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ABSTRACT

Can Agricultural Extension and Input Support Be Discontinued? Evidence from a Randomized Phaseout in Uganda*

Many development programs are short-term interventions, either because of external funding constraints or an assumption of impact sustainability. Using a novel randomized phaseout research method, we provide experimental tests of phaseout effects of an extension program designed for women smallholder farmers in Uganda. We find that program phaseout does not diminish demand for improved seeds, as farmers shift purchases from NGO-sponsored village supply networks to market sources, indicating persistent learning effects. We find no evidence of declines in improved cultivation practices taught by the program. These results have implications for both efficient program design and for models of technology adoption.

JEL Classification: O13, O33, I32, Q12

Keywords: agricultural extension, agricultural technology adoption, food security, supply chain, subsidies, randomized phaseout, high-yielding varieties, randomized controlled trial, Uganda

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1. Introduction

Economic development programs are often based on short-term interventions, even though the conceptual or empirical basis for limiting their duration is little discussed. In some cases, the underlying premise is that interventions can trigger changes that persist post program termination; in others, duration is arbitrarily determined by external funding cycles. However, there is at best thin evidence by which the premise of persistence can be tested, let alone the causal effects of program termination.

This paper reports novel estimates of the impacts of program phaseout in the context of a large-scale agricultural development program designed to improve cultivation methods of smallholder women farmers in Uganda. The program's general features, such as extension and input subsidies, are widespread in the numerous agricultural development programs employed to alleviate rural poverty in many developing countries, some of which consist of temporary efforts and others are essentially permanent (see e.g. Anderson and Feder, 2007). After several years of implementation, the Uganda program was first terminated in a randomized subsample of the treatment population, allowing us to estimate the causal impacts of phaseout.

Our estimates add to the relatively few existing post phaseout impact evaluations, particularly in the context of agriculture,[1] but also make a more fundamental contribution. Rather than comparing outcomes between the initial treatment and control group after a program is phased out, we compare outcomes between a random sub-sample of the treatment group in which the program is phased-out to the remaining treatment group, in which treatment is continued. This allows us to estimate the causal impacts of phaseout, and answer a distinct, if related, question that has important lessons for policy design but cannot be answered in the existing approach: when, if at all, should development interventions be terminated? For example, finding that a program's impacts persist post phaseout does not determine whether continued implementation would have resulted in further increases (or declines) in impacts, and whether continuation is cost-ineffective. Similarly, finding that impacts diminish post phaseout does not allow one to determine whether a continued implementation would have maintained the original impacts. Existing approaches also face problems of assigning causal-

[1]Recent notable exceptions include Carter et al. (2016) on agriculture; Baird et al. (2016) on deworming and Maluccio et al. (2009) on early childhood nutrition supplements.

ity: changes in differences between treated and control groups that occur after phaseout may result from other time varying factors (such as spillovers), that are unrelated to the phaseout itself.

It is not obvious whether or when to terminate an apparently successful intervention, from either a theoretical or a practical viewpoint. In the agricultural context, permanent government extension programs and interventions in input supply chains are common in both developing and developed countries. From a theoretical point of view, the impact of phasing out the supply of subsidized inputs on farmers' input use depends on whether these inputs are normally unused because they are unprofitable (Suri, 2011), or because of limited access to information, credit, insurance, or some other complementary factor (for example, see Foster and Rosenzweig, 2010; Bardhan and Mookherjee, 2011; Duflo et al., 2011; Karlan et al., 2014; Emerick et al., 2016). Similarly, the impact of phasing out extension and demonstration programs of improved practices depends on farmers' learning processes (Hanna et al., 2012). For example, high variability in yields resulting from other factors may make it difficult for farmers to learn about the profitability of a technology on the basis of just a few years' observations (see Munshi, 2004).

The agricultural extension program we examine was implemented in Uganda by BRAC, a large NGO.[2] The program's goal was improved food and nutrition security (Barua, 2011); activities focused on both basic practices, and on the use of improved seeds, which remains very low in Uganda, as in much of Sub Saharan Africa.[3] Low usage of improved seeds is a simultaneous problem of low demand and low supply, and the BRAC program attempted to stimulate both by engaging women farmers to conduct demonstrations and training as well as to sell subsidized improved seeds.

These interventions may be considered to persist post program termination from the supply side if a successful experience with selling seeds encourages informal village suppliers to continue to work as (for-profit) distribution agents; and from the demand side if a positive experience with improved seeds and practices permanently increases demand for such seeds and farming practices by local farmers.

Our results suggest that the semi-informal supply of improved seeds, as well as training activi-

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[2]For details on BRAC, see Smillie (2009). BRAC Uganda has been the subject of prior research, not only on agriculture (Pan et al., 2018), but also in other programs addressing rural women (Bandiera et al., 2017).

[3]For information on low seed use in Sub-Saharan Africa, see World Bank (2007) and Sheahan and Barrett (2016). For the role of lack of knowledge of improved farming practices in the region, see Davis et al. (2012).

ties, declines markedly as a result of phaseout. At the same time, while seed purchases from BRAC sources decline in phaseout villages, we find strong evidence that farmers switch to purchasing improved seeds from local market sources, so that after a brief period of adjustment the total impact on improved seed usage from all sources remained nearly unchanged. We also find no evidence of declines in the use of agricultural practices taught by BRAC in phased-out villages, suggesting that knowledge transfer also has "sustainable" effects. These results are observed consistently across three repeated household surveys that are conducted up to three years (six seasons) post-phaseout, providing unusual confidence in their "temporal external validity" (Rosenzweig and Udry, 2019).

Our methodology allows for a clean interpretation of lack of post phaseout impacts when the original intervention is also experimentally designed. As with most programs, the original BRAC intervention was not randomized in the same sample in which our own study is conducted (although it was randomized in a different sample, as we explain in greater detail below). A general challenge for interpreting the results of a randomized phaseout when the original intervention was not experimentally implemented is that without other evidence, the absence of post phaseout impacts could be interpreted both as evidence of persistence and as a reflection of the absence of any impacts of the program itself. In this paper we address this challenge with two strategies. First, we compare our data with results from a new experimental evaluation of the BRAC program in a different region in Uganda, which finds significant impacts on improved seeds purchases (among other results). Second, PSM analysis using comparable but never-treated households in the phase-out study region shows significant differences in outcomes corresponding to the BRAC program interventions, including the use of improved seeds. Farmers in those villages are significantly less likely to be using improved seeds.

Based on these findings, as well as those reported in previous literature, we conclude that the sum of the evidence strongly supports our interpretation that the experimental phaseout results indicate the program had positive impacts that "survive" program termination, in particular on improved seed use and the adoption of better basic practices including crop rotation and line-sowing. Ideally, some future applications of randomized phaseout evaluation research can be conducted for samples from interventions that are also randomized from the onset. This was not possible in the context of the specific intervention studied here - and is unlikely to be feasible in many or most such applications - but this does not deter from the merit of the methodology when other strong evidence is available. Our most important specific findings on persistence appear to be robust to this limitation.

The remainder of the paper is structured as follows. Section 2 presents further background on the BRAC program and the Ugandan context. Section 3 lays out the experimental design. Section 4 describes our experimental phaseout results on the use of improved seeds and practices. Section 5 describes the evidence of initial program impacts through results from a new RCT of the BRAC agriculture program in Southwest Uganda, and from a comparison of initially treated and never treated villages in our randomized phaseout sample; this section also presents further counterfactual sensitivity analysis of sustainability. Section 6 concludes.

2. Overview of the Intervention

BRAC's agriculture program in Uganda began in 2009. The program has many features in common with other extension programs[4] and seeks to improve the agricultural productivity, incomes and food security of smallholder women farmers by promoting the usage of improved farming practices and inputs, especially high yielding variety (HYV) seeds, also called improved seeds. Improved seed varieties are bred by agricultural research organisations to provide, under suitable conditions, higher yields than "traditional" varieties, or "local seeds" typically obtained by farmers from previous harvests. The low rate of usage of improved seeds is widely considered to be one of the principal causes of stagnant yields in Sub-Saharan Africa (World Bank, 2007). The BRAC program, and therefore this study, is mostly focused on maize, the dominant crop grown by farmers in the area.

The failure to use improved seeds is a simultaneous problem of low demand and low supply. To address these problems, BRAC followed a two-pronged approach: stimulating demand through demonstrations, training and distributions of free samples of improved seeds[5]; and stimulating supply by creating semi-informal supply chains within villages. These parallel functions are imple-

[4]For background on agricultural extension and similar programs see Barrett (2002), Anderson and Feder (2007) and Barrett et al. (2010).

[5]Previous studies of the impacts of agricultural extension include Feder et al. (1987); Owens et al. (2003); Feder et al. (2004); Godtland et al. (2004); Dercon et al. (2009); Cole and Fernando (2012); Davis et al. (2012); Larsen and Lilleør (2014); Beaman et al. (2015). See also reviews by Birkhaeuser et al. (1991), Evenson (2001) and Anderson and Feder (2007). Studies of learning between farmers include Foster and Rosenzweig (1995), Munshi (2004), Bandiera and Rasul (2006), and Conley and Udry (2010). Also see Jack (2013).

mented through two types of agents that were recruited from local communities and engaged by BRAC: the Community Agriculture Promoter (CAP) and the Model Farmer (MF).

CAPs were engaged as for-profit distribution agents to provide BRAC's improved seeds (as well as other inputs) in their villages at reasonable costs (Barua, 2011).[6] MFs were engaged to demonstrate improved practices and inputs in their own farms and to train other farmers in the village in their application.[7] Both CAPs and MFs were selected from female farmers in the village between 25 and 60 years of age who own a plot of at least 1 acre in size, which could be used for demonstration purposes, and were willing to attend training sessions and meetings. Each season, CAPs and MFs received week-long training in improved farming practices by BRAC program staff, who also monitored their activities throughout the season. Both CAPs and MFs received modest compensation for their time and travel costs.

MFs were expected to implement a variety of improved practices in their farms, including crop rotation, line sowing and intercropping, and the use of of improved seeds and organic fertilizer. They were also expected to hold regular training sessions for about 10-12 farmers per season, in which they would demonstrate and explain the benefits of these improved practices and inputs.[8] Each season, the MFs also received a small amount of improved seeds for use in their own farms and for distribution as samples during the trainings.

CAPs were encouraged to buy improved seeds from BRAC and to sell it to farmers. BRAC provided seeds to CAPs at a discounted rate (up to 20% relative to market sources) and transported it to their villages, providing them with advantages over conventional input dealers located in towns and market centers who might with to sell to these villagers. The ability to generate profits from seed sales was meant to incentivize CAPs and increase the potential for longer-term sustainability past BRAC phaseout. While CAPs did not provide formal training in agricultural practices to

[6]In addition, as Barua (2011, page 5) notes, the CAPs' "role is to provide general farmers and their local communities with farm inputs at a reasonable price. These inputs include seeds (such as high yielding varieties of maize, rice, beans, groundnuts, cabbage, tomatoes, and eggplants), tools (such as hoes and pangas), and inorganic fertilizers."

[7]The idea of using model farmers in agricultural extension programs has a long history. Recent studies of these models include Krishnan and Patnam (2014), who find that learning from neighboring farmers has a longer lasting effect than learning from conventional extension agents; and BenYishay and Mobarak (2015) who report that "farmers find communicators who face agricultural conditions and constraints most comparable to themselves to be the most persuasive."

[8]There was no restriction on the number of times a farmer could participate in the training sessions, and some farmers received training two or more times. BRAC indicated that in some villages in which the program had been active since 2009, most if not all farmers who were interested in training had received it at least once.

the farmers, they were encouraged to give advice based on knowledge gained through their own participation in BRAC training sessions.

Taken together, one can think of BRAC's strategy to achieve sustainability as an effort to establish a new equilibrium, first generating demand by making farmers aware through direct experience of the benefits of improved seeds; and second generating supply by overcoming market or coordination and information failures to establish otherwise profitable missing markets (see in Section 4.3).[9]

Post phaseout, CAPs and MFs stopped receiving financial incentives to carry out their activities. CAPs cased to be visited or encouraged by BRAC to sell seeds. They could continue to procure seed from BRAC (or other sellers) and resell it to farmers, but they would have to take the initiative and they no longer received the same discounted prices or BRAC's assistance with transport.

3. Experimental Design and Data

3.1. Experimental Design

BRAC operations, particularly seed distribution and training, are organized around groups of villages called *branches*. While the program was implemented in a broader area, this study is based on a sample of farmers from 15 branches in Eastern Uganda. The unit of analysis in this study is a *village cluster*, one or at most two villages no further than 2 KMs apart, that have one active CAP and one active MF. Overall, 99 clusters were included in the phaseout experiment, of which 18 consisted of two villages and the rest consisted of a single village.

Within each branch, village clusters were randomly assigned to three treatment arms: Continuation (no change), CAP phaseout and MF phaseout. Village clusters that were assigned to either of the phaseout groups had that particular component of the program discontinued in early 2013. One year (or two agricultural seasons) later the remaining component was discontinued as well, meaning that differences between the two phaseout groups were only in effect for the first year of the experiment. Overall, 32 clusters were assigned to Continuation, 34 assigned to CAP phaseout and 33 to MF phaseout (the clusters are mapped in the Appendix).

[9] In this light, if an intervention is unsustainable, it acts as a temporary shock, after which the agricultural household returns to its earlier equilibrium (for a framework comparing types of farm household equilibria shifts, see Kwak and Smith, 2013). BRAC certified seeds might help overcome a "lemons" problem of poor (if not counterfeit) HYV seed quality (Bold et al., 2017).

3.2. *Data Collection and Summary Statistics*

We surveyed a sample of randomly selected farmers from amongst those who had received training from MFs in either of the two seasons preceding the start of the phaseout. The annual cropping calendar in the region of study consists of two maize growing seasons: the first lasts from approximately March to July/August and the second from approximately September to December/January. We conducted a pre-phaseout baseline at the end of the 2013 first season harvest (February 2013); and three follow-up surveys in September 2013, September 2014 and February 2016, i.e. at the end of 1, 3 and 6 seasons following the phaseout. Each survey collected detailed information about the cropping practices of the concluding and previous season (with the exception of the second follow-up survey); an overview of the timing and scope of each survey is found in Figure I.

Attrition rates were 15.2% after one season and 17.8% after three seasons and were uncorrelated with treatment status or baseline characteristics (see Appendix Tables A.I and A.II). The final sample of households observed in all surveys consists of 1124 households, of which 405 are in the Continuation arm, 352 in are in the CAP phaseout arm, and 367 in the MF phaseout arm.

Table I reports mean values of key baseline characteristics at each of the three experimental groups. Columns 1-3 report the difference between the Continuation and the combined phaseout sample, and Columns 4-7 report differences between the Continuation and each of the two phaseout groups separately. For the most part, baseline attributes and use of improved practices and inputs are balanced across the three groups, with significant but small differences in the use of line sowing, weeding and organic fertilizer between the Continuation and one of the phaseout groups.[10]

A majority of the respondents (82%) report using local maize seeds, and about 59% of the respondents report making use of improved seeds (the two are not mutually exclusive since farmers may use a combination of improved and local seeds on different portions of their land). Of these, 32% report obtaining these seeds from market sources (including input suppliers, general shops, local markets and moving vendors) and 24% report obtaining them from BRAC sources (MFs, CAPs, and other BRAC sources combined). More than 70% of the farmers practice line sowing and intercropping, and 55% practice crop rotation at baseline.

[10]Six of 161 coefficients, or 3.7%, are statistically significant at the 5% level, about as many as could be expected by chance.

[TABLE I HERE]

3.3. *Empirical Specification*

Our primary empirical specification follows directly from the experimental design. We estimate regressions of the form:

$$y^s_{i,v,b} = \rho PH_v + \beta \cdot X_i + \gamma_b + \epsilon_{i,v,b} \tag{1}$$

where y^s is the outcome of interest, observed $s = 1, 3, 5, 6$ seasons after phaseout (see Figure III) for household i in village v in branch b. We estimate impacts in each season through a separate regression. The vector X contains the value of the outcome variable at baseline, and baseline attributes that are less well balanced across treatment groups (see below). The regression also includes branch fixed effects γ_b. The errors $\epsilon_{i,v,b}$ are clustered at the village level.

The variable PH is a binary indicator of phaseout and the coefficient ρ is the coefficient of interest. In our primary specification, we bundle the two phaseout treatment arms together into a single phaseout arm. We also report the separate impacts of each of the phaseout arms (CAP and MF) in the Appendix.

4. Effects of Program Phaseout

We now turn to our main analysis, i.e. the impact of the phaseout on farmers' use of improved seeds and farming practices. We present results for each of the survey rounds for which the relevant data was collected, i.e. up to three years, or six cropping seasons after the first component of treatment was discontinued in the two phaseout groups.

4.1. *Use of Improved Seeds*

We begin by examining program phaseout impacts on improved seed usage and sources.

4.1.1. *Overall Use of Improved and Local (Unimproved) Seeds*

Table II.a reports the estimated effect (and 95% confidence intervals) of program phaseout on a binary indicator of improved seed use (i.e. the extensive margin). We find no indication of a negative effect, with estimates that are statistically indistinguishable from zero and of modest size in each of the four seasons for which we have data up to three years post phaseout. We are able to bound the negative effect in season 6 to be no higher than about 6% with 95% confidence.

We note that while MFs distributed small samples of free seeds during the training, almost all farmers who make use of improved seeds purchase at least some of them, i.e. binary indicators of use and purchase of improved seeds are nearly identical. We therefore focus on indicators of usage throughout.

[TABLE II.a HERE]

Table II.b reports estimated effects on the *quantity* of improved seeds use (measured in terms of total amount, Columns 1-2, or amount per acre, Columns 3-4), for which we have data only in seasons 3 and 5. Here too, we find no indication of any negative effect, although the estimates are somewhat noisier (and shift sign between seasons).

[TABLE II.b HERE]

As a further check, we also examine effects on the use of local seeds, which would be expected to increase in tandem with any reduction in the use of improved seeds. The results, reported in Tables III.a (for binary indicators) and III.b (for quantities) also fail to reject the null hypothesis of no effect, with estimates that are statistically insignificant and small in size. In sum, the evidence indicates that the phaseout of BRAC activities did not lead to a decline in improved seed use.

[TABLE III.a HERE]
[TABLE III.b HERE]

We also explore the possibility that there were heterogeneous effects of phaseout on the use of improved seeds, based on the number of times farmers were trained, how recently they were last trained, the size of their cultivated area and other indicators of wealth, among others; however, this does not appear to have been the case (results omitted for brevity and available from the authors upon request).

4.1.2. Use of Improved Seeds from Various Sources

To better understand why the phaseout did not seem to affect the use of improved seeds, we next examine the procurement of improved seeds from various sources. Our surveys asked improved seed users to indicate their sources, which we group into three categories: BRAC program sources (MFs and CAPs), other BRAC sources (mainly direct procurement from BRAC branch offices), and market sources (including all types of commercial vendors not related to BRAC, such as input dealers and local shops in regional trading centers). Estimates of the effect of the phaseout on the probabilities of obtaining improved seeds from these three sources are reported in Table IV and summarized in Figure II.

The phaseout led to a reduction of purchases from CAPs and MFs of about 5 percentage points (p.p.) after one season, 6 p.p after three seasons, and 10 p.p. after six seasons (see Table IV, column 1), amounting to a decline of 50% to almost 100% of the mean level of usage in the Continuation group. This decline is consistent with the decline in CAP activity in the villages reported above.

However, the decline in purchases from CAP and MF sources is accompanied by a parallel increase in purchases from market sources, starting from about a 2 p.p. increase after one season, to 6 p.p. after 3 seasons and 12 p.p. after 6 seasons (Table IV, column 2). These effects are also sizable, amounting eventually to around 40% of usage in the Continuation group. There is also an initial, but smaller increase in purchases from other BRAC sources - mostly direct purchases from BRAC branch offices - of 1-2 p.p. which tends to disappear or even reverse three years post phaseout (Table IV, column 3).

Results obtained by limiting the sample to farmers who use improved seeds at baseline follow a very similar pattern but are larger in magnitude: In the first season after phaseout, procurement from CAP and MFs declines by 12 p.p., whereas procurement from market sources does not display a significant increase. Later on, procurement from CAP and MFs continues to decline by 16 p.p after 3 seasons and 31 p.p. after 6 seasons, while procurement from market sources increases by 13 p.p. and 32 p.p. in the corresponding time periods.[11]

These results suggest that farmers facing reduced supply from CAPs and MFs, rather than shifting to the use of unimproved local seeds, turn to alternative sources of improved seeds which

[11] Results omitted for brevity but available upon request.

initially include other BRAC sources but eventually consist entirely of market sources. The estimates suggest that despite the greater effort (and cost) required to obtain seeds from other sources, the substitution is essentially complete. Moreover, the shift does not appear to take place immediately, suggesting a delayed response; this further highlights the need for long-term monitoring in impact evaluations.

Results obtained by separating the effect of the initial CAP and MF phaseouts (see Appendix, Table A.XVIII) do not display significant differences. Point estimates are somewhat larger and more precise for the MF phaseout after 3 seasons (though statistically indistinguishable); but after 6 seasons, results become very similar in magnitude, and are both statistically significant.

[TABLE IV HERE]

4.2. Cultivation Practices

BRAC's training and dissemination activities, conducted through the MFs, included the practices of crop rotation, intercropping, line sowing, zero tillage, weeding, irrigation, pest and disease management, and post-harvest management.[12] In Table V, we report estimates of phaseout on binary indicators of the application of these practices. Overall, we do not find evidence of any negative impacts of the phaseout, with most estimates being of small size, of mixed sign, and statistically insignificant, with the two exceptions of a negative impact on zero tillage after 6 seasons and positive impact on pest management after 3 seasons.

[TABLE V HERE]

An analysis of the effects of phaseout on the use of other inputs (hired labor, fertilizers and pesticides) and tools (plows and pesticides pumps) also finds no significant differences (Appendix Table A.III). We also find no evidence of negative impacts on maize cultivation (Appendix Table A.IV) or yields (Appendix Table A.V), on agricultural revenue or profits (Appendix Table A.VI), or on crop diversification[13] (Appendix Table A.IV, columns 5-8).

[12]Note that these practices have been demonstrated in general to improve yields in the short run; they also promote conservation in the long run and thus may show added benefits in coming years as climate change adaptations - already used as such by farmers in Ethiopia - become more important (Malik and Smith, 2012). This may be a useful setting for future research on climate change adaptation.

[13]Note that, on the consumption side, food variety is often considered an indicator of food security (Pan et al., 2018). Part of BRAC's training focused on teaching farmers about new crops, including vegetables, and techniques such as intercropping.

4.3. Phase-out effects on improved seed sales by CAPs

To investigate whether the program was successful in developing a sustainable input supply chain, we conducted a survey of CAPs. Table A.VII (see Appendix) presents results of OLS regressions using three dependent variables: (1) whether CAPs continue selling BRAC seeds; and if so, (2) in what quantities and (3) at what price. Our explanatory variable is a dummy for phased-out CAPs. After six seasons, phased out CAPs are 25 percentage points less likely to sell any seeds (Table A.VII, column 1); and among those still selling seeds, point estimates suggest the phaseout increased prices and reduced quantities (estimates are usually statistically insignificant, likely due to small sample size). Among potential causes of the rise in CAP prices post-phaseout, the share of respondents who say transport costs caused them not to sell seeds is 31% in the Continuation group and 51% in the phased-out groups, a statistically significant difference. Moreover, six seasons after phaseout, farmers in phaseout clusters were less likely to report seeking advice or training from the CAP in their village (by 5 p.p., $p<0.01$) or having purchased seeds from CAPs in the previous year (by 10 p.p., $p<0.01$).

5. Initial Impacts of the Program

In the previous section, we presented a range of results indicating that phasing out the BRAC program did not lead to a reduction in improved seeds use, as farmers turned to market sources for a supply of improved seeds in place of diminishing supply from BRAC. We interpret these results as evidence of persistent program effects, deriving from farmers' positive experience with improved seeds and farming practices. This interpretation rests on the assumption that the BRAC program itself originally increased the use of improved seeds and practices.

The BRAC program was not experimentally implemented in our own study area. Instead, we test the above assumption using results from two other datasets and find initial program impacts: first, we report evidence from a recent experimental evaluation of the BRAC program impacts in a different region of Uganda; and second, evidence obtained from comparing our study villages to a matched contemporaneous sample in the phaseout region. Taken together, this evidence indicates the BRAC program had a strong initial impact on a range of outcomes.

5.1. Experimental Estimates of BRAC Program Impacts in Southwest Uganda

We turn to estimates from an ongoing experimental evaluation of the BRAC program in a different part of Uganda (the Southwest Kabale region). The evaluation, for which one of this paper's coauthors (Sulaiman) is co-PI, is intended to study the combined effects of BRAC's agricultural and microfinance interventions, using a sample of 230 villages randomly selected into one of the four possible combinations of these two treatments. Here, we report estimated impacts on the agricultural outcomes that are directly relevant to our study. These estimates are based on data collected only two seasons after the intervention begun, while our data was collected post phaseout, which occurred up to eight seasons after the initial rollout of the program; thus the impacts may have been less than for our sample. The comparability of the survey instrument is substantial, but imperfect.

Table VI reports two sets of estimates. In Column 1, the treated sample consists of all villages that received the agricultural intervention; and the control group consists of all villages that did not, irrespective of whether they also received the microfinance treatment. In Column 2, the treated group consists of all villages that received the agricultural intervention alone (without microfinance); and the control group consists of all villages that received neither the agriculture nor the microfinance intervention. Our preferred estimates are from Column 1, largely because some households in the phaseout experimental sample also benefit from BRAC's microfinance program, and the larger sample allows for more precise estimates.

Results for the broader sample (Column 1) show statistically significant impacts on 7 of the 15 outcome variables: number of acres cultivated; number of crops, purchase of improved seeds, purchased improved seeds from BRAC sources, total production, whether received revenue from crop sales, and crop sales revenues. The narrower sample has statistically significant impacts for purchase of improved seeds, purchased improved seeds from BRAC sources, and crop sales revenues; the signs are also positive and of broadly similar magnitude for the other four variables, although the coefficients drop below conventional significance levels.

The BRAC agriculture program impact on improved seed use is not only significant at the 1% level; it is already quite substantial in magnitude at about 7 percentage points in both broad and narrow household samples, just one year after program implementation. Cash revenue impact is also very substantial in magnitude in both samples at over 29,000 Ugandan shillings. Moreover, point estimates are similar for the other variables for which impacts are statistically significant in the broader sample but not in the narrower sample. Taken as a whole, the RCT estimates of the program already show substantial impacts after a relatively short period of implementation.

[TABLE VI HERE]

5.2. The No-Treatment Comparison Group for the Randomized Phaseout

We next turn to an estimation of initial program impacts derived from a comparison group of villages in which the BRAC program was never implemented. These "No Treatment" (NT) villages were chosen, prior to the start of the phaseout, from the areas of the same branches that constitute our main sample and were included in the household surveys conducted three seasons past phaseout.

Given that several years have elapsed since the initiation of the BRAC program, estimates of its impacts through a comparison of the NT villages to those in our main sample can be downward biased due to spillovers (downwards or upwards) and due to selection effects. BRAC's written policy is to implement its agricultural program in villages located up to 6 KMs away from its branch offices (Pan et al., 2018). In Table VII, we present comparisons of characteristics that are unlikely to have been impacted by the BRAC program, and find that the NT villages are, accordingly, located farther away from BRAC branch offices (see map in the Appendix, Figure A.I) and have lower membership in BRAC microfinance groups; but they are similar to the villages in our main sample in terms of education, age and land and asset ownership. Branch offices are generally located in the main town or trading center of the branch area, meaning that NT farmers are likely to be more distant from input suppliers and from markets, potentially impacting the likelihood of purchases of improved inputs. Access to microfinance could also affect NT farmers' ability to invest in costly inputs, including improved seed, although, as we show below, we do not find evidence for such an association, which is unsurprising given that the microfinance program provided loans designed for non-farm microenterprise activities.

[TABLE VII HERE]

In comparing outcomes between the NT sample and villages in our main sample, we follow two approaches. Our main identification utilizes a matched set of households from the NT sample using Propensity Score Matching (PSM) methods. We match households on the basis of attributes that are unlikely to have been impacted by the BRAC program but are likely to have affected treatment status, namely distance to the branch office and a woman's age and education level. Propensity scores are estimated using a logit model with errors clustered at the village cluster level and matching is done within branches.[14] Below, we report PSM results that are obtained using nearest-neighbor matching within caliper=0.025, but alternative matching specifications yield similar results and are reported in Appendix Table A.XIII. To account for clustering, standard errors are obtained by block bootstrapping at the village cluster level. We also present OLS estimates, controlling for distance to the branch office and for administrative indicators of the presence of a BRAC microfinance group in the village. We report OLS and PSM estimates obtained by comparing the NT sample to both the entire main sample and to the Continuation group alone. These alternatives reflect a tradeoff between a smaller sample size (latter choice) and the possibility of dilution of impacts in the phaseout groups (former choice).

5.2.1. Use of Improved and Local (Unimproved) Seeds

Comparisons of improved seed use between the NT group and the main sample are reported in Table VIII and suggest that the program has led to substantial increases of 13%-17% in improved seed use, with estimates that are statistically significant and similar in magnitude regardless of whether the comparison group is the full phaseout sample or only the Continuation group, and whether they are calculated using OLS or PSM (Columns 1-4). Effects of this size are highly unlikely to be explained by the distribution of free seeds by MFs, since almost every farmer that reports using improved seeds in the main sample also reported purchasing some of them. Note that access to microfinance does not appear to be correlated with improved seed use, while being farther away from branch offices seems to reduce it somewhat (about 1 p.p. per KM). Using results from the pre-phaseout season as well as the first post-phaseout season yields very similar results (Appendix Table A.XI).

Data from the last survey round provide further indications that differences in improved seed use between the NT group and the main sample are related to the BRAC program. First, amongst farmers who reported using improved seeds in the NT sample, only 6% reported having been exposed to it by BRAC, as compared to 69% in the Continuation group. Second, the maize seed

[14] See the Appendix for details of the propensity score matching procedure.

promoted by BRAC belongs to the Longe5 open pollinated variety. Other common varieties in the area include the Longe4 variety and hybrid varieties such as Longe6H, Longe7H and Longe10H. The proportion of farmers who report being familiar with the Longe5 variety was 22 p.p. higher in the main sample than in the NT sample ($p<0.01$). The corresponding difference for the Longe4 variety was also significant, but much lower at only 6 p.p. There was no statistically significant difference in the case hybrid seeds.

[TABLE VIII HERE]

As noted in Section 4.1, increases in improved seed use are likely to be accompanied by declines in the use of local seeds (even though farmers may well use both types of seeds in tandem). Table IX reports estimated BRAC program impacts on local seeds use in similar format to Table VIII that are indicative of a decline of 3-5 p.p. in (a binary indicator of) local seed use. Estimates obtained by only using the Continuation group are of very similar magnitude to those obtained by using the entire main sample, but are less precisely estimated, likely owing to the smaller sample size.

[TABLE IX HERE]

5.2.2. Effects on Cultivation Practices

Table X reports comparisons of the prevalence of the practices promoted by BRAC between the Continuation group and the NT sample using OLS and PSM (for brevity, we do not report estimates obtained by using the full main sample, although results thus obtained display very similar patterns and are available from the authors upon request). The results suggest that the program had mixed success in disseminating these practices, but significant and strong effects robust to estimation method are found for the two practices that received the greatest emphasis, i.e. crop rotation and line sowing. For line sowing, the PSM estimate is an 18 percentage point gain; the OLS estimate is a 13 percentage point increase. For crop rotation, the PSM estimate is a 15 percentage point gain and the OLS estimate is a 10 percentage point increase; this is consistent with estimates from another dataset examining this program using regression discontinuity methods (Pan et al., 2018).[15]

[15] The impact was 8 p.p. at the 1% significance level. Data used in the Pan et al. (2018) study are representative of BRAC branches for the whole of Uganda except semi-arid Northern Uganda; that paper did not have data on line sowing. The two other farming practices variables that overlap with those in our data, intercropping and irrigation, both show positive, statistically significant program impacts.

As above, additional data from the last survey round provides further indications that differences in the use of crop rotation and line sowing are related to the BRAC program. Among those farmers in the NT sample who were familiar with these practices, only 2% said they learned line sowing and 1% said they learned crop rotation from BRAC. In the Continuation sample, those rates were 68% and 56%, respectively.[16]

The program had a positive impact on crop diversification, as seen in Table XI. The mean value of the number of crops grown by farmers in the No Treatment group is 3.27, while in the Continuation group it is significantly higher - by 0.38 if OLS is used, or 0.47 using PSM. However, these estimates fall within the confidence intervals of phaseout effects on crop diversification given in Table A.IV, making it less clear that these program impacts are sustainable. The positive impact on the number of crops grown may be related to the impact on consumption variety, reported in Pan et al. (2018). Impacts on some inputs that were not explicitly encouraged in the training are presented in the Appendix, Table A.IX.

5.3. *Comparisons of Initial Program Impacts and the Effects of Phaseout*

Figure III presents a comparative summary of the estimates of the phaseout (six seasons after phaseout[17]) vis-a-vis estimated program impacts presented in this section. The estimated effect of phaseout on the use of improved and local seed, use of fertilizer, line sowing and crop rotation is represented by black circles with 95% confidence intervals, whereas the anticipated impacts of the program, under the assumption of zero persistence, are represented by the red (OLS) and grey (PSM) squares. These latter estimates are simply obtained from the previous presented in this section (by reversing their sign). The figure shows that for most outcomes, the range of likely phaseout effects is greater than the estimated initial impact (i.e. less negative), suggestive of persistence in these program impacts.

[FIGURE III HERE]

[16]These responses reflect data from 6 seasons post-phaseout; similar results were found in earlier survey rounds.

[17]The same chart with results three seasons after phaseout is in the Appendix, Figure A.II.

6. Conclusion

This paper has addressed a basic question for rural development and poverty alleviation: how sustainable are benefits from agricultural extension programs for smallholder women farmers? In doing so it introduced a novel research method, a randomized phaseout (or reverse-randomized control trial), designed to identify the causal impact of the removal of some or all components of an intervention. The context is the phaseout of an agricultural extension program for smallholder women farmers operated in Uganda since 2009 by the NGO BRAC. The program features two components, broadly targeting farmer knowledge and practices, and input market development, particularly for improved maize seeds. BRAC stimulated demand for improved seeds by providing free samples provided in model farmer (MF) trainings. BRAC stimulated supply by appointing and training community agricultural promoters (CAPs), who sold BRAC's improved seeds in villages. MFs taught improved farming practices to female farmers in their villages. Using data collected from a specially constructed control group, and from an RCT of the BRAC agriculture program from a different part of Uganda, we present evidence that this program had a number of positive impacts; for example, participating smallholders adopted better farming practices. These findings supplement other research on this program that found positive effects on food security and other impacts (Pan et al., 2018).

Due to loss of funding BRAC scheduled this program to be phased-out from early 2013.[18] The sustainability (or persistence) of the program structures, and program impacts, were tested through a randomized phaseout of the program. In early 2013, villages were randomly assigned to continue in the program (the control group) or to be part of two program phaseout groups. For the Continuation (control) group the program continued without changes.

After six growing seasons improved practices continue: farmers in the phaseout villages showed no statistically significant impacts on the use of crop rotation, intercropping, line sowing, zero tillage, weeding, irrigation, pest and disease management, or post-harvest management.

Effects of phaseout on improved seed use are more complex. In phaseout villages fewer CAPs sold seeds; and among CAPs who carried on despite loss of BRAC sponsorship quantities sold fell and sale prices rose. Evidence points to CAPs' post-phaseout transport costs as a key reason for the

[18] Fortunately, limited funding was available for the RCT program in Southwest Uganda and other research activities.

decline in their activity. On the other hand, purchases from local input dealers rose substantially in the phaseout groups, sufficient to (nearly) compensate for the decline in BRAC improved seeds.

Results suggest that there is a lag between discontinuation of the program and farmers connecting to alternative sellers of seed. This is one reason why it takes time to determine whether a program has been sustainable - some practices may hold on longer than others before farmers stop using them; and in addition, the transition itself may take time, possibly resulting in a U-shape response as input use falls until a farmer finds a viable alternative source.

Our method provides a straightforward interpretation whenever lack of persistence is identified, even if no estimates of initial impact are available. A general challenge for randomized phaseout experimental design is that absence of post phaseout impacts can be reliably interpreted as persistence only to the extent that initial program impacts are identified. Our sample was not originally randomized into program participation status; we addressed this challenge with two strategies. First, we present results of a new RCT of the BRAC agriculture program from a different part of Uganda. Second, we surveyed households in villages neighboring those in the phaseout area never treated by BRAC that were comparable on observables to our Continuation and phaseout samples. In both cases, we found significant differences (improvements) in agricultural practices that correspond to program interventions. Other research on the program reviewed also identified positive impacts.

In low-income countries it is common for both government and NGO programs to be initiated, show some apparent progress, and then be terminated, often due to lack of funding. Such discontinuations are sometimes accompanied by a statement that the program has "become sustainable". However, sustainability even for high-return activities initiated in NGO and other programs is far from certain (Kremer and Miguel, 2007). Anecdotal reports that impacts prove unsustainable after funding ends is a recurrent theme in discussions of rural development programs. Randomized phaseouts provide a new research strategy to identify effects (such as farming practices and household outcomes) of program phase out and termination.

More generally, a randomized phaseout may be helpful in several circumstances. If an intervention is discontinued entirely, the counterfactual of continuation cannot be observed: if gains from the program are retained among former participants, we do not know if those gains would have been even greater had the program continued; or if gains were lost, it is impossible to tell whether this would have happened even with program continuance.[19] For example, when a government budgetary crisis forces the closure of an agricultural extension or other program, if funds can be found to continue to program for a small randomly selected continuation group and for follow up surveys, estimates of the effects can help guide later policy. Similarly, if an NGO has reached a preliminary decision to discontinue a program - due to stringent budget constraints say, or an expectation that a new program would work better (or provide the NGO with better outside funding) - a randomized phaseout can be informative for leaders making the decision; or, having decided to terminate a program, it can nonetheless be continued for a minimal number of randomly selected participants whose outcomes are then compared with a randomly selected sample of those discontinued. To learn further lessons, a randomized phaseout could also be used to determine the effects of such program rules as that individuals' ongoing participation in programs be dependent on individual outcome variables.

More expansively, randomized phaseouts may help estimate impacts of alternative designs, such as duration and phaseout of program components. The method could reveal program and participant characteristics associated with sustainability of impacts potentially offering insight into targeting design. Randomized phaseout research may clarify tradeoffs from a program sustainability perspective; given budget constraints, often a decision must be made on whether to include more participants in a shorter-duration program or fewer participants in a longer-duration program. Moreover, randomization research on program phaseouts could inform other aspects of new program design, identifying which program components are most vital to sustainability

Funding for program implementers including NGOs may be directed only or primarily to new programs - and perhaps only after NGOs have declared their previous program to be sustainable. The randomized phaseout or "reverse-RCT" approach offers a research method to examine whether this approach makes sense within a given context.

[19]For example, gains could have been lost as a result of general factors in the wider economy.

References

Anderson, J. R. and Feder, G. (2007). Agricultural extension. *Handbook of agricultural economics*, 3:2343–2378.

Baird, S., Hicks, J. H., Kremer, M., and Miguel, E. (2016). Worms at work: Long-run impacts of a child health investment. *The Quarterly Journal of Economics*, 131(4):1637–1680.

Bandiera, O., Buehren, N., Burgess, R., Goldstein, M., Gulesci, S., Rasul, I., and Sulaiman, M. (2017). *Womens empowerment in action: Evidence from a randomized control trial in Africa*. World Bank.

Bandiera, O. and Rasul, I. (2006). Social networks and technology adoption in northern Mozambique. *The Economic Journal*, 116(514):869–902.

Bardhan, P. and Mookherjee, D. (2011). Subsidized farm input programs and agricultural performance: a farm-level analysis of West Bengal's Green Revolution, 1982–1995. *American Economic Journal: Applied Economics*, 3(4):186–214.

Barrett, C. B. (2002). Food security and food assistance programs. *Handbook of agricultural economics*, 2:2103–2190.

Barrett, C. B., Carter, M. R., and Timmer, C. P. (2010). A century-long perspective on agricultural development. *American Journal of Agricultural Economics*, 92(2):447–468.

Barua, P. (2011). Assessment of the short-run impact of BRAC's agriculture and livestock programme in Uganda. *BRAC International Working Paper Series*.

Beaman, L., BenYishay, A., Magruder, J., and Mobarak, A. M. (2015). Can network theory based targeting increase technology adoption. *Unpublished Manuscript*.

BenYishay, A. and Mobarak, A. M. (2015). Social learning and incentives for experimentation and communication. *Yale University Working Paper*.

Birkhaeuser, D., Evenson, R. E., and Feder, G. (1991). The economic impact of agricultural extension: A review. *Economic development and cultural change*, 39(3):607–650.

Bold, T., Kaizzi, K. C., Svensson, J., and Yanagizawa-Drott, D. (2017). Lemon technologies and adoption: Measurement, theory and evidence from agricultural markets in uganda. *The Quarterly Journal of Economics*, 132(3):1055–1100.

Carter, M. R., Laajaj, R., and Yang, D. (2016). Savings, subsidies, and technology adoption: Field experimental evidence from Mozambique. *NBER Working Paper 20465*.

Cole, S. and Fernando, A. N. (2012). The value of advice: Evidence from mobile phone-based agricultural extension.

Conley, T. G. and Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. *The American Economic Review*, 100(1):35–69.

Davis, K., Nkonya, E., Kato, E., Mekonnen, D. A., Odendo, M., Miiro, R., and Nkuba, J. (2012). Impact of farmer field schools on agricultural productivity and poverty in East Africa. *World Development*, 40(2):402–413.

Dercon, S., Gilligan, D. O., Hoddinott, J., and Woldehanna, T. (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics*, 91(4):1007–1021.

Duflo, E., Kremer, M., and Robinson, J. (2011). Nudging farmers to use fertilizer: Theory and experimental evidence from Kenya. *The American Economic Review*, 101(6):2350–2390.

Emerick, K., de Janvry, A., Sadoulet, E., and Dar, M. H. (2016). Technological innovations, downside risk, and the modernization of agriculture. *American Economic Review*, 106(6):1537–61.

Evenson, R. E. (2001). Economic impacts of agricultural research and extension. *Handbook of agricultural economics*, 1:573–628.

Feder, G., Murgai, R., and Quizon, J. B. (2004). The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. *Journal of agricultural economics*, 55(2):221–243.

Feder, G., Slade, R. H., and Lau, L. J. (1987). Does agricultural extension pay? the training and visit system in northwest india. *American Journal of Agricultural Economics*, 69(3):677–686.

Foster, A. D. and Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of Political Economy*, pages 1176–1209.

Foster, A. D. and Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annual review of Economics*, 2.

Godtland, E. M., Sadoulet, E., De Janvry, A., Murgai, R., and Ortiz, O. (2004). The impact of farmer field schools on knowledge and productivity: A study of potato farmers in the Peruvian Andes. *Economic development and cultural change*, 53(1):63–92.

Hanna, R., Mullainathan, S., and Schwartzstein, J. (2012). Learning through noticing: theory and experimental evidence in farming. National Bureau of Economic Research Working Paper No.18401.

Jack, B. K. (2013). Market inefficiencies and the adoption of agricultural technologies in developing countries.

Karlan, D., Osei, R., Osei-Akoto, I., and Udry, C. (2014). Agricultural decisions after relaxing credit and risk constraints. *The Quarterly Journal of Economics*, 129(2):597–652.

Kremer, M. and Miguel, E. (2007). The illusion of sustainability. *The Quarterly Journal of Economics*, 122(3):1007–1065.

Krishnan, P. and Patnam, M. (2014). Neighbors and extension agents in Ethiopia: Who matters more for technology adoption? *American Journal of Agricultural Economics*, 96(1):308–327.

Kwak, S. and Smith, S. C. (2013). Regional agricultural endowments and shifts of poverty trap equilibria: Evidence from Ethiopian panel data. *The Journal of Development Studies*, 49(7):955–975.

Larsen, A. F. and Lilleør, H. B. (2014). Beyond the field: The impact of farmer field schools on food security and poverty alleviation. *World Development*, 64:843–859.

Malik, A. S. and Smith, S. C. (2012). Adaptation to climate change in low-income countries: lessons from current research and needs from future research. *Climate Change Economics*, 3(02):1250005.

Maluccio, J. A., Hoddinott, J., Behrman, J. R., Martorell, R., Quisumbing, A. R., and Stein, A. D. (2009). The impact of improving nutrition during early childhood on education among Guatemalan adults. *The Economic Journal*, 119(537):734–763.

Munshi, K. (2004). Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of Development Economics*, 73(1):185–213.

Owens, T., Hoddinott, J., and Kinsey, B. (2003). The impact of agricultural extension on farm production in resettlement areas of Zimbabwe. *Economic Development and Cultural Change*, 51(2):337–357.

Pan, Y., Smith, S. C., and Sulaiman, M. (2018). Agricultural extension and technology adoption for food security: Evidence from Uganda. *American Journal of Agricultural Economics*, 100(4):1012–1031.

Rosenzweig, M. R. and Udry, C. (2019). External validity in a stochastic world: Evidence from low-income countries. *The Review of Economic Studies*, forthcoming.

Sheahan, M. and Barrett, C. (2016). Subsidies and the persistence of technology adoption: Field experimental evidence from Mozambique. *Food Policy*, forthcoming.

Smillie, I. (2009). *Freedom from want: The remarkable success story of BRAC, the global grassroots organization that's winning the fight against poverty*. Kumarian Press.

Suri, T. (2011). Selection and comparative advantage in technology adoption. *Econometrica*, 79(1):159–209.

World Bank (2007). *World development report 2008: Agriculture for development*. World Bank.

Tables

Table I: Balance of Sample Characteristics at Pre-phaseout Baseline, by Treatment Group

	(1) Continuation	(2) Combined Phase Out	(3) Columns (1) - (2)	(4) CAP Phase Out	(5) Columns (1) - (4)	(6) MF Phase Out	(7) Columns (1) - (6)
Program components - inputs (binary indicators)							
Improved seed use	0.594	0.545	0.048	0.550	0.043	0.540	0.054
	(0.025)	(0.019)	(0.031)	(0.027)	(0.036)	(0.026)	(0.036)
BRAC seed use	0.244	0.252	-0.007	0.265	-0.021	0.239	0.005
	(0.021)	(0.016)	(0.027)	(0.024)	(0.032)	(0.022)	(0.031)
Market seed use	0.317	0.271	0.045	0.266	0.051	0.275	0.042
	(0.023)	(0.017)	(0.030)	(0.024)	(0.033)	(0.023)	(0.033)
Organic fertilizer use	0.138	0.109	0.029	0.130	0.007	0.088	0.049**
	(0.017)	(0.012)	(0.020)	(0.018)	(0.025)	(0.015)	(0.023)
Program components - practices (binary indicators)							
Crop rotation	0.548	0.585	-0.037	0.578	-0.030	0.592	-0.043
	(0.025)	(0.019)	(0.031)	(0.027)	(0.036)	(0.026)	(0.036)
Intercropping	0.707	0.666	0.041	0.657	0.050	0.674	0.032
	(0.023)	(0.018)	(0.029)	(0.026)	(0.034)	(0.026)	(0.033)
Line sowing	0.718	0.678	0.041	0.638	0.081**	0.716	0.003
	(0.022)	(0.018)	(0.028)	(0.026)	(0.034)	(0.024)	(0.033)
Weeding	0.891	0.842	0.049**	0.879	0.012	0.807	0.083**
	(0.016)	(0.014)	(0.021)	(0.018)	(0.023)	(0.021)	(0.026)
Zero tillage	0.088	0.072	0.016	0.069	0.019	0.074	0.014
	(0.0142)	(0.010)	(0.017)	(0.014)	(0.020)	(0.014)	(0.020)
Pest&disease mgmt	0.472	0.452	0.020	0.427	0.046	0.476	-0.042
	(0.025)	(0.019)	(0.031)	(0.027)	(0.037)	(0.026)	(0.036)
Household characteristics							
Farmer age	39.87	39.63	0.234	39.22	0.644	40.03	-0.162
	(0.587)	(0.438)	0.733	(0.592)	(0.834)	(0.643)	(0.871)
Cultivated land	2.473	2.397	0.0758	2.454	0.019	2.342	0.131
in acres	(0.080)	(0.060)	(0.100)	(0.089)	(0.120)	(0.080)	(0.113)
Own ag. land	2.088	2.131	-0.043	2.159	-0.071	2.105	-0.016
in acres	(0.073)	(0.058)	(0.093)	(0.083)	(0.110)	(0.082)	(0.110)
Formal title to land	0.558	0.509	0.049	0.488	0.070*	0.530	0.029
yes/no	(0.025)	(0.019)	(0.032)	(0.028)	(0.037)	(0.027)	(0.037)
# of rooms in house	2.691	2.623	0.069	2.638	0.054	2.609	0.083
	(0.077)	(0.055)	(0.095)	(0.081)	(0.112)	(0.074)	(0.107)
At least 2 sets clothes	0.968	0.941	0.027**	0.952	0.015	0.931	0.037**
yes/no	(0.009)	(0.009)	(0.013)	(0.012)	(0.015)	(0.014)	(0.016)
At least 2 pairs shoes	0.781	0.791	-0.009	0.820	-0.038	0.764	0.017
yes/no	(0.021)	(0.016)	(0.027)	(0.022)	(0.030)	(0.023)	(0.031)
Mobile phone	0.764	0.870	-0.106	0.892	-0.128	0.849	-0.085
number owned by HH	(0.055)	(0.042)	(0.069)	(0.062)	(0.083)	(0.056)	(0.079)

Table I – *Continued from previous page*

	(1) Continuation	(2) Combined Phase Out	(3) Columns (1) - (2)	(4) CAP Phase Out	(5) Columns (1) - (4)	(6) MF Phase Out	(7) Columns (1) - (6)
HH appliances	1.873	1.977	-0.104	2.058	-0.185	1.903	-0.030
number owned by HH	(0.134)	(0.114)	(0.181)	(0.150)	(0.201)	(0.171)	(0.218)
Poultry	5.631	6.174	-0.542	6.650	-1.019	5.711	-0.079
number owned by HH	(0.379)	(0.395)	(0.593)	(0.561)	0.677	(0.555)	(0.672)
Livestock, small	2.424	2.313	0.112	2.606	0.181	2.030	0.395
number owned by HH	(0.191)	(0.214)	(0.316)	(0.348)	(0.381)	(0.254)	(0.313)
Livestock, large	1.188	1.255	-0.067	1.434	-0.246*	1.086	0.102
number owned by HH	(0.081)	(0.072)	(0.112)	(0.107)	(0.134)	(0.095)	(0.125)
N	405	719		352		367	

Note: Standard errors are in parentheses.

Table II.a: Phaseout effect on improved seed use, binary indicator

	Improved seed use			
	1 season post-phaseout (1)	3 seasons post-phaseout (2)	5 seasons post-phaseout (3)	6 seasons post-phaseout (4)
Phaseout combined	0.0083	0.0207	-0.0411	0.0160
	(0.0334)	(0.0336)	(0.0393)	(0.0374)
95% CI	[-0.0581 0.0746]	[-0.0460 0.0874]	[-0.1191 0.0368]	[-0.0582 0.0902]
R^2	0.180	0.174	0.099	0.082
N	1037	1032	921	925
Mean value in Continuation	0.427	0.386	0.424	0.317

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. All variables are binary indicators. All regressions include controls: binary indicators for outcome at pre-phaseout baseline and the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table II.b: Phaseout effect on improved seed use, quantities

	Improved seed quantities, total		Improved seed quantities, per acre	
	3 seasons post-phaseout (1)	5 seasons post-phaseout (2)	3 seasons post-phaseout (3)	5 seasons post-phaseout (4)
Phaseout combined	0.5304	-0.2164	0.2890	-0.0259
	(0.5033)	(0.4776)	(0.2267)	(0.2931)
95% CI	[-0.4684 1.5291]	[-1.1640 0.7312]	[-0.1609 0.7389]	[-0.6076 0.5557]
R^2	0.092	0.086	0.085	0.099
N	1029	926	998	878
Mean value in Continuation	3.48	3.19	1.85	1.95

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Quantities of improved seeds are in kilograms; all other variables are binary indicators. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table III.a: Phaseout effect on local seed use, binary indicator

	Local seed use			
	1 season post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout	6 seasons post-phaseout
	(1)	(2)	(3)	(4)
Phaseout combine	-0.0158	-0.0258	-0.0057	-0.0006
	(0.0227)	(0.0260)	(0.0288)	(0.0300)
95% CI	[-0.0609 0.0292]	[-0.0774 0.0258]	[-0.0650 0.0536]	[-0.0601 0.0590]
R^2	0.189	0.090	0.056	0.061
N	1038	1031	930	934
Mean value in Continuation	0.878	0.869	0.859	0.836

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. All variables are binary indicators. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table III.b: Phaseout effect on local seed use, quantities

	Local seed quantities, total		Local seed quantities, per acre	
	3 seasons post-phaseout	5 seasons post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout
	(1)	(2)	(3)	(4)
Phaseout combined	1.0340	-0.9170	-0.8154	0.4697
	(1.7809)	(1.7755	(1.2825)	(0.8156)
95% CI	[-2.5002 4.5681]	[-4.4399 2.6059]	[-3.3608 1.7301]	[-1.1486 2.0879]
R^2	0.119	0.201	0.076	0.175
N	1009	925	978	922
Mean value in Continuation	17.5	15.9	11.9	9.4

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Quantities of local seeds are in kilograms; all other variables are binary indicators. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table IV: Phaseout effect on sources of improved seed

1 season after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
Phaseout combined	-0.0490*	0.0207	0.0120*
	(0.0261)	(0.0288)	(0.0068)
R^2	0.075	0.172	0.069
N	1037	1037	1015
Mean value in Continuation	0.096	0.271	0.005

3 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
Phaseout combined	-0.0555*	0.0572*	0.0174***
	(0.0305)	(0.0343)	(0.0065)
R^2	0.110	0.150	0.029
N	1032	1032	1032
Mean value in Continuation	0.102	0.256	0.002

5 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
Phaseout combined	-0.117***	0.0650**	-0.0002
	(0.0289)	(0.0263)	(0.0092)
R^2	0.113	0.084	0.201
N	907	907	907
Mean value in Continuation	0.142	0.234	0.018

6 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
Phaseout combined	-0.0993***	0.1150***	-0.0125
	(0.0263)	(0.0258)	(0.0105)
R^2	0.107	0.074	0.034
N	911	911	911
Mean value in Continuation	0.117	0.139	0.021

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Dependent variables are binary indicators of whether farmers used seeds from market, CAP/Model farmer or Other BRAC sources; independent variables are binary indicators of treatment status. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table V: Phaseout effect on cultivation practices, binary indicator

3 seasons after phaseout

	Crop rotation	**Intercropping**	**Line sowing**	**Irrigation**	**Proper weeding**	**Zero tillage**	**Pest and disease management**	**Post-harvest management**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Phaseout combined	-0.0164	-0.0188	-0.0108	0.0069	-0.0046	-0.0142	0.0585*	0.0219
	(0.0368)	(0.0236)	(0.0335)	(0.0067)	(0.0180)	(0.0120)	(0.0299)	(0.0329)
95% CI	[-0.0894 0.0566]	[-0.0656 0.0281]	[-0.0773 0.0558]	[-0.00640 0.0202]	[-0.0404 0.0311]	[-0.0380 0.0097]	[-0.0008 0.11770]	[-0.0433 0.0871]
R^2	0.118	0.342	0.259	0.041	0.044	0.164	0.103	0.232
N	1029	1029	1031	1030	1033	1028	1021	1027
Mean value in Continuation	0.685	0.594	0.730	0.018	0.938	0.060	0.214	0.609

6 seasons after phaseout

	Crop rotation	**Intercropping**	**Line sowing**	**Irrigation**	**Proper weeding**	**Zero tillage**	**Pest and disease management**	**Post-harvest management**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Phaseout combined	0.0115	0.0023	0.0413	0.0052	0.0117	-0.0207*	0.0252	0.0104
	(0.0426)	(0.0415)	(0.0371)	(0.0146)	(0.0313)	(0.0112)	(0.0382)	(0.0301)
95% CI	[-0.0730 0.0961]	[-0.0801 0.0847]	[-0.0323 0.1149]	[-0.0238 0.0343]	[-0.0504 0.0739]	[-0.0429 0.0015]	[-0.0506 0.1009]	[-0.0494 0.0702]
R^2	0.210	0.108	0.292	0.033	0.141	0.055	0.060	0.262
N	926	927	925	934	927	919	918	934
Mean value in Continuation	0.477	0.412	0.579	0.035	0.812	0.032	0.199	0.678

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table VI: Program impact estimates from RCT in Kabale, SW Uganda

		A **Ag only + Ag and MF** **vs. MF + None**	B **Ag only** **vs. None**
Number of acres cultivated	Coefficient	0.090*	0.062
	SE	(0.047)	(0.071)
	N	6,007	3,049
Number of crops produced	Coefficient	0.205**	0.134
	SE	(0.100)	(0.145)
	N	6,230	3,156
Purchased any improved seeds	Coefficient	0.061***	0.077***
	SE	(0.013)	(0.018)
	N	6,105	3,094
Purchased seeds from BRAC sources	Coefficient	0.062***	0.066***
	SE	(0.010)	(0.014)
	N	6,105	3,094
Adopted crop rotation	Coefficient	0.022	-0.009
	SE	(0.025)	(0.036)
	N	6,229	3,156
Adopted inter cropping	Coefficient	-0.008	-0.005
	SE	(0.005)	(0.008)
	N	6,226	3,154
Adopted line sowing	Coefficient	0.012	0.026
	SE	(0.014)	(0.020)
	N	6,227	3,153
Adopted proper weeding	Coefficient	0.005	-0.008
	SE	(0.018)	(0.025)
	N	6,229	3,156
Spent money on pesticide	Coefficient	0.008	0.003
	SE	(0.010)	(0.015)
	N	6,230	3,156
Spent money on manure	Coefficient	-0.001	-0.001
	SE	(0.001)	(0.001)
	N	6,230	3,156
Spent money on hiring labour	Coefficient	0.008	0.014
	SE	(0.017)	(0.026)
	N	6,230	3,156
Total agriculture production (in ’000 UGX)	Coefficient	81.143**	50.304
	SE	(31.596)	(46.556)
	N	6,167	3,126
Production per acre (in ’000 UGX)	Coefficient	17.941	7.113
	SE	(16.938)	(23.643)
	N	5,725	2,915
Received cash revenue from crop sales	Coefficient	0.060**	0.060
	SE	(0.025)	(0.037)

Table VI – *Continued from previous page*

		A	B
		Ag only + Ag and MF vs. MF + None	**Ag only vs. None**
	N	6,230	3,156
Cash revenue from crop sales	Coefficient	29.218***	29.263*
(in '000 UGX)	SE	(11.228)	(16.213)
	N	6,167	3,124

Note: Regressions are OLS models with standard errors clustered at the village cluster level. Regressions include branch fixed effects. Baseline values of dependent variables are included as controls.

Table VII: Descriptive statistics of No Treatment vs. Continuation groups

	No Treatment	Continuation	Difference
Farmer age	42.18	41.93	0.251
	(0.538)	(0.603)	(0.824)
Education level, highest grade completed	5.344	5.569	-0.225
	(0.151)	(0.201)	(0.251)
Cultivated land, in acres	1.978	2.155	-0.177
	(0.070)	(0.088)	(0.113)
Own agricultural land, in acres	2.314	2.369	-0.055
	(0.169)	(0.110)	(0.232)
Formal title to land	0.556	0.604	-0.048
	(0.020)	(0.024)	(0.032)
At least two sets of clothes	0.887	0.906	-0.019
	(0.012)	(0.014)	(0.019)
At least two sets of shoes	0.645	0.665	-0.02
	(0.018)	(0.023)	(0.030)
Livestock, large	1.154	1.169	-0.015
	(0.092)	(0.102)	(0.143)
Livestock, small	1.368	1.23	0.138
	(0.091)	(0.092)	(0.137)
Microfinance member	0.238	0.655	-0.417***
	(0.016)	(0.023)	(0.027)
Distance to BRAC branch office	6.497	4.065	2.432***
	(0.142)	(0.114)	(0.203)

Note: Standard errors in parentheses.

Table VIII: Program impact on improved seed use

	Improved seed use				Improved seed purchases			
	OLS		PSM		OLS		PSM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated	0.1481***		0.1253**		0.1291***		0.0992	
	(0.0314)		(0.0609)		(0.0322)		(0.0663)	
Continuation		0.1549***		0.1703**		0.1405***		0.1485*
		(0.0500)		(0.0816)		(0.0515)		(0.0794)
BRAC microfinance	0.0307	-0.0188			0.0362	-0.0029		
member	(0.0320)	(0.0420)			(0.0308)	(0.0434)		
Distance to	-0.0104**	-0.0162***			-0.0079*	-0.0120**		
BRAC office	(0.0043)	(0.0049)			(0.0041)	(0.0048)		
R^2	0.188	0.219			0.191	0.211		
N	1781	1073	1437	863	1779	1072	1435	862
Mean value in No Treatment	0.240				0.227			

Note: Standard errors (in parentheses) are clustered at the village cluster level. Dependent variables are binary indicators of seed use or purchases. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers). PSM uses k-nearest neighbor matching (k=1, caliper 0.025) to find matches within branches only. Results restricted to households on the common support.

Table IX: Program impact on local seed use

	Local seed use			
	OLS		PSM	
	(1)	(2)	(3)	(4)
Treated	-0.0384**		-0.0670**	
	(0.0177)		(0.0274)	
Continuation		-0.0358		-0.0526
		(0.0239)		(0.0396)
BRAC microfinance member	0.0202	0.0101		
	(0.0204)	(0.0275)		
Distance to BRAC office	0.0110***	0.0080***		
	(0.0029)	(0.0030)		
R^2	0.068	0.077		
N	1782	1074	1438	864
Mean value in No Treatment	0.922			

Note: Standard errors (in parentheses) are clustered at the village cluster level. Dependent variables are binary indicators of seed use or purchases. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers). PSM uses k-nearest neighbor matching (k=1, caliper 0.025) to find matches within branches only. Results restricted to households on the common support.

Table X: Program impact on cultivation practices

	Crop rotation		Intercropping		Line sowing		Irrigation	
	OLS	PSM	OLS	PSM	OLS	PSM	OLS	PSM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Continuation dummy	0.1037**	0.1472*	-0.0475	0.0131	0.1295***	0.1856**	-0.0147	0.0044
	(0.0404)	(0.0841)	(0.0361)	(0.0591)	(0.0397)	(0.0808)	(0.0093)	(0.0128)
BRAC microfinance member	-0.0024		0.0076		-0.0478		0.0099	
	(0.0456)		(0.0341)		(0.0097)		(0.0278)	
Distance to BRAC office	0.0098*		0.0028		-0.0001		0.0050	
	(0.0056)		(0.0039)		(0.0011)		(0.0040)	
R^2	0.096		0.377		0.033		0.066	
N	1011	876	1018	866	874	866	1026	868
Mean value in No Treatment	0.685		0.588		0.753		0.015	
	Proper weeding		Zero tillage		Pest and disease management		Post-harvest storage	
	OLS	PSM	OLS	PSM	OLS	PSM	OLS	PSM
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Continuation dummy	0.0096	0.0261	0.0153	0.0175	0.0453	0.0437	0.0327	0.1026
	(0.0245)	(0.0490)	(0.0184)	(0.0206)	(0.0401)	(0.0580)	(0.0532)	(0.0951)
BRAC microfinance member	0.0361		-0.0003		-0.0645		-0.0595	
	(0.0392)		(0.0196)		(0.0425)		(0.0478)	
Distance to BRAC office	0.0036		0.0002		0.0028		-0.0011	
	(0.0051)		(0.0025)		(0.0046)		(0.0054)	
R^2	0.175		0.134		0.079		0.236	
N	986	866	693	866	949	866	855	866
Mean value in No Treatment	0.922		0.060		0.177		0.777	

Note: Standard errors (in parentheses) are clustered at the village cluster level. Dependent variables are binary indicators of whether a practice is used. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers). PSM uses k-nearest neighbor matching (k=1, caliper 0.025) to find matches within branches only. Results restricted to households on the common support.

Table XI: Program impact on crop diversification

	Number of crops grown		**Cultivated maize**	
	OLS	PSM	OLS	PSM
	(1)	(2)	(3)	(4)
Continuation dummy	0.3758**	0.4738*	0.0709***	0.0480
	(0.1618)	(0.2700)	(0.0243)	(0.0463)
BRAC microfinance member	-0.2331		-0.0067	
	(0.1413)		(0.0269)	
Distance to BRAC office	0.0278		-0.0028	
	(0.0307)		(0.0037)	
R^2	0.091		0.262	
N	1098	868	1077	866
Mean value in No Treatment	3.274		0.786	

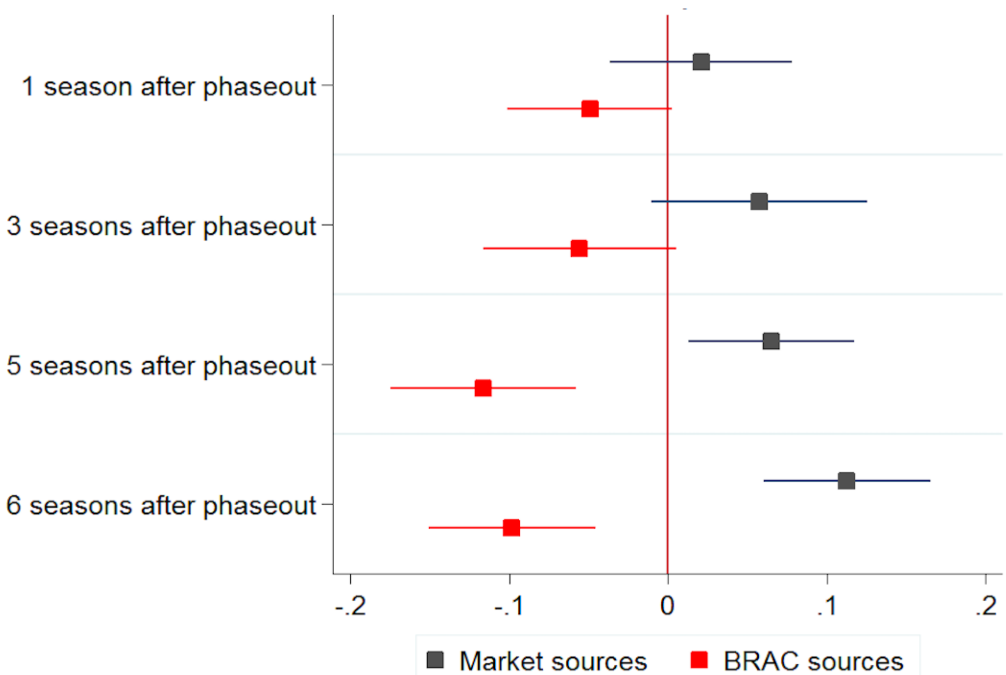
Note: Standard errors (in parentheses) are clustered at the village cluster level. The dependent variable in columns 3 and 4 is a binary indicator of maize cultivation. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers). PSM uses k-nearest neighbor matching (k=1, caliper 0.025) to find matches within branches only. Results restricted to households on the common support.

Figures

Figure I: Timeline of phaseout and data collection activities

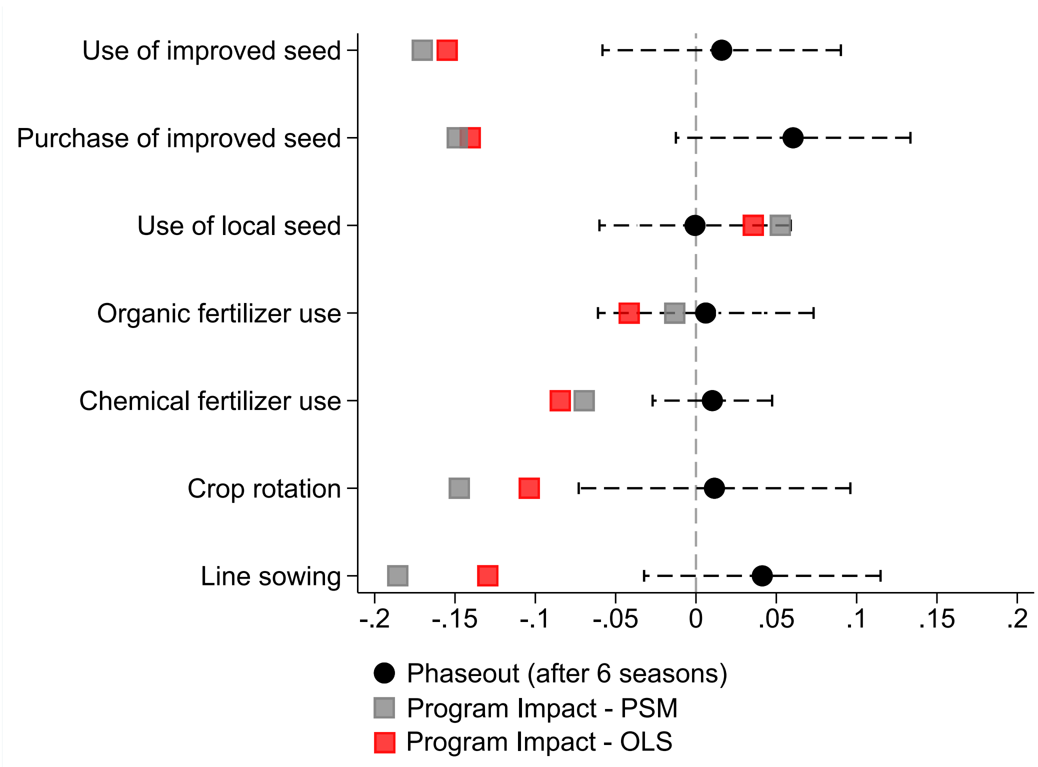
Data collection			Program
Seasons covered by survey	Survey	Date	Program stage
		2009	Program implemented
T-1 (recall), T	Baseline survey	February 2013	Phaseout Stage 1 - Model Farmer component phased out in MF Phaseout arm - CAP component phased out in CAP Phaseout arm
T (recall), T+1	Followup survey 1	September 2013	
		February 2014	Phaseout Stage 2 - Remaining treatment phased out in both phaseout arms
T+3	Followup survey 2	September 2014	
T+5 (recall), T+6	Followup survey 3	February 2016	
		late 2016	Phaseout Stage 3 - Treatment stopped in Continuation arm

Figure II: Phaseout effects on seed sources



Note: Error bars denote 95% confidence intervals.

Figure III: Phaseout impact confidence intervals - 6 seasons after phaseout



Note: Error bars denote 95% confidence intervals. OLS and PSM point estimates are from regressions using No Treatment and Continuation groups only.

Appendix A. Additional Tables and Figures

Table A.I: Attrition by treatment group

	Continuation	Difference wrt Continuation	
	Attrition rate	**CAP Phaseout**	**Model Farmer Phaseout**
1 season after phaseout	0.152	0.029	0.055
		(0.036)	(0.048)
3 seasons after phaseout	0.178	0.036	0.065
		(0.045)	(0.042)

Note: Standard errors are in parentheses.

Table A.II: Baseline characteristics of attritors and non-attritors

	Improved seed use (yes/no)	**Organic fertilizer use** (yes/no)	**Crop rotation** (yes/no)	**Inter-cropping** (yes/no)	**Line sowing** (yes/no)	**Mixed cropping** (yes/no)
Difference between attritors and non-attritors	0.019	0.037	0.013	-0.026	-0.059*	0.028
	(0.038)	(0.042)	(0.034)	(0.033)	(0.032)	(0.031)
N	1628	1616	1639	1640	1639	1641

	Weeding (yes/no)	**Zero tillage** (yes/no)	**Farmer age**	**Farmer literacy** (yes/no)	**At least 2 sets of clothes** (yes/no)	**At least 2 pairs of shoes** (yes/no)
Difference between attritors and non-attritors	-0.038	-0.053	-0.000	0.014	-0.05	0.033
	(0.035)	(0.046)	(0.000)	(0.009)	(0.064)	(0.039)
N	1638	1631	1131	1129	1506	1518

	# rooms in main house	**Cultivated land** in acres	**Land title** (yes/no)	**Mobile phone** (yes/no)
Difference between attritors and non-attritors	-0.000	-0.010	0.035	0.034
	(0.011)	(0.007)	(0.030)	(0.034)
N	1529	1658	1560	1534

Note: Standard errors are in parentheses.

Table A.III: Phaseout effect on other inputs and tools, binary indicator

3 seasons after phaseout

	Hired labor	**Organic fertilizer**	**Inorganic fertilizer**	**Pesticide**	**Hand plow**	**Mechanized plow**	**Pump for pesticides**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Phaseout combined	0.0321	-0.0261	-0.0242	0.0298	-0.0322	0.0208**	0.0316
	(0.0339)	(0.0252)	(0.0226)	(0.0275)	(0.0302)	(0.0096)	(0.0299)
95% CI	[-0.0353 0.0995]	[-0.0760 0.0238]	[-0.0692 0.0207]	[-0.0248 0.0845]	[-0.0921 0.0277]	[0.0017 0.0398]	[-0.0278 0.0910]
R^2	0.102	0.119	0.098	0.103	0.653	0.669	0.090
N	1033	1030	1029	1030	1007	1003	1030
Mean value in Continuation	0.602	0.145	0.120	0.211	0.344	0.055	0.190

6 seasons after phaseout

	Hired labor	**Organic fertilizer**	**Inorganic fertilizer**	**Pesticide**	**Hand plow**	**Mechanized plow**	**Pump for pesticides**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Phaseout combined	0.0056	0.0061	0.0102	0.0307	0.0326	0.0043	0.0407
	(0.0492)	(0.0338)	(0.0187)	(0.0405)	(0.0268)	(0.0150)	(0.0376)
95% CI	[-0.0921 0.1032]	[-0.0610 0.0732]	[-0.0270 0.0474]	[-0.0496 0.1110]	[-0.0206 0.0858]	[-0.0255 0.0341]	[-0.0339 0.1154]
R^2	0.080	0.149	0.100	0.127	0.163	0.117	0.087
N	925	919	918	923	894	888	866
Mean value in Continuation	0.466	0.199	0.076	0.199	0.026	0.026	0.150

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.IV: Phaseout effect on crop diversification

	Number of crops						**Cultivated maize (yes/no)**					
	1 season post-phaseout		3 seasons post-phaseout		5 seasons post-phaseout		1 season post-phaseout		3 seasons post-phaseout		5 seasons post-phaseout	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Phaseout combined	-0.1021		-0.1191		-0.2072		0.0057		-0.0349		-0.0072	
	(0.3416)		(0.1888)		(0.1290)		(0.0242)		(0.0242)		(0.0253)	
95% CI	[-0.7801 0.5760]		[-0.4938 0.2556]		[-0.4632 0.0488]		[-0.0431 0.0534]		[-0.0629 0.0316]			
	[-0.0573 0.0429]											
CAP Phaseout		0.0197		-0.1006		-0.2186		0.0135		-0.0283		-0.0103
		(0.0362)		(0.2497)		(0.1512)		(0.0257)		(0.0240)		(0.0294)
95% CI		[-0.6995 0.7388]		[-0.5960 0.3949]		[-0.5185 0.0813]		[-0.0385 0.06410]		[-0.0591 0.0496]		[-0.0687 0.0480]
MF Phaseout		-0.2416		-0.1383		–0.1948		-0.0023		-0.0417		-0.0039
		(0.4109)		(0.2024)		(0.1361)		(0.0324)		(0.0323)		(0.0313)
95% CI		[-1.0571 0.5738]		[-0.5400 0.2635]		[-0.4649 0.0753]		[-0.0669 0.0613]		[-0.0862 0.0324]		[-0.0660 0.0583]
R^2	0.272	0.273	0.063	0.064	0.262	0.262	0.202	0.203	0.194	0.195	0.261	0.261
N	857	857	1051	1051	915	915	1034	1034	1038	1038	918	918
Mean value in C	4.485		3.569		2.849		0.881		0.753		0.770	

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Controls are values for outcome at pre-phaseout baseline, and binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.V: Phaseout effects on crop yields

	Maize yield, log kg					
	1 season post-phaseout		**3 seasons post-phaseout**		**5 seasons post-phaseout**	
	(1)	(2)	(3)	(4)	(5)	(6)
Phaseout combined	0.0192		0.1069		0.0918	
	(0.0688)		(0.0642)		(0.0937)	
95% CI	[-0.1174 0.1557]		[-0.0206 0.2344]		[-0.0942 0.2777]	
CAP Phaseout		0.0083		0.1147		0.0144
		(0.0909)		(0.0728)		(0.1044)
95% CI		[-0.1720 0.1887]		[-0.0298 0.2593]		[-0.1927 0.2216]
MF Phaseout		0.0303		0.0978		0.1705
		(0.0799)		(0.0747)		(0.1108)
95% CI		[-0.1283 0.1889]		[-0.0505 0.2461]		[-0.0494 0.3904]
R^2	0.203	0.203	0.149	0.149	0.124	0.127
N	773	773	706	706	688	688
Mean value in Continuation	5.608		5.198		5.339	

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title. Dependent variables are in logarithms. Maize yield is calculated as kilograms of maize per acre of land on which maize is cultivated.

Table A.VI: Phaseout effects on revenues and profits

	Revenues, in UGX						**Profits**, in UGX					
	after 1 season		after 3 seasons		after 5 seasons		after 1 season		after 3 seasons		after 5 seasons	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Phaseout	-46987.7		-7668.1		-51699.0		-572043.3		-47377.4		-75143.6	
	(32056.7)		(35350.4)		(53228.3)		(421554.6)		(64768.9)		(65574.6)	
CAP Phaseout		-51316.5		-49050.2		-45384.6		-584099.2		-46684.3		-83546.9
		(36068.9)		(34995.9)		(60725.1)		(479153.8)		(78417.7)		(66458.4)
MF Phaseout		-42980.5		30397.2		-58243.7		-559264.9		-48101.5		-66191.0
		(39494.3)		(44638.1)		(60544.9)		(397793.3)		(65028.0)		(75093.2)
R^2	0.201	0.201	0.069	0.074	0.127	0.127	0.031	0.031	0.036	0.036	0.067	0.067
N	554	554	626	626	700	700	570	570	970	970	917	917
Mean value in Continuation	383712.5		419823.3		455971.9		191508		976772.3			

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.VII: Phaseout effects on CAP seed sales

3 seasons after phaseout

	Sale of BRAC seed dummy (1)	**Maize seed sold - quantity** log kg (2)	**Maize seed sold - price** log UGX/kg (3)
Phaseout combined	0.0329	-0.218	0.124
	(0.101)	(0.534)	(0.154)
R^2	0.358	0.661	0.533
N	76	34	34
Mean value in Continuation	0.436	4.081	7.945

6 seasons after phaseout

	Sale of BRAC seed dummy (1)	**Maize seed sold - quantity** log kg (2)	**Maize seed sold - price** log UGX/kg (3)
Phaseout combined	-0.245**	-0.687	0.397
	(0.106)	(0.570)	(0.496)
R^2	0.411	0.590	0.278
N	77	21	22
Mean value in Continuation	0.444	3.313	7.695

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Includes branch fixed effects. Independent variables are binary indicators.

Table A.VIII: Agricultural production function

	Total yield, kg per acre	**Maize yield, kg per acre**
	log	log
	(1)	(2)
Treatment dummy	-0.0253	0.0119
	(0.0257)	(0.0199)
Cultivated land, own	-0.0963***	
in acres	(0.0201)	
Cultivated land, rented	-0.156***	
in acres	(0.0316)	
Cultivated land, total#		-0.00498
in acres		(0.0159)
Dummy variables:		
Improved seed	0.155**	0.153***
	(0.0642)	(0.0521)
Organic fertilizer	0.145*	-0.102
	(0.0796)	(0.0762)
Chemical fertilizer	0.0878	0.161**
	(0.0916)	(0.0656)
Pesticide, herbicide	0.0876	0.103**
	(0.0661)	(0.0519)
Hired labor	0.0772	0.0613
	(0.0546)	(0.0481)
Animals for plowing	0.206**	0.235***
	(0.0928)	(0.0687)
Hand plow	-0.0116	-0.189**
	(0.102)	(0.0884)
Mechanized plow	0.148	0.578***
	(0.127)	(0.121)
Crop rotation	0.304***	0.0910*
	(0.0603)	(0.0468)
Intercropping	0.0813	-0.181***
	(0.0598)	(0.0578)
Mixed cropping	0.0377	-0.0931
	(0.0610)	(0.0564)
Line sowing	0.180**	0.0233
	(0.0732)	(0.0650)
Weeding	-0.107	0.0280
	(0.103)	(0.0904)
Irrigation	0.0305	0.0314
	(0.153)	(0.160)
Education level	0.00136	0.00204
	(0.00625)	(0.00553)
R^2	0.217	0.204

Table A.VIII – *Continued from previous page*

	Total yield, kg per acre	**Maize yield, kg per acre**
	log	log
	(1)	(2)
N	1355	1305

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Includes branch fixed effects

Data on own vs. rented land was only gathered for the plot size overall, but not for cultivation areas of individual crops.

Total yield (kg per acre) for each farmer is calculated using information on output of all crops grown (in kilograms) and the total cultivated area; maize yield is calculated as total maize output in kg divided by the area used for maize cultivation.

Table A.IX: Program impact on other inputs

	Organic fertilizer		**Chemical fertilizer**		**Pesticide**		**Hired labor**		**Mechanized plow**	
	OLS	PSM	OLS	PSM	OLS	PSM	OLS	PSM	OLS	PSM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Continuation dummy	0.0416	0.0132	0.0844**	0.0696	0.0508	0.0565	0.1025*	0.1370**	-0.0077	0.0351
	(0.0297)	(0.0581)	(0.0348)	(0.0533)	(0.0339)	(0.0538)	(0.0526)	(0.0681)	(0.0217)	(0.0369)
BRAC microfinance	0.0151		-0.0455		-0.0425		0.0533		0.0765***	
member	(0.0271)		(0.0317)		(0.0362)		(0.0418)		(0.0275)	
Distance to	-0.0049		-0.0037		0.0028		0.0005		-0.0017	
BRAC office	(0.0032)		(0.0032)		(0.0044)		(0.0055)		(0.0020)	
R^2	0.112		0.139		0.076		0.103		0.426	
N	1087	872	1089	874	1090	875	1090	875	1069	860
Mean value in No Treatment	0.059		0.065		0.17		0.454		0.080	

	Animals for plowing		**Hand plow**		**Fuel**		**Transport**	
	OLS	PSM	OLS	PSM	OLS	PSM	OLS	PSM
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Continuation dummy	0.1067**	0.0680	0.0801**	0.0811**	0.0014	0.0044	-0.0039	0.0393
	(0.0399)	(0.0.0551)	(0.0351)	(0.0400)	(0.0044)	(0.0077)	(0.0549)	(0.0716)
BRAC microfinance	-0.0616*		-0.0157		-0.0050		0.0553	
member	(0.0353)		(0.0300)		(0.0059)		(0.0472)	
Distance to	-0.0005		0.0054		-0.0010**		-0.0019	
BRAC office	(0.0060)		(0.0037)		(0.0005)		(0.0051)	
R^2	0.544		0.690		0.028		0.156	
N	1069	862	1069	859	1070	860	1071	861
Mean value in No Treatment	0.376		0.265		0.003		0.214	

Note: Standard errors (in parentheses) are clustered at the village cluster level. Dependent variables are binary indicators of input use. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers). PSM uses k-nearest neighbor matching (k=1, caliper 0.025) to find matches within branches only. Results restricted to households on the common support.

Table A.X: Program impact estimate on improved seed use using alternative measure of BRAC microfinance group membership

	Improved seed use		**Improved seed purchases**	
	OLS		OLS	
	(1)	(2)	(3)	(4)
Treated	0.1078***		0.0926***	
	(0.0285)		(0.0290)	
Continuation		0.1005**		0.0903*
		(0.0463)		(0.0468)
BRAC microfinance member	0.1837***	0.2254***	0.1708***	0.2223***
	(0.0280)	(0.0370)	(0.0281)	(0.0378)
Distance to BRAC office	-0.0118***	-0.0142***	-0.0095**	-0.0107**
	(0.0039)	(0.0044)	(0.0038)	(0.0043)
R^2	0.209	0.245	0.210	0.242
N	1781	1075	1779	1074
Mean value in No Treatment	0.240		0.227	

Note: Standard errors (in parentheses) are clustered at the village cluster level. Dependent variables are binary indicators of seed use or purchases. OLS regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting self-reported BRAC microfinance group membership) and distance to BRAC branch office (measured in kilometers).

Table A.XI: Impact on improved seed use, by season

	Improved seed use		
	Pre-phaseout - t-1	Post-phaseout - t+1	Post-phaseout - t+3
	(1)	(2)	(3)
Continuation	0.160**	0.127**	0.155***
	(0.0653)	(0.0544)	(0.0498)
BRAC microfinance membership	-0.0907*	-0.0542	-0.0189
	(0.0526)	(0.0537)	(0.0420)
Distance to BRAC office	-0.0194***	-0.00837	-0.0162***
	(0.00659)	(0.00613)	(0.00488)
R^2	0.257	0.164	0.221
N	1006	1003	1079

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Dependent variables are binary indicators of seed use. Regressions include branch fixed effects and controls for microfinance membership (binary indicator denoting existence of a BRAC microfinance group in the village) and distance to BRAC branch office (measured in kilometers).

Figure A.I: Map of treated and untreated households - Eastern District, Uganda

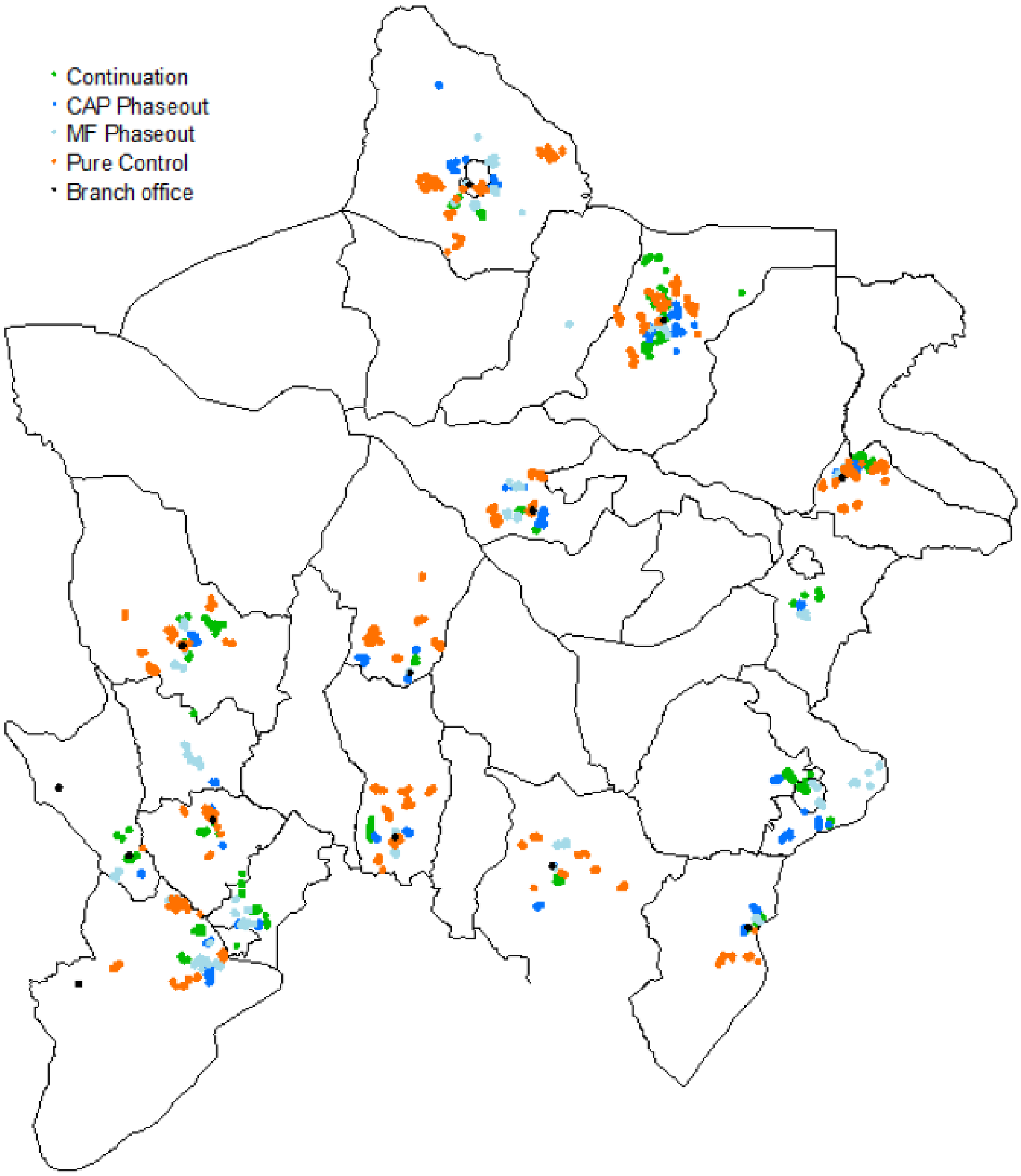
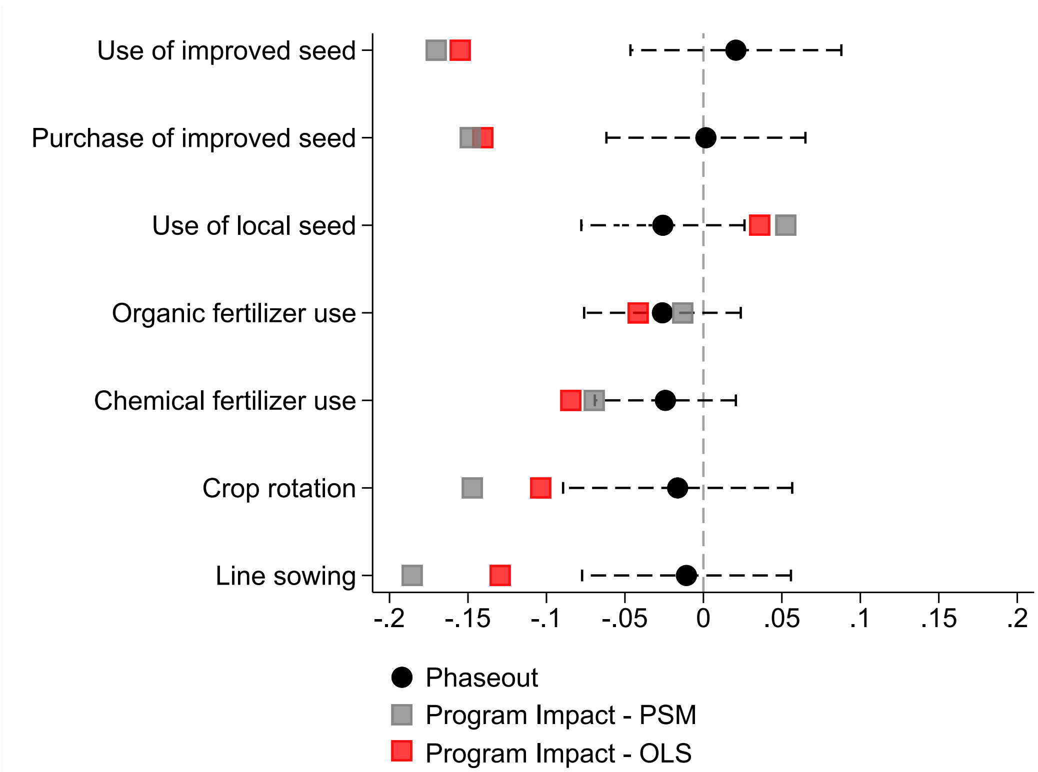


Figure A.II: Phaseout impact confidence intervals - 3 seasons after phaseout



Note: Error bars denote 95% confidence intervals. OLS and PSM point estimates are from regressions using No Treatment and Continuation groups only.

Figure A.III: Propensity score distribution

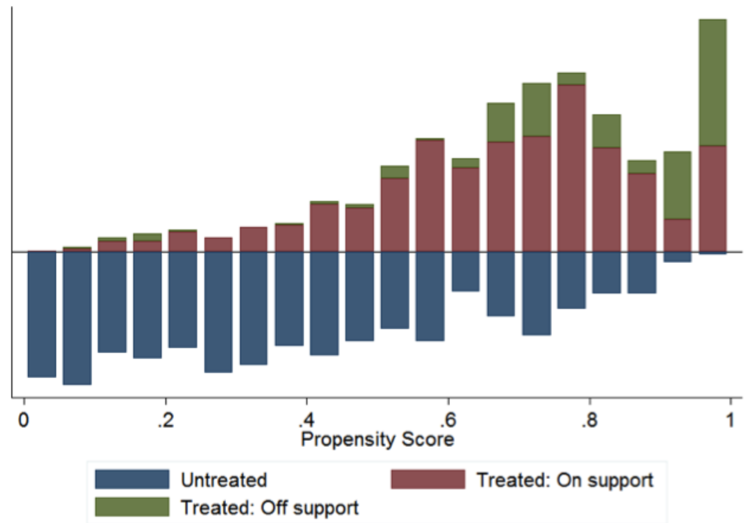


Table A.XII: Sample comparison pre- and post-matching - improved seed use

Sample	Pseudo R^2	LR chi^2	p >chi^2	MeanBias	MedBias	B	R	%Var
Unmatched	0.110	226.26	0	34.5	18.9	80.5*	0.47*	67
Matched	0.003	5.27	0.153	5.6	3.8	12.7	0.96	67

Table A.XIII: Alternative PSM methods - improved seed use (No Treatment vs. all treated groups)

Matching method	Caliper=0.01	Caliper=0.025	Caliper=0.05	Radius with caliper = 0.025	Kernel bandwidth=0.05
Estimated coefficient	0.1266**	0.1253**	0.1170**	0.1237**	0.1146**
SE	(0.0577)	(0.0627)	(0.0564)	(0.0615)	(0.0514)

Phaseout impacts, separate treatment arms

Table A.XIV: Phaseout effect on improved seed use, binary indicator

	Improved seed use			
	1 season post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout	6 seasons post-phaseout
	(1)	(2)	(3)	(4)
CAP Phaseout	0.0072	-0.0101	-0.0248	0.0067
	(0.0370)	(0.0390)	(0.0483)	(0.0468)
95% CI	[-0.0662 0.0806]	[-0.0875 0.0673]	[-0.1205 0.0710]	[-0.0862 0.0996]
MF Phaseout	0.0094	0.0524	-0.0577	0.0255
	(0.0389)	(0.0391)	(0.0429)	(0.0400)
95% CI	[-0.0678 0.0865]	[-0.0253 0.1300]	[-0.1428 0.0274]	[-0.0539 0.1049]
R^2	0.180	0.177	0.099	0.082
N	1037	1032	921	925
Mean value in Continuation	0.427	0.386	0.424	0.317

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. All variables are binary indicators. All regressions include controls: binary indicators for outcome at pre-phaseout baseline and the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.XV: Phaseout effect on improved seed use, quantities

	Improved seed quantities, total		Improved seed quantities, per acre	
	3 seasons post-phaseout	5 seasons post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout
	(1)	(2)	(3)	(4)
CAP Phaseout	0.1834	-0.2038	-0.0725	-0.0095
	(0.5550)	(0.5275)	(0.2331)	(0.3219)
95% CI	[-0.9179 1.2847]	[-1.2506 0.8429]	[-0.5350 0.3901]	[-0.6483 0.6293]
Model Farmer Phaseout	0.8879	-0.2292	0.6720*	-0.0424
	(0.6785)	(0.5576)	(0.3111)	(0.03395)
95% CI	[-0.4586 2.2344]	[-1.3356 0.8771]	[0.0546 1.2895]	[-0.7160 0.6312]
R^2	0.093	0.086	0.090	0.099
N	1029	926	998	878
Mean value in Continuation	3.48	3.19	1.85	1.95

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Quantities of improved seeds are in kilograms; all other variables are binary indicators. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.XVI: Phaseout effect on local seed use, binary indicator

	Local seed use			
	1 season post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout	6 seasons post-phaseout
	(1)	(2)	(3)	(4)
CAP Phaseout	-0.0319	-0.0043	-0.0220	-0.0158
	(0.0279)	(0.0277)	(0.0357)	(0.0360)
95% CI	[-0.0873 0.0235]	[-0.0592 0.0506]	[-0.0928 0.0488]	[-0.0874 0.0558]
MF Phaseout	0.0008	-0.0480	0.0111	0.0153
	(0.0257)	(0.0320)	(0.0324)	(0.0317)
95% CI	[-0.0501 0.0518]	[-0.1116 0.0156]	[-0.0531 0.0753]	[-0.0476 0.0782]
R^2	0.190	0.093	0.057	0.062
N	1038	1031	930	934
Mean value in Continuation	0.878	0.869	0.859	0.836

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. All variables are binary indicators. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.XVII: Phaseout effect on local seed use, quantities

	Local seed quantities, total		**Local seed quantities, per acre**	
	3 seasons post-phaseout	5 seasons post-phaseout	3 seasons post-phaseout	5 seasons post-phaseout
	(1)	(2)	(3)	(4)
CAP Phaseout	2.0567	-1.1625	-0.5613	-0.0393
	(2.0496)	(1.8236)	(1.5440)	(0.8868)
95% CI	[-2.0106 6.1241]	[-4.7808 2.4559]	[-3.6257 2.5030]	[-1.7991 1.7204]
Model Farmer Phaseout	-0.0297	-0.6663	-1.0874	0.9919
	(2.1304)	(2.1000)	(1.4731)	(1.0311)
95% CI	[-4.25746 4.1980]	[-4.8331 3.5005]	[-4.0110 1.8363]	[-1.0540 3.0378]
R^2	0.120	0.201	0.076	0.176
N	1009	925	978	922
Mean value in Continuation	17.5	15.9	11.9	9.4

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Quantities of local seeds are in kilograms; all other variables are binary indicators. Controls are binary indicators for the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.

Table A.XVIII: Phaseout effect on sources of improved seed

1 season after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
CAP Phaseout	-0.0465*	0.0288	0.0062
	(0.0269)	(0.0336)	(0.0079)
Model Farmer Phaseout	-0.0517*	0.0124	0.0180*
	(0.0303)	(0.0345)	(0.0095)
R^2	0.075	0.172	0.071
N	1037	1037	1015
Mean value in Continuation	0.096	0.271	0.005

3 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
CAP Phaseout	-0.0347	0.0305	0.0136
	(0.0322)	(0.0394)	(0.0095)
Model Farmer Phaseout	-0.0768**	0.0847**	0.0234**
	(0.0327)	(0.0388)	(0.0093)
R^2	0.114	0.152	0.037
N	1032	1032	1032
Mean value in Continuation	0.102	0.256	0.002

5 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
CAP Phaseout	-0.112***	0.0756**	0.0007
	(0.0306)	(0.0371)	(0.0107)
Model Farmer Phaseout	-0.123***	0.0538*	-0.0013
	(0.0302)	(0.0292)	(0.0106)
R^2	0.113	0.084	0.021
N	907	907	907
Mean value in Continuation	0.142	0.234	0.018

6 seasons after phaseout

	CAP and Model Farmer (yes/no)	**Market sources** (yes/no)	**Other BRAC sources** (yes/no)
	(1)	(2)	(3)
CAP Phaseout	-0.0965***	0.117***	-0.0050
	(0.0264)	(0.0371)	(0.0137)
Model Farmer Phaseout	-0.102***	0.113***	-0.0205**
	(0.0288)	(0.0284)	(0.0091)
R^2	0.107	0.074	0.037
N	911	911	911
Mean value in Continuation	0.117	0.139	0.021

Note: Regressions are OLS models with standard errors (in parentheses) clustered at the village cluster level. Regressions include branch fixed effects. Dependent variables are binary indicators of whether farmers used seeds from market, CAP/Model farmer or Other BRAC sources; independent variables are binary indicators of treatment status. Controls are binary indicators for outcome at pre-phaseout baseline, the use of agricultural practices that differ at baseline (weeding, line sowing and organic fertilizer use) and land title.