 10.7 percentage points (or 66%) higher the season after the pilot, This effect is statistically significant, and does not represent a trivial increase. However, it

[2] We have collected data on farmers' belief about fertilizer costs and benefits both in treatment and comparison groups. The analysis of this data is not yet complete, however.

also suggests in the season after the trial, only 27% of the farmers, on average use fertilizer. This does suggest that lack of know-how is not the only barrier to the adoption of fertilizer. Panel B restricts the sample to farmers that are observed in the three seasons following the trials and investigates whether the effect of participating in a trial declines over time. In this sample, the effect in the season after the trial was initially larger than in the larger sample (17%), but declines the season after (to 11%), and seems to remain stable thereafter (at 11%).

B.2 Learning by doing

The trials gave the farmers the opportunity to experiment with fertilizer in their own farm, but it also provided them with additional inputs: the fertilizer was applied with an ICS field officer, who also visited the farmers regularly, and who helped them compute their rate of return and gave information on results obtained by others at the end of the intervention. To distinguish the effect of learning by doing from the effect of the additional information provided, ICS implemented two separate programs in different samples.

The first program was designed to evaluate the impact of learning by doing. In this program, each farmer was provided with a “starter kit”, consisting of a small quantity of fertilizer or fertilizer and hybrid seeds (for a sub-sample) sufficient for a 30-square-meter plot. Farmers were instructed that the kit was sufficient for this amount of space, and were given twine to measure two plots of the relevant size. Beyond this, there was no monitoring of whether or not (and how) the farmers used the starter kit. Starter kits have been used elsewhere; for instance, the Malawian government distributed 2.86 million such packs beginning in 1998 (Masters et al., 2000). In the ICS program, field staff explained how to use the inputs but did not formally monitor or measure the yields.

Starter kits were distributed to over 400 farmers randomly selected within 20 schools, in three seasons. Their impact on the adoption of fertilizer or other seeds were evaluated for this entire sample in the two seasons following the pilot. The results are presented in table 3. Starter kits cause a significant increase in fertilizer adoption in the following season, although the effect is about half the size of the own farm trial (5 percentage point), and does not persist in the following year.

B.3 Learning by Watching

The other component of the agricultural trial was regular contact with a field officer who demonstrated how to use fertilizer, and guided the farmers through a computation of the rate of returns for themselves and for other farmers in the same area. To evaluate the impact of this component, and to separate it from the effect of experimenting in one's own farm, in three of the trials, ICS asked the farmer to name 3 people with whom they regularly discuss agriculture. In two the of the trials, they then invited one farmer randomly selected from this set to the key stages of the trial (notably, planting, harvest, and the discussion of profitability). In the third trials, they invited all the friends named by the farmer.

The impact on subsequent adoption of fertilizer amongst these farmers is presented in Table 4. The first two columns compare the adoption of fertilizer of the farmers who were invited to watch the trial on their friend's farm to adoption among other contacts of the pilots and contacts of the comparison farmers (we also include a dummy for being a friend of the pilot, but not having been invited to the trials; we will discuss this variable below). After one season, adoption of fertilizer treatment is 9 percentage points higher in the first group. This suggests that the effect of being invited to watch a demonstration on someone else's plot is as large as the effect of experimenting on one's own plot. It is possible to learn from others. Note that not all farmers who were invited actually came to the trials. If there are no large direct effect on future adoption of being invited even for those who did not go, this suggest an even larger effect of watching the trials for farmers who chose to attend: the IV estimates are presented in panel B, and suggest that for those who decided to come to the trial, the effect of watching the trial is 21%. While these are overestimates to the extent that the very fact of being invited may have had a direct impact even for those who decide not to attend (in particular, this may prompt a conversation on fertilizer between the farmer and his or her friend), it is sensible that the effects are indeed larger for those who chose to participate, since those who decided to come were probably those who were interested to learn in the first place.

Since these results suggest that learning from experience in another field is possible, ICS set up a school-based demonstration intervention, which would make it possible to replicate this experience on a larger scale. They randomly selected 8 of 16 schools for this treatment. In those 8 schools, they selected one grade, and they invited all the parents to participate on a demonstration plot on the school ground (schools have typically space to grow a small maize farm). The demonstration followed the same protocol as the demonstration on the pilot farm: 2 plots were set up (though they were larger than the previous demonstration plots), and one of them received fertilizer, while the other was left as a control plot. Parents of this grade, and of one randomly selected grade in comparison, also received a starter kit at the beginning of the next season.

The results on these experimental plots were disappointing, however. Parents and children are responsible for maintaining the school's farm. But in many cases, the maize was not properly taken care of, and in some plots the crop was entirely destroyed (by animals) or stolen. Even in plots that were harvested, the overall yield, and consequently the returns to fertilizer were low. As a result, the plots had negative returns for most of the 8 plots. At the post-harvest de-briefing, parents were told that the returns on their plot and that of the other school in this season were negative, and that other trials conducted in the area had shown positive results.

In the next season, ICS field officers collected adoption data among the parents of these schools. The results are shown in table 5, column 1: parents who have a child in class selected for the demonstration plot are actually *less* likely to adopt fertilizer than those who are not. Given the low performance of the treatment plots, the fact that the coefficient is insignificant and the point estimate is negative is actually reassuring: it suggests that the increased adoption in response to the pilot was actually the result of them updating their belief about fertilizer in response to a positive experience. In contrast they do not update positively, and may be even update negatively, in response to a negative experience.[3]

This also suggest that while agricultural trials may be effective in diffusing information, on-farm agricultural trials are expensive, while community based trials may not deliver expected results, due to the public good problem involved with properly maintaining the plots. This implies that, while farmer can learn from them, trials may not be a cost effective way to diffuse information about technology, unless these technologies diffuses rapidly once it is introduced. This is what we turn to now.

B.4 Learning from others

We studied diffusion, by following both the neighbors (geographical network) and the people named as agricultural contacts (actual network) of the pilot and the comparison farmers. As we

[3] We have actually collected extensive data on belief regarding the cost and benefits of fertilizer, before and after the experiments. These will be analyzed in the next draft.

discussed, diffusion of agricultural technology has been a focus of much attention in previous literature, but this setup allows us to provide experimental evidence that does not suffer from omitted variable or simultaneity bias.

Table 6 shows the results for agricultural contacts (panel A) and neighbors (panel B). The second row in table 4, panel A, also show similar results[4] In each of these panels, we compare the friends (or the neighbors) of the pilot farmers with the friends (or the neighbors) of the comparison farmers. Panel A shows no evidence of the diffusion of the use of fertilizer: The difference between the friends of the pilot farmers and the friends of the comparison farmers is only 1.7%. the standard errors are large enough to reject a 7 percentage point increase, which is smaller than the effect we found on own farmer or on the "invited friends". Panel B's result suggests that the same is true for neighbors. The point estimates are actually slightly negative, though they are not significantly different from zero. Since these experiments took place early on in the project, these friends and neighbors are followed up over a long period of time. But it does not appear that even after 4 seasons and later, there is any impact of being a friend or a pilot of a neighbor on adoption. In fact, even pooling the data across years, which generates a large sample and smaller standard errors (we cluster the standard error at the farmer level since we observe the same farmers several times), the result remain really close to zero and insignificant.

These results do suggest that farmers do not discuss much about agriculture: if they did, they would probably be able to learn from each other's experience, as the other experiments show. To verify this, we interviewed farmers about their neighbors and cross-checked their answers. Indeed, there seems to be considerable uncertainty regarding the activities of the neighbors: 39% farmers agree about whose harvest was better. Only 46% of farmers correctly state when their neighbor planted. Pilot farmers and their neighbors do not have more accurate information about each other than comparison farmers and their neighbors

Overall, what may be surprising about these effects is that all the learning effects are quite small: adoption increases from 18% to 28% the season after a pilot conducted in one's own farm, from 18% to 23% after experimenting with a starter kit, . There is no diffusion to the neighbors and the people that the farmers talk to about agriculture, though we have shown that this does not stem from an inability to learn from another plot (since the effect of being invited to watch a

[4] The only difference between Panel A of table 6 and panel A of table 3 is that the sample is restricted to friends who were not invited to the trials.

demonstration on someone else's plot is as large as the effect of doing the demonstration on one's own plot). It seems that something else is preventing farmers to adopt fertilizer.

C. Savings, Commitment, and Reminders

C.1 Pilot Programs

These results suggest that knowledge both about how to use fertilizer and the returns to fertilizer are a factor in future adoption. However, even after participating in the experiment, more than half the farmers do not use fertilizer. A possible explanation is that farmers are unable to save the money they need to buy fertilizer, despite their desire to do so. This suggests that a savings mechanism in which to hold their money could help them invest in agricultural inputs. To explore this issue, ICS set up the Savings and Fertilizer Initiative (SAFI) in 2001, a program which provides a commitment device for those farmers who wanted to use fertilizer.

The main idea behind the SAFI program is that farmers would like to use fertilizer, but do not have the money on hand when fertilizer is needed (at planting or top dressing). The general principle of the SAFI program is that the farmer is visited right after harvest (when maize and, potentially, money is relatively plentiful), and is offered the option of purchasing a voucher for fertilizer. ICS then delivers the fertilizer at the time of planting. The program is therefore a commitment device, akin to a 401(k) program. The first step was to conduct a series of small pilot programs, where different variables which, based on theories from psychology and form economics, are likely to affect the take up were combined,. Panel A of table 8 presents the take up aggregated over the various pilot programs.

In the first version of the program (SAFI 2), a group of farmers were randomly selected, and visited right after harvest. They were visited twice, once to ask them whether they wanted to participate in the program, and one other time, a few days to a couple of weeks later, to collect the money. Sixty-six percent of the farmers expressed interest, and 22.6% eventually purchased fertilizer. In the subsequent versions of the program (SAFI 3, 4, and 5), we combined SAFI with the pilot program: pilot farmers were asked whether they wanted to use some of the maize that they had just harvested to purchase fertilizer. Moreover, in SAFI 4, we had asked them to sell us part of their harvest anyway. In either case, we asked them to make a decision and give us the money right away, so that they had no chance to procrastinate.

The take up of SAFI 3 and 4 was very high: Among those who were offered SAFI 3 or 4, over 80% of farmers did indeed purchase fertilizer. The interpretation of these results is complicated by two facts. SAFI 3 was offered only to farmers who had done particularly well in the experiments (we therefore need to compare take up of fertilizer between farmers who were offered SAFI and those who were not among those who had done well in the experiment). For SAFI 4, all Pilot 4 farmers were asked to sell part of their maize anyway: farmers may have been happier to hold on to maize than to hold on to cash, if they thought that cash was more likely to be dissipated rapidly. Nevertheless, these results are quite striking, and do suggest that the farmers make use of the commitment device, at least when they have an unexpectedly high harvest or an extra amount of cash available.

We offered the SAFI program again in the following year to a subset of the farmers who had been offered SAFI 4. They still had the option of selling us maize to buy fertilizer. However, since they were not compelled to sell maize for some other reason, they were left the option of taking a few days to collect the money. The take up of SAFI 4 exhibits the same pattern as the take up for SAFI 2: Most (81.8%) of the farmers initially expressed interest, but after a few days, only 30% eventually purchased for fertilizer. This is still substantially higher than the fraction of farmers who are using fertilizer in the control group, which suggest that, even if all the farmers who were going to use fertilizer anyway purchased fertilizer from us, the program increased the fraction of people who are using fertilizer.

SAFI 5 explicitly explored the value of the commitment device. All Pilot 5 farmers were asked to sell a small quantity of maize for the experiment. They were then divided into three groups. The first group was offered the same program as before: They had the option of buying fertilizer right away, paying either in cash or by selling maize. The second group were offered the program, but were told that we would come back in a few days to collect the money. The third group was asked whether they wanted us to come back at the time of top dressing with fertilizer that they would then pay for (either in cash or in maize). The contrast between the three groups is striking: In all cases, about 50% of farmers expressed interest in the scheme. However, the actual take up decreases from 50% when the money is collected on that day to 29% when the money is collected a few days later, to 0% when the money is collected at the time of top dressing.

The results from Pilot 4 suggested that individuals may be more willing to invest in fertilizer after harvest if they hold wealth in a liquid asset like cash instead of maize. Pilot 6 explored this issue further, by offering two SAFI variants. In the first, farmers were encouraged to sell their maize to ICS so that they would have more cash on hand; the second was of the standard SAFI variety. Seventy-one percent of those that were encouraged to sell maize took up SAFI compared to 50% of the standard SAFI group, suggesting that the cash had some effect on take-up.

C2. SAFI, Subsidy, and Free delivery

C2.1. Experimental Design

The results from the different take up in the pilot suggest that SAFI was successful in encouraging fertilizer adoption. However, the samples in the different versions of SAFI were small and not necessarily comparable. We therefore set up, in conjunction with ICS, a large scale SAFI experiment conducted over two seasons, to evaluate the impact of a SAFI program conducted on a large scale, and to tests key hypotheses helping us to understand the impact of the program.

The questions and hypotheses the experiments set out to answer or test were as follows, First, the main hypothesis is that SAFI leads to higher adoption because of the *timing* at which people are offered to buy fertilizer, not only because, by offering to deliver fertilizer at home, the NGO is strongly endorsing fertilizer or because the free deliver was convenient. And is timing is what matter, how does the elasticity of fertilizer purchase compare to that with respect to price?

Second, there are some questions which have to do with the design of SAFI: is SAFI more valuable when the individual as cash on hands? Does it vary with previous exposure to fertilizer? Does it vary if people can chose in advance the timing at which the offer should be made: are they sophisticated enough to request an early visit, rather than a late visit if they are asked in advance which date to chose?

In order to answer this question, we set up a two-year large scale SAFI experiment in the 16 schools that form the treatment and the control for the school based demonstration program. The experiment started in the season following the demonstration plots experiment. In this season (the 2004 Long Rains), a simple SAFI program (no choice of timing, the offer is a take it or leave it offer) was offered to 244 farmers after stratifying by school and class (i.e. whether or not the farmer received a starter kit).

In the following season (the 2004 Short Rains), the experimental design was set up to allow us to test a variety of hypotheses. .

First, to study the impact of the availability of liquidity on the purchase of fertilizer, a set of farmers was asked to sell some maize at an increased price ("buy" condition)
SAFI was then offered to randomly selected farmers, stratifying by school, starter kit status, prior SAFI status, and "buy" status. Second, two variants of SAFI were offered:

- No choice condition: the farmer must buy a voucher immediately if he wishes to participate (offered at harvest time)
- Choice condition: the farmer can decide *before harvest* when he would like the field officer to come back to offer the SAFI. The farmer could request that the field officer return at harvest, at planting, or at top dressing time. This condition was set up to test whether farmers are sophisticated in their decision of purchasing fertilizer (and program it in advance), or whether the fertilizer purchase right after harvest is an "impulse purchase".

In total, 417 farmers were offered SAFI in this program.

In addition, a set of farmers that were not sampled for SAFI were visited at planting time during the same (2004 Short Rains) season. These farmers were sampled using the same stratified sampling method as for SAFI and were offered fertilizer either at full price (but with free delivery) or at half price. Thus those offered fertilizer at full price were saved travel costs and were offered an implicit "endorsement" of fertilizer usage, while those offered fertilizer at half price were offered these incentives plus a subsidy on the price.

C2.2 Results: Take up of the program

The main results concerning the take up of of these interventions are summarized in Table 8. The average take up in the "visit" group (those offered fertilizer at planting time at full price) was 21%; that is, 21% of those visited at planting did buy fertilizer for planting. The average take up in the 50% "subsidy" group was 46.2%. The average take up in the SAFI group was 39.8%. The difference in take-up between those offered fertilizer at full price and the SAFI and subsidy groups is significant, but the average difference between SAFI and the 50% subsidy is not. This suggests that SAFI increases fertilizer purchase over and above "endorsement" and "convenience," and that its effect on purchase of fertilizer is roughly equivalent to that of a 50% subsidy.

This result confirms that the timing of the SAFI offer is central to its adoption. One more result is important to understand the role that the offer of buying fertilizer at this particular moment for the farmer means: in the group that was asked before the harvest (in the lean season) whether and when the field officer should come back to sell them fertilizer, and if when at what time, the eventual purchase of fertilizer was *as large* as in the group that did not have the choice. This is because a large fraction of farmers (46.8%) in the choice condition asked the field officer to come back immediately after harvest. This suggest that the decision to buy fertilizer when the farmers were "flush with cash" do not correspond to an impulse purchased prompted by the cue given by the field officer. If this were the case and fertilizer were not purchase that the farmer knows they would want to make, when visited before harvest they would ask the field officer to come back at planting, and would end up not purchasing fertilizer. In fact, they ask them to come early, and they do buy fertilizer when they come. Another important result, which goes in the same direction, is the lack of difference in take up in the two groups where the farmers had cash on hands (because they were asked to sell some maize for the experiment). Contrary to what was observed in the smaller pilots, farmers were no more likely (in fact marginally *less* likely) to purchase fertilizer right after they had sold maize. This does suggest that their decision to purchase maize under SAFI is not only taking an opportunity to get rid of extra liquid resources.

C2.3 Results: Adoption of fertilizer

A major advantage of this experimental set up (unlike, for example many experiments conducted on 401k or IRA) is that we are able to evaluate the impact of the program on the final decision of interest (did the farmer use fertilizer). We can thus measure the extent to which the farmers who purchased fertilizer under the program would have done it anyway, and to what extent the take up is a substitution effect, and also to what extend those who bought fertilizer did not actually use it (i.e., to what extent purchasing fertilizer in advance is actually a commitment device).

A detailed survey on the adoption of fertilizer by *everyone* in the family (farmers grow different plots, some in common, and some for their private use, in particular in multi-wives household) was conducted in three seasons in the schools where SAFI programs were implemented. In this survey, when farmers who had purchased fertilizer under any of this program reported not using fertilizer, we also asked them what they did with it (it had been very explicit at the time of the program that the fertilizer they purchased was theirs, and they could do what they wanted with it). Roughly 75% of the farmers who purchased fertilizer under the program initially say that they have used any fertilizer. When the 25% remaining ones are asked what they did with the fertilizer they purchased under SAFI, roughly 24% of them do not remember having ever gotten fertilizer through SAFI (these are only 8 farmers in total), and among the remaining ones, most report having used fertilizer after all, having kept it for another season, or having used it on another crop than maize. In almost no circumstance did the fertilizer spoil or was it sold or given away to someone else. It therefore does look that fertilizer purchased under the SAFI program is indeed used on the maize crop.

The fraction of those who purchased fertilizer at the time of planting, either at half price or at reduced price, who initially said they used fertilizer is lower (68% and 61%) respectively. When probed, most say that they have actually used the fertilizer. Interestingly, though anecdotally, two farmers say that they did not use the fertilizer because it spoiled, which is very unlikely, since it was sold just before it should be used.

Similar adoption data was collected for comparison farmers. Since there was no comparable probing of whether or not the farmer really used fertilizer for comparison farmers, we use in both cases the “raw”, uncorrected data (that is, if a farmer who purchased fertilizer through SAFI or any other ICS program initially tells us that they did not use fertilizer, we count them as not using fertilizer even if they corrected their answer later on (the corrected results are presented in an appendix table, and the conclusion are qualitatively very similar). The results on adoption are presented in tables 9 and 10. Since not all programs took place in the same year we show in bold the coefficient in the first year where we expect to see an effect. Panel A does not have control variables, while panel B control for education, some indicator of wealth, and prior use of fertilizer.

Column 1 in panel A suggest that the first SAFI (where take up was about 30%) leads to a net increase in fertilizer adoption of 10%. Column 2 show that the second SAFI (where the take up was 40%) leads to an increase in adoption of 16%. Both suggest the same level of substitution, and suggest that the SAFI program has a significant net effect. The coefficients are slightly larger in the regressions with control variables: 13% and 20% for the first and second SAFI seasons, respectively.

Interestingly, in column 2, we see that the point estimate of the net effect of the 50% subsidy on fertilizer adoption is lower than that of SAFI, even though the take up of the program was similar. This is particularly striking in the regression with control variables, where the effect of SAFI on take up is 20 percentage points, and that of subsidy is 12 percentage points. Moreover, the impact of the full-price visit is also significant once control variables are introduced, and the effect is 14 percentage points, lower than that of SAFI but higher than that of subsidy. It suggests that a 50% subsidy does not have an additional impact on net usage of fertilizer over the free delivery, even though twice as many farmers take it up: clearly, most farmers who did take it up were infra-marginal, and would have used fertilizer anyway. This is much less true of SAFI, however, which seems to generate a large fraction of new adopters.

C2.4 Interpretation

This could be a simple story of commitment device (such as the one told by Ashraf, Karlan and Yin (2004)). There is, however, a very puzzling fact lingering in the background: the farmers are asked when they want the fertilized to be delivered. In most cases, they want it right away (i.e. much before they will actually use it). This is reasonable, since they may not trust ICS to conserve their money for a long period of time, and fertilizer keeps well over a period of a few weeks. But given this, and the fact that they seem to know their limitation, why don’t they buy fertilizer themselves right after harvest? It seems that a sophisticated farmers (which many seem to be) has the ability to do exactly what we did for them. Yet, almost nobody (even among the people who use fertilizer) buys fertilizer in advance.

We do not yet have a very good answer to this question. One possibility is that the farmers know they have an inconsistent time preference problem, but they procrastinate dealing with it, because they have to pay a small cost today, which they may be reluctant to do, precisely because they have time inconsistent time preferences. If this were the case, a small discount on the price of fertilizer today, but with a strong deadline (expiring shortly around harvest) would induce farmers to buy fertilizer at harvest time. We have tried this idea on a pilot basis, by distributing farmers in one school coupons to buy fertilizer at a 6 shilling (15%) discount. The coupons could be redeemed at any of the three stores in the villages. The take up of this program was quite high, at 29.8%. This suggests that the story we just told may be right. This also suggests a way to transform the SAFI program into a cost effective development intervention: while it is costly and logistically difficult to visit all the farmers exactly at the time of harvest, the coupons program would be relatively easy to generalize.

We have also visited a sample farmers at harvest time and reminded them that buying fertilizer at harvest time is possible, and that many farmers who want to use fertilizer do not end up doing it if they don't buy it at harvest time. This will tell us whether the only role of the SAFI program is to remind farmers of their time inconsistency problem: if the reminder intervention is as effective as SAFI, it will suggest that the main effect of SAFI is to remind people to act now and get fertilizer before they have postponed it long enough that they do not have resources for it anymore.

D. Conclusion

The problem of fertilizer adoption is both important in itself and because it embodies all the problems of technology adoption that we encounter in developing countries: from computers, to deworming drugs, to condoms. We have set up a series of randomized experiment to try to understand the determinants of fertilizer adoption. We conclude that while information matters, it only goes part of the way, and whatever information is provided seems to be forgotten fast and not diffused to friends and neighbors in the mean time. Other things seem important as well, in particular the ability to finance the purchase of fertilizer, which for many farmers, is synonymous with the ability to buy fertilizer at the time of harvest. We have seen that if farmers are offered to buy fertilizer at the time of harvest, many do, and this lead to substantial increases in adoption.

We are still to resolve why they do not do it themselves, and why the market is not proactively seeking this opportunity.

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Table 1: Returns to Fertilizer

	Top dressing 1/4 teaspoon			Top dressing 1/2 teaspoon			Top dressing 1 teaspoon			Full treatment		
	mean	median	obs	mean	median	obs	mean	median	obs	mean	median	obs
Panel A: Not Annualized												
25 Ksh per goro-goro	0.108	-0.173	117	0.396	0.164	203	-0.254	-0.428	275	-0.476	-0.494	85
40 Ksh per goro-goro	0.772	0.322	117	1.234	0.862	203	0.194	-0.084	275	-0.161	-0.191	85
Panel B: Annualized												
25 Ksh per goro-goro	0.506	-0.533	117	2.799	0.835	203	-0.690	-0.893	275	-0.925	-0.935	85
40 Ksh per goro-goro	0.696	0.294	117	1.100	0.775	203	0.178	-0.078	275	-0.150	-0.178	85

Table 2: Adoption for Farmers Participating in Demonstration Plot

	1 season later		*2 seasons later*		*3 seasons later*		*4 seasons later*		*5 seasons later*	
Panel A. All Farmers	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Demonstration Plot Farmer	0.107	0.107	0.089	0.061	0.101	0.06	0.156	0.118	0.229	0.258
	(0.039)***	(0.042)**	(0.044)**	(0.046)	(0.050)**	(0.054)	(0.089)*	(0.098)	(0.093)**	(0.100)**
Observations	580	577	523	521	450	447	116	116	109	109
Panel B. Only Farmers with at least 3 seasons of Adoption Data										
	(1)	(2)	(3)	(4)	(5)	(6)				
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*				
Demonstration Plot Farmer	0.169	0.172	0.113	0.065	0.112	0.079				
	(0.050)***	(0.056)***	(0.054)**	(0.059)	(0.054)**	(0.060)				
Observations	371	364	371	364	371	364				

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions control for school.

Table 3: Adoption for Farmers Offered Starter Kits

	1 season later		*2 seasons later*	
	(1)	(2)	(3)	(4)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.051	0.063	0.019	0.021
	(0.029)*	(0.029)**	(0.029)	(0.029)
Observations	1045	1042	1060	1059

Standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Regressions control for school.

Table 4: Adoption for Agricultural Contacts

	1 season later		*2 seasons later*		*3 seasons later*		*4 seasons later*		*5 seasons later*	
Panel A. OLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Invited Agricultural Contact	0.093	0.103	0.031	0.054	-0.014	-0.022	-0.059	-0.05	0.026	0.048
	(0.055)*	(0.059)*	(0.061)	(0.065)	(0.058)	(0.064)	(0.063)	(0.068)	(0.068)	(0.075)
Uninvited Agricultural Contact	0.002	-0.042	-0.015	-0.004	-0.015	-0.013	-0.08	-0.051	-0.132	-0.184
	(0.035)	(0.038)	(0.038)	(0.041)	(0.037)	(0.040)	(0.068)	(0.073)	(0.089)	(0.097)*
Observations	708	706	580	580	557	556	215	215	177	176
B. Panel B: 2SLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Came to Treatment (instrumented	0.212	0.236	0.072	0.126	-0.03	-0.049	-0.123	-0.104	0.053	0.094
with Invited Agricultural Contact)	(0.127)*	(0.138)*	(0.142)	(0.151)	(0.129)	(0.141)	(0.133)	(0.142)	(0.137)	(0.150)
Uninvited Agricultural Contact	-0.002	-0.047	-0.017	-0.007	-0.014	-0.012	-0.082	-0.053	-0.131	-0.182
	(0.037)	(0.040)	(0.039)	(0.042)	(0.037)	(0.041)	(0.068)	(0.072)	(0.088)	(0.098)*
Observations	708	706	580	580	557	556	215	215	177	176

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions control for school.

Table 5: Adoption for Parents Sampled for School-Based Demonstration

	1 season later		*2 seasons later*		*3 seasons later*	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Control for School	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.085	0.091	**0.047**	**0.041**	0.011	-0.006
	(0.045)*	(0.046)**	**(0.049)**	**(0.049)**	(0.045)	(0.046)
Sampled to Participate in School Demonstration Plot	**-0.046**	**-0.051**	0.018	0.010	-0.016	0.039
	(0.064)	**(0.066)**	(0.071)	(0.072)	(0.065)	(0.066)
Observations	874	874	752	750	900	899
Panel B. Other Controls	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.093	0.096	**0.027**	**0.010**	-0.016	-0.020
	(0.045)**	(0.045)**	**(0.047)**	**(0.048)**	(0.049)	(0.050)
Sampled to Participate in School Demonstration Plot	**-0.075**	**-0.083**	-0.021	-0.028	-0.052	-0.024
	(0.065)	**(0.066)**	(0.069)	(0.070)	(0.072)	(0.073)
Home has mud walls	-0.175	-0.109	-0.088	-0.085	0.064	0.064
	(0.079)**	(0.080)	(0.083)	(0.084)	(0.086)	(0.088)
Home has mud floor	-0.046	-0.107	-0.031	-0.040	-0.127	-0.100
	(0.073)	(0.074)	(0.077)	(0.077)	(0.080)	(0.081)
Home has thatch roof	-0.034	-0.039	0.080	0.063	-0.050	-0.060
	(0.037)	(0.038)	(0.039)**	(0.039)	(0.040)	(0.041)
Education primary respondent	0.009	0.009	-0.004	-0.006	0.015	0.016
	(0.004)**	(0.004)**	(0.004)	(0.004)	(0.005)***	(0.005)***
Gender	0.016	0.006	0.003	0.017	-0.040	-0.045
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Has household ever used fertilizer before?	0.24	0.28	0.17	0.20	0.08	0.16
	(0.037)***	(0.038)***	(0.041)***	(0.041)***	(0.042)*	(0.043)***
Household had used fertilizer in the 1st season after			0.390	0.387		
			(0.039)***	(0.040)***		
Household had used fertilizer in the 2nd season after					0.305	0.231
					(0.039)***	(0.040)***
Observations	774	774	648	646	652	651

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions control for school.
Coefficient in bold indicate the season in which we would expect to see an effect. Seasons are measured starting with the season of the demonstration plot. Starter kits were given out in the 1st season after the demonstration plot.

Table 6: Adoption for Other Contacts of Demonstration Plot Farmers

	1 season later		*2 seasons later*		*3 seasons later*		*4 seasons later*		*5 seasons later*	
Panel A: Agricultural Contacts of Demonstration Plot Farmers (not invited to witness treatment)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Pilot Friend (not invited to treatment)	0.017	-0.019	-0.01	-0.001	0.009	0.024	-0.049	-0.03	-0.103	-0.168
	(0.037)	(0.041)	(0.041)	(0.044)	(0.040)	(0.043)	(0.076)	(0.079)	(0.097)	(0.103)
Observations	547	545	436	436	423	422	139	139	97	97
Panel B. Neighbors of Demonstration Plot Farmers										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Pilot Neighbor	-0.04	-0.071	-0.037	-0.037	-0.023	-0.043	-0.034	-0.019	-0.074	-0.091
	(0.049)	(0.055)	(0.048)	(0.051)	(0.047)	(0.051)	(0.055)	(0.059)	(0.058)	(0.063)
Observations	264	264	383	383	366	365	247	247	265	265

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions control for school.

Table 7: Adoption for SBSK1 Friends

	1 season later		*2 seasons later*		*3 seasons later*	
	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
frsbsk1_reg	0.086	0.027	0.048	-0.036	0.115	0.030
	(0.073)	(0.077)	(0.074)	(0.080)	(0.072)	(0.074)
frsbsk1_frdemo_reg	-0.018	0.012	-0.072	0.021	0.011	0.067
	(0.105)	(0.110)	(0.104)	(0.113)	(0.103)	(0.104)
frsafi_lr04_reg	0.000	0.015	0.029	0.050	0.112	0.105
	(0.061)	(0.064)	(0.059)	(0.064)	(0.060)*	(0.061)*
frsafi_sr04_reg	0.045	0.001	-0.011	-0.065	0.031	-0.011
	(0.080)	(0.084)	(0.075)	(0.081)	(0.077)	(0.078)
frsubsidy_reg	-0.039	-0.038	-0.077	-0.081	-0.005	-0.044
	(0.092)	(0.096)	(0.090)	(0.097)	(0.090)	(0.091)
frfullprice_reg	0.000	-0.053	-0.120	-0.181	0.059	-0.069
	(0.094)	(0.099)	(0.092)	(0.099)*	(0.092)	(0.093)
Observations	370	370	315	313	387	387

Standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Take-up of Various Commitment Savings Products (SAFI Program)

Panel A. Pilot SAFI Programs		*Number of Farmers*	*Percentage*
option 1: take-it-or-leave-it	Offered SAFI	54	
	Initially accepted	30	0.556
	Actually paid	30	0.556
option 2: take-it-or-leave-it	offered SAFI	49	
(with cash effect)	initially accepted	39	0.796
	actually paid	39	0.796
option 3: return in a few days	offered SAFI	50	
to collect the money	initially accepted	35	0.700
	actually paid	15	0.300
option 4: return in a few months	offered SAFI	71	
to collect the money	initially accepted	44	0.620
	actually paid	12	0.169

Panel B. School Based SAFI Program		*Number of Farmers*	*Percentage*
SAFI Long Rains 2004	Bought Fertilizer	74	0.306
	Didn't buy Fertilizer	168	0.694
SAFI Short Rains 2004			
Given Choice X Bought Maize	Bought Fertilizer	19	0.322
	Didn't buy Fertilizer	40	0.678
Given Choice X Didn't Buy Maize	Bought Fertilizer	66	0.440
	Didn't buy Fertilizer	84	0.560
Not Given Choice X Bought Maize	Bought Fertilizer	24	0.414
	Didn't buy Fertilizer	34	0.586
Not Given Choice X Didn't Buy Maize	Bought Fertilizer	57	0.380
	Didn't buy Fertilizer	93	0.620
Total	Bought Fertilizer	166	0.398
	Didn't buy Fertilizer	251	0.602
Subsidy Short Rains 2004	Bought Fertilizer	67	0.462
	Didn't buy Fertilizer	78	0.538
Full Price Visit Short Rains 2004	Bought Fertilizer	28	0.196
	Didn't buy Fertilizer	115	0.804

Table 9: Adoption for Parents Sampled for School-Based SAFI and Subsidy

	1 season later		*2 seasons later*		*3 seasons later*	
Panel A. Control for School	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.085	0.091	**0.047**	**0.041**	0.011	-0.006
	(0.045)*	(0.046)**	**(0.049)**	**(0.049)**	(0.045)	(0.046)
Sampled to Participate in School Demonstration Plot	**-0.046**	**-0.051**	0.018	0.010	-0.016	0.039
	(0.064)	**(0.066)**	(0.071)	(0.072)	(0.065)	(0.066)
SAFI Long Rains 2004	**0.103**	**0.082**	-0.020	-0.024	-0.018	-0.001
	(0.038)* **	**(0.039)** **	(0.043)	(0.043)	(0.039)	(0.039)
SAFI Short Rains 2004	-0.037	-0.079	**0.169**	**0.135**	-0.033	-0.047
	-0.047	(0.048)*	**(0.053)*** **	**(0.054)** **	-0.048	-0.048
Subsidy Short Rains 2004	-0.046	-0.091	**0.142**	**0.113**	0.024	-0.009
	(0.056)	(0.057)	**(0.063)** **	**(0.064)* **	(0.057)	(0.057)
Full Price Visit Short Rains 2004	-0.089	-0.114	**0.070**	**0.042**	-0.064	-0.086
	(0.056)	(0.057)**	**(0.063)**	**(0.064)**	(0.057)	(0.057)
Observations	874	874	752	750	900	899
Panel B. Other Controls						
	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.093	0.096	**0.027**	**0.010**	-0.016	-0.020
	(0.045)**	(0.045)**	**(0.047)**	**(0.048)**	(0.049)	(0.050)
Sampled to Participate in School Demonstration Plot	**-0.075**	**-0.083**	-0.021	-0.028	-0.052	-0.024
	(0.065)	**(0.066)**	(0.069)	(0.070)	(0.072)	(0.073)
SAFI Long Rains 2004	**0.134**	**0.124**	-0.041	-0.036	0.001	-0.005
	(0.038)* **	**(0.039)*** **	(0.041)	(0.041)	(0.043)	(0.044)
SAFI Short Rains 2004	-0.020	-0.064	**0.198**	**0.179**	-0.073	-0.093
	(0.047)	(0.048)	**(0.051)*** **	**(0.052)*** **	(0.054)	(0.055)*
Subsidy Short Rains 2004	-0.077	-0.116	**0.129**	**0.108**	-0.002	-0.047
	(0.056)	(0.057)**	**(0.061)** **	**(0.061)* **	(0.063)	(0.065)
Full Price Visit Short Rains 2004	-0.073	-0.094	**0.140**	**0.132**	-0.118	-0.116
	(0.057)	(0.058)	**(0.062)** **	**(0.062)** **	(0.064)*	(0.066)*
Home has mud walls	-0.175	-0.109	-0.088	-0.085	0.064	0.064
	(0.079)**	(0.08)	(0.08)	(0.08)	(0.09)	(0.09)
Home has mud floor	-0.046	-0.107	-0.031	-0.040	-0.127	-0.100
	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)
Home has thatch roof	-0.034	-0.039	0.080	0.063	-0.050	-0.060
	(0.04)	(0.04)	(0.039)**	(0.04)	(0.04)	(0.04)
Education primary respondent	0.009	0.009	-0.004	-0.006	0.015	0.016
	(0.004)**	(0.004)**	(0.00)	(0.00)	(0.005)***	(0.005)***
Gender	0.016	0.006	0.003	0.017	-0.040	-0.045
	(0.032)	(0.033)	(0.034)	(0.035)	(0.036)	(0.037)
Has household ever used fertilizer before?	0.239	0.275	0.174	0.196	0.083	0.159
	(0.037)***	(0.038)***	(0.041)***	(0.041)***	(0.042)*	(0.043)***
Household had used fertilizer in the 1st season after			0.390	0.387		
			(0.039)***	(0.040)***		
Household had used fertilizer in the 2nd season after					0.305	0.231
					(0.039)***	(0.040)***
Observations	774	774	648	646	652	651

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Coefficient in bold indicate the season in which we would expect to see an effect. Seasons are measured starting with the season of the demonstration plot. Starter kits were given out in the 1st season after the demonstration plot. SAFI for the 2004 Long Rains also took place in the 1st season.
SAFI for the 2004 Short Rains, and the Subsidy and Full Price Visits took place in the 2nd season.

Table 10: Adoption for Parents Sampled for SAFI, Subsidy

	1 season later		*2 seasons later*		*3 seasons later*	
Panel A. Control for School	(1)	(2)	(1)	(2)	(1)	(2)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.097	0.089	**0.076**	**0.063**	0.017	-0.011
	(0.047)**	(0.048)*	**(0.051)**	**(0.052)**	(0.047)	(0.048)
Sampled to Participate in School Demonstration Plot	**-0.047**	**-0.052**	0.015	0.007	-0.016	0.039
	(0.064)	**(0.066)**	(0.071)	(0.072)	(0.065)	(0.066)
SAFI Long Rains 2004	**0.102**	**0.081**	-0.022	-0.026	-0.017	-0.001
	(0.038)* **	**(0.039)** **	(0.043)	(0.043)	(0.039)	(0.039)
SAFI Short Rains 2004	-0.037	-0.104	**0.149**	**0.117**	-0.034	-0.058
	(0.054)	(0.056)*	**(0.062)** **	**(0.062)* **	(0.055)	(0.056)
Subsidy Short Rains 2004	-0.045	-0.091	**0.143**	**0.114**	0.025	-0.009
	(0.056)	(0.057)	**(0.063)** **	**(0.064)* **	(0.057)	(0.057)
Full Price Visit Short Rains 2004	-0.088	-0.114	**0.073**	**0.044**	-0.064	-0.086
	(0.056)	(0.057)**	**(0.063)**	**(0.063)**	(0.057)	(0.057)
Bought Maize for SAFI Short Rains 2004	-0.045	0.009	**-0.109**	**-0.081**	-0.025	0.016
	(0.053)	(0.054)	**(0.058)* **	**(0.059)**	(0.055)	(0.055)
Choice of Return Time for SAFI Short Rains 2004	0.026	0.042	**0.097**	**0.079**	0.017	0.012
	(0.044)	(0.045)	**(0.048)** **	**(0.049)**	(0.045)	(0.046)
Observations	874	874	752	750	900	899
Panel B. Other Controls	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.112	0.105	**0.059**	**0.036**	-0.032	-0.038
	(0.046)**	(0.047)**	**(0.049)**	**(0.050)**	(0.051)	(0.053)
Sampled to Participate in School Demonstration Plot	**-0.074**	**-0.081**	-0.020	-0.028	-0.054	-0.024
	(0.065)	**(0.066)**	(0.069)	(0.070)	(0.072)	(0.074)
SAFI Long Rains 2004	**0.134**	**0.124**	-0.042	-0.037	0.001	-0.005
	(0.038)* **	**(0.039)*** **	(0.041)	(0.041)	(0.043)	(0.044)
SAFI Short Rains 2004	0.000	-0.070	**0.206**	**0.190**	-0.075	-0.110
	(0.055)	(0.055)	**(0.059)*** **	**(0.060)*** **	(0.063)	(0.064)*
Subsidy Short Rains 2004	-0.075	-0.115	**0.130**	**0.109**	-0.003	-0.048
	(0.056)	(0.057)**	**(0.061)** **	**(0.061)* **	(0.063)	(0.065)
Full Price Visit Short Rains 2004	-0.072	-0.094	**0.144**	**0.136**	-0.121	-0.119
	(0.057)	(0.058)	**(0.062)** **	**(0.062)** **	(0.064)*	(0.066)*
Bought Maize for SAFI Short Rains 2004	-0.080	-0.037	**-0.124**	**-0.103**	0.062	0.068
	(0.053)	(0.054)	**(0.057)** **	**(0.057)* **	(0.060)	(0.061)
Choice of Return Time for SAFI Short Rains 2004	0.006	0.032	0.052	0.036	-0.034	-0.006
	(0.044)	(0.045)	(0.047)	(0.047)	(0.049)	(0.050)
Home has mud walls	-0.170	-0.104	-0.078	-0.077	0.057	0.062
	(0.079)**	(0.080)	(0.083)	(0.084)	(0.086)	(0.088)
Home has mud floor	-0.050	-0.113	-0.043	-0.048	-0.120	-0.097
	(0.073)	(0.075)	(0.077)	(0.077)	(0.080)	(0.082)
Home has thatch roof	-0.039	-0.040	0.071	0.056	-0.047	-0.056
	(0.037)	(0.038)	(0.039)*	(0.039)	(0.040)	(0.041)
Education primary respondent	0.009	0.009	-0.004	-0.006	0.015	0.016
	(0.004)**	(0.004)**	(0.004)	(0.004)	(0.005)***	(0.005)***
Gender	0.015	0.006	0.003	0.016	-0.041	-0.044
	(0.032)	(0.033)	(0.034)	(0.035)	(0.036)	(0.037)
Has household ever used fertilizer before?	0.241	0.274	0.177	0.199	0.081	0.156
	(0.037)***	(0.038)***	(0.041)***	(0.041)***	(0.043)*	(0.044)***
Household had used fertilizer in the 1st season after			0.384	0.382		
			(0.039)***	(0.040)***		
Household had used fertilizer in the 2nd season after					0.311	0.235
					(0.039)***	(0.040)***
Observations	774	774	648	646	652	651

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Coefficient in bold indicate the season in which we would expect to see an effect. Seasons are measured starting with the season of the demonstration plot. Starter kits were given out in the 1st season after the demonstration plot. SAFI for the 2004 Long Rains also took place in the 1st season.
SAFI for the 2004 Short Rains, and the Subsidy and Full Price Visits took place in the 2nd season.

Table 11: SAFI Reliabilities

	SAFI Long Rains 2004 (1)		*SAFI Short Rains 2004* (2)		*Subsidy Visit Short Rains 2004* (3)		*Full Price Visit Short Rains 2004* (4)	
Of those that bought fertilizer through Program:								
Reported Using Fertilizer in Survey	53	0.746	108	0.766	39	0.684	16	0.615
Reported not Using Fertilizer in Survey	18	0.254	33	0.234	18	0.316	10	0.385
Of those that Reported Not Using Fertilizer in Survey:								
says bought from program	13	0.765	29	0.879	12	0.750	8	0.800
says didn't buy from program	4	0.235	4	0.121	4	0.250	2	0.200
What did they do with fertilizer?								
1 - gave away / sold	0	0.000	1	0.036	0	0.000	0	0.000
4 - fertilizer spoiled	2	0.125	1	0.036	2	0.167	0	0.000
5 - used on different crop	1	0.063	7	0.250	0	0.000	1	0.125
6 - kept for another season	1	0.063	9	0.321	1	0.083	2	0.250
7 - used on different plot	0	0.000	2	0.071	1	0.083	1	0.125
8 - used on maize crop	11	0.688	7	0.250	7	0.583	4	0.500
9 - other	1	0.063	1	0.036	1	0.083	0	0.000

Table A1: Adoption for Parents Sampled for SAFI, Subsidy with Corrected Adoption Estimates

	1 season later		*2 seasons later*		*3 seasons later*	
Panel A. Control for School	(1)	(2)	(1)	(2)	(1)	(2)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.086	0.091	**0.034**	**0.024**	0.011	-0.006
	(0.045)*	(0.046)**	**(0.050)**	**(0.050)**	(0.045)	(0.046)
Sampled to Participate in School Demonstration Plot	**-0.028**	**-0.033**	0.029	0.025	-0.016	0.039
	(0.065)	**(0.067)**	(0.072)	(0.073)	(0.065)	(0.066)
SAFI Long Rains 2004	**0.142**	**0.122**	-0.023	-0.025	-0.018	-0.001
	(0.038)* **	**(0.039)*** **	(0.043)	(0.044)	(0.039)	(0.039)
SAFI Short Rains 2004	-0.034	-0.077	**0.187**	**0.153**	-0.033	-0.047
	-0.047	-0.048	**(0.054)*** **	**(0.054)*** **	-0.048	-0.048
Subsidy Short Rains 2004	-0.022	-0.068	**0.217**	**0.181**	0.024	-0.009
	(0.056)	(0.058)	**(0.064)*** **	**(0.064)*** **	(0.057)	(0.057)
Full Price Visit Short Rains 2004	-0.092	-0.118	**0.097**	**0.069**	-0.064	-0.086
	(0.056)	(0.058)**	**(0.064)**	**(0.064)**	(0.057)	(0.057)
Observations	874	874	752	750	900	899
Panel B. Other Controls						
	(1)	(2)	(3)	(4)	(5)	(6)
	fertilizer	*any treatment*	*fertilizer*	*any treatment*	*fertilizer*	*any treatment*
Starter Kit Farmer	0.088	0.091	**0.021**	**0.000**	-0.016	-0.020
	(0.045)*	(0.046)**	**(0.049)**	**(0.049)**	(0.049)	(0.050)
Sampled to Participate in School Demonstration Plot	**-0.050**	**-0.058**	-0.012	-0.013	-0.052	-0.024
	(0.066)	**(0.067)**	(0.071)	(0.072)	(0.072)	(0.073)
SAFI Long Rains 2004	**0.172**	**0.162**	-0.049	-0.041	0.001	-0.005
	(0.039)* **	**(0.039)*** **	(0.042)	(0.043)	(0.043)	(0.044)
SAFI Short Rains 2004	-0.021	-0.065	**0.221**	**0.200**	-0.073	-0.093
	(0.048)	(0.049)	**(0.053)*** **	**(0.053)*** **	(0.054)	(0.055)*
Subsidy Short Rains 2004	-0.063	-0.101	**0.209**	**0.181**	-0.002	-0.047
	(0.057)	(0.058)*	**(0.063)*** **	**(0.063)*** **	(0.063)	(0.065)
Full Price Visit Short Rains 2004	-0.082	-0.103	**0.166**	**0.159**	-0.118	-0.116
	(0.058)	(0.059)*	**(0.064)*** **	**(0.064)** **	(0.064)*	(0.066)*
Home has mud walls	-0.176	-0.111	-0.086	-0.051	0.064	0.064
	(0.080)**	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)
Home has mud floor	-0.038	-0.100	-0.018	-0.056	-0.127	-0.100
	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Home has thatch roof	-0.022	-0.026	0.064	0.050	-0.050	-0.060
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Education primary respondent	0.008	0.008	-0.001	-0.003	0.015	0.016
	(0.004)**	(0.004)**	(0.00)	(0.00)	(0.005)***	(0.005)***
Household had used fertilizer in the 1st season after	0.034	0.024	-0.008	0.001	-0.040	-0.045
	(0.033)	(0.033)	(0.036)	(0.036)	(0.036)	(0.037)
Household had used fertilizer in the 2nd season after	0.239	0.275	0.165	0.183	0.083	0.159
	(0.038)***	(0.038)***	(0.042)***	(0.043)***	(0.042)*	(0.043)***
Gender			0.365	0.359		
			(0.040)***	(0.041)***		
Has household ever used fertilizer before?					0.305	0.231
					(0.039)***	(0.040)***
Observations	774	774	648	646	652	651

Standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Coefficient in bold indicate the season in which we would expect to see an effect. Seasons are measured starting with the season of the demonstration plot. Starter kits were given out in the 1st season after the demonstration plot. SAFI for the 2004 Long Rains also took place in the 1st season. SAFI for the 2004 Short Rains, and the Subsidy and Full Price Visits took place in the 2nd season.