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Evaluation of the pilot project to improve soybean productivity in the Agricultural Development Centre 4 in Benin: An experimental study of gender-differentiated impact (PIERI 20374)

Impact Evaluation Report

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Summary

We design an experiment to assess the impact of the *Union Nationale des Producteurs de Soja* (UNPS) intervention on soybean production knowledge and productivity. We also test the effectiveness of a female-farmer biased targeting mechanism of the intervention. Our study involved at baseline 760 households across 38 villages randomly selected after a paired-wise matching. We used a two-stage randomization approach to assign households either to Group 1) a treated group in which the decision of who will be targeted (direct beneficiary) to receive the intervention is left to the husband (male-farmer) and the wife (female-farmer); Group 2) a treated group in which the female-farmer is imposed as the target who will receive the intervention; Group 3) a control group in which households do not receive any intervention. Our econometric analysis shows that the UNPS intervention has a positive and statistically ($p < .01$) significant impact on the knowledge score of both male and female farmers. The size of the estimate is 9.51 score for male farmers and 9.84 score for female farmers. We also find positive and statistically ($p < .01$) significant impact on soybean productivity for both male and female farmers. Male and female farmers who enjoy the UNPS intervention increased their productivity by almost 275 kg/ha and 405 kg/ha, respectively. The intervention targeting mechanism has gender-differentiated impact. When the female farmer is imposed as the direct beneficiary, we find that her knowledge score and productivity do increase while the knowledge score and productivity of the male decreases. The household average knowledge score and productivity do increase slightly but remains statistically non-significant. There is a huge appetite for soybean production among farmers. Male farmers in households who enjoyed UNPS intervention are 10 percentage points less likely to plant soybean in the next season if there were either offered access to the market support of membership in group organization. Female farmers in households who enjoyed UNPS intervention are 13 percentage points less likely to plant soybean in the next season if there were group training offered. Female farmers in households where the female farmer was imposed are 18, 17 and 11 percentage points more likely to plan soybean if they were offered group training, follow-up via phone calls, free inputs, respectively. While female farmers benefited from the targeting mechanism, this did not translate into improvements in male and household soybean production knowledge and productivity. We recommend UNPS to scale up the intervention. As far as the targeting mechanism is concerned, there will be need to engage with male farmers. This could be through sensibilization activities. Future research could explore the impact of the female farmers-biased targeting approach with additional women empowerment components. The provision of continuous technical support via phone calls also paves the way to testing how information and communication technologies can be used to improve or replace traditional in person visits.

Key words: Experiment, soybean production, knowledge and productivity, female-biased targeting, Benin.

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LIST OF ACRONYMS

ATDA	:	Agence Territoriale de Développement Agricole
FAO	:	Organisation des Nations unies pour l'alimentation et l'agriculture
HH	:	Household
ICC	:	Intra correlation coefficient
INSAE	:	*Institut National de la Statistique et de l'Analyse Economique*
LARDES	:	*Laboratoire d'Analyse et de Recherche sur les Dynamiques Economiques et Sociales*
MAEP	:	Ministère de l'Agriculture, de l'Elevage et de la Pêche
OCDE	:	Organisation de la Coopération et du Développement Economique
WFP	:	Word Food Programme
PEP	:	Partnership for Economic Policy
RCT	:	Randomized Controlled Trial
UNPS	:	*Union Nationale des Producteurs de Soja du Bénin*

1. INTRODUCTION

Soybean production in Benin has increasingly been recognized as a potential crop to improve household food and nutritional security (MAEP, 2017). The government is currently exploring ways to promote the production by improving productivity and further developing a competitive soybean value chain. In that respect, the *Union Nationale des Producteurs de Soja* (hereinafter referred to as UNPS) has developed a contract farming-based intervention package based to improve soybean productivity. Yet, there is no rigorous evidence on the possible impact of the proposed intervention. We design a two-stage Randomized Controlled Trial (RCT) to evaluate the impact of the UNPS package. We also explore whether choices made by households in terms of who will be the direct beneficiary of the intervention lead to a different outcome/impact than female-biased targeting. Our study adds to the evidence basis on contract farming-based interventions in two ways. First, we generate rigorous evidence and contributes to inform the on-going debates on the effectiveness of contract farming-based interventions on farmers´ knowledge and productivity. Secondly, our focus on the gender of the direct intervention beneficiary sheds light on the importance of female-biased targeting mechanisms in rural development interventions.

In Benin, 36.2% of the population live below the monetary poverty line with 39.7% in rural areas (INSAE, 2015). About 74% of the rural population live in food insecurity (WFP, 2014) characterised by a poorly diversified diet and major deficiencies in foods rich in animal proteins, fruits, milk and dairy products. In Benin, soybeans became the first legume in Benin because of their importance in reducing malnutrition, especially in rural areas (Ogouniyi, 2019). In addition to the nutritional values, soybean production and processing involve several other benefits. The production contributes to farmers´ income diversification. Soybean plants improve soil structure, protect it from erosion and activate microbial life. Its inclusion in crop rotations would help raise the fertility level of poor land (Badou *et al.,* 2013). Since soybean cultivation is less demanding in terms of production factor (land, labor, capital) (Biaou, 2011), it appears today as one of the crops that are increasingly positioning themselves as a cash crop for rural households even replacing cotton (Ogouvide and Sodjinou, 2012). Soybean processing offers several products for human consumption (e.g., oil, soy yogurt, soy cheese, bean sprouts, infant meal). Against this backdrop, the government of Benin is increasingly recognizing the soybean sector as a potential leading sector for several agroecological zones and production areas (MAEP, 2015). One of the first and key challenges is however the low crop productivity (current yields are about 500 kg/ha against an expected yield of 3t/ha - Agnoro, 2008; Kpenavoun *et al.,* 2018).

Building on its 10-year field experience in supporting farmers over the years, UNPS has developed a novel contract farming-based intervention package to improve soybean productivity. The package has two key aspects: training and inputs. The training aspect involves group training and monthly follow-up visits to individual farmers. The inputs aspect includes improved seeds, herbicide, inoculum, and fertilisers deliver on credit to farmers in their village. On top of these aspects, farmers were also offered some flexibility in terms of prices. Although the package is developed based on the rich experience of UNPS, there is no rigorous evidence on its effectiveness that can support scaling-up by the policy decision-makers. To address this knowledge gap and policy question, we design an experiment to generate preliminary but high-quality evidence to inform the on-going debates on the ways to develop the soybean sector in Benin. Given the role of women in agriculture in general and particularly in soybean production and processing, we also explore the effectiveness of a female-farmers biased targeting mechanism of the intervention beneficiaries. Our main research questions are: Does the UNPS package improve farmers´ knowledge and soybean productivity? Does a female-farmer biased targeting mechanism improve farmers´ knowledge and soybean productivity?

Beyond the focus on the UNPS package, our study explores the broader effectiveness of contract farming-based intervention. The break-out of the Covid-19 which leads to the disruption of the traditional inputs supply chains in Benin while the study was on-going relaunch the importance of contract farming. The remainder of this report is organised in 5 sections. These are the methodology, the results, the discussion of the results and implication for the experiment, and a conclusion.

2. INTERVENTION AND THEORY OF CHANGE

2.1. Description of the intervention

The intervention under evaluation is at a pilot phase. Its evolved from UNPS 10-year field experience and was designed to respond several practical issues such as farmers´ low technical knowledge on soybean best production practices, liquidity constraints at the onset of the rainy season, availability of quality inputs in the villages, price volatility at harvest, limited access to resources and inputs by of women, etc. The intervention is a package based on a contract (between UNPS and individual farmers) farming approach that integrates three elements:

- **Capacity building**: Here farmers are trained on best practices to produce soybean but thy also enjoy continuous technical support. The main training is a group training on the technical aspects of soybean production, from soil preparation to harvesting and storage. The training also covers good agricultural practices as recommended by UNPS in each agroecological zone with emphasis on recent innovations in soybean production. The continuous technical support is offered to individual farmers via routine mobile phone calls to discuss specific issues encountered by the farmers in their field. Where required, farmers received in-person visits from UNPS extension officers. Capacity building was offered to farmers who subscribed to the inputs package described below. On the other hand, effective participation in the training was mandatory and thus is a precondition for receiving the inputs package described below.

- **Quality inputs delivery**: Good quality inputs is one of the conditions required for optimal yield. To enable farmers to implement the training knowledge, quality inputs are provided by UNPS on credit at zero percent interest rate. The inputs initially certified seeds, soybean inoculum and soybean specific fertilizers. Because of the Covid-19 however, only the certified seeds and soybean inoculum were provided to farmers in the current study. Fertilizers supply chains involve Microfinance Institutions who were not able to send their officers in the study villages to enrol farmers and do the required background checks due to the restricted mobility imposed by the Covid-19 pandemic. Farmers subscribe to the inputs package on voluntary basis. They sign a commitment with UNPS that binds them to repay the cost of the inputs. For the sake of the pilot study, farmers were only allowed to subscribe of 0.25 ha inputs package, implying a cost of about 15 dollars USD. Repayment of the cost was due at harvest.

- **Access to market**: This involves facilitating the contact between soybean producers and potential buyers. This is still under development and discussions are in favour of setting up a clustering system that facilitate marketing. It is important to note that farmers are not obliged to sell their crop to UNPS and therefore can sell at higher prices on the market. Within the framework of the impact evaluation, access to market support was offered when farmers express the need.

In addition to assessing the overall effectiveness of the UNPS intervention, we also investigate the impact of the targeting mechanism. Here, a beneficiary household was either requested to choose who between the male and the female farmer will be the direct/primary beneficiary of the intervention or was imposed to have the female farmers as the direct/primary beneficiary. The direct/primary beneficiaries of the intervention should attend the group training, collect the inputs, benefit from continuous technical support via mobile phone calls, identify a 0.25 ha plot of land as self-demonstration plot, be the person who decides how/when to use inputs the plot of land and be respondent for all the surveys related to the 0.25 ha to the plot of land.

The study, including the intervention was implemented over a one-year period from December 2019 to December 2020. Figure 1 shows the time line of the intervention, including the main data collection described below.

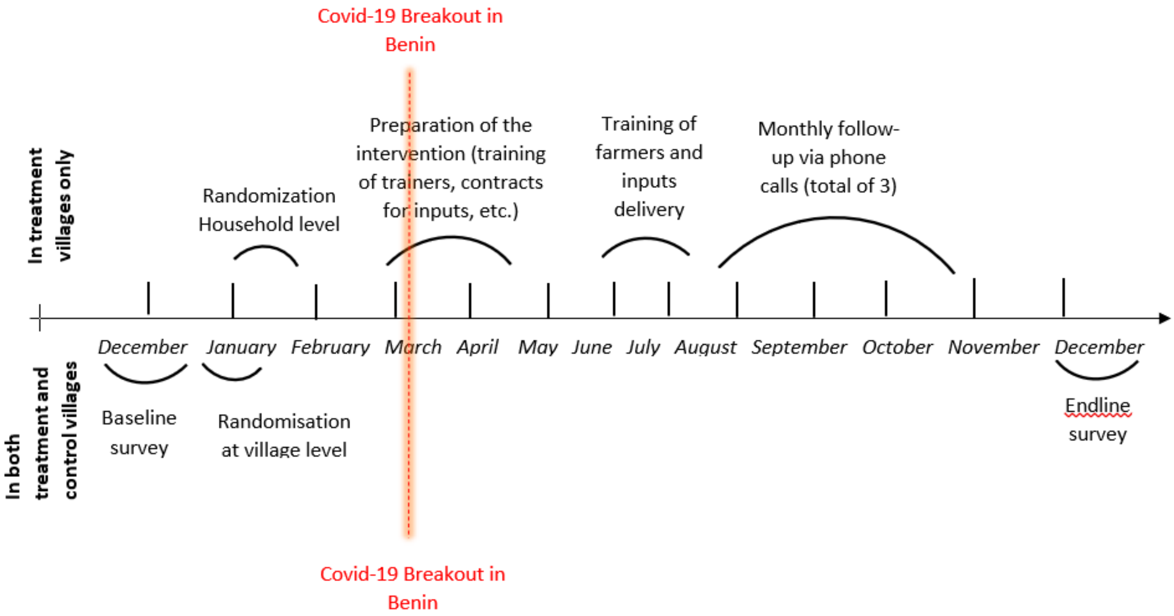


Figure 1: Intervention implémentation timeline

2.2. Theory of change (ToC)

We developed the intervention ToC in a participatory manner, involving UNPS and other key stakeholders such as the Agricultural Extension Offices in the study zone. Our ToC suggests that training farmers on best practices for soybean production would help to improve awareness and knowledge among smallholder farmers and increase their likelihood to adopt better farming practices. Improvements in both knowledge and farm practices coupled with timely delivery of quality inputs would result in positive effects on productivity. This can further translate into increases in income and better livelihoods. In addition to these impact pathways, we believe that the intervention targeting mechanism (HH choice vs female farmer biased) can potentially generate intra household knowledge spillovers through the gender dynamics within the household. In that regard, both the direct/primary and the non-direct/secondary beneficiaries of the intervention will see their knowledge improved and their productivity increased. Key assumptions underlying our ToC are: staff are well qualified and well trained, training materials are understandable by farmers, farmers attend training, quality inputs are delivered to farmers in time, farmers do not change attitude towards soybean, farmers apply new knowledge, intra household dynamics support knowledge exchange between male and female farmers, and farmers are rational. It is also important to note that one of the reasons why women are targeted is to increase empowerment. The decision at the household level on who will benefit directly may also be a function of the level of empowerment and bargaining power. Figure 2 illustrates our ToC.

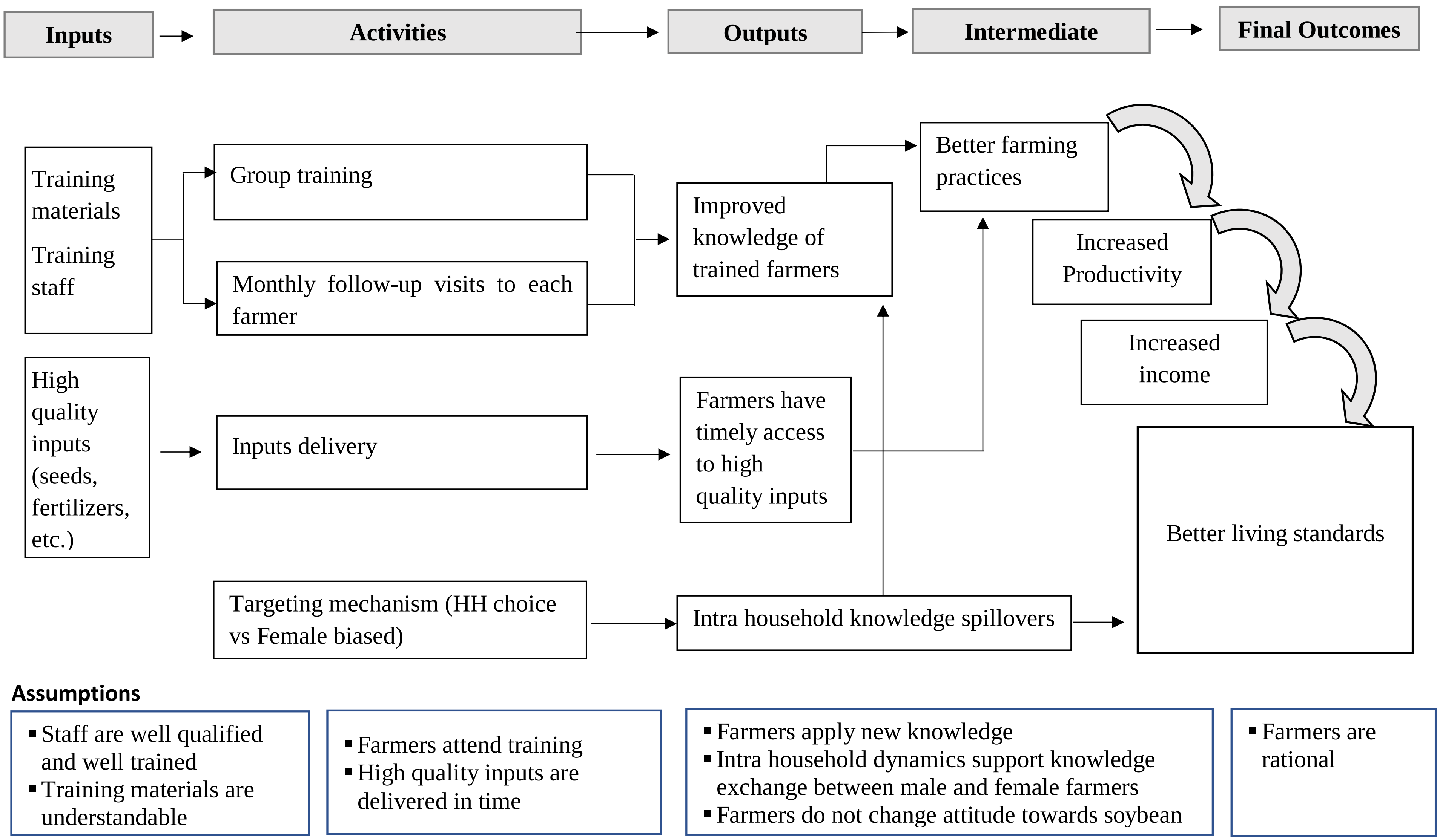


Figure 2: Theory of change of the intervention

3. METHODOLOGY

3.1. Study zone

Our study zone is the *Pole de Développement Agricole* 4 (PDA 4) in Benin. It includes 16 municipal areas organised in 4 administrative Departments (Figure 3). PDA 4 is located between the South and the far North of Benin. Agriculture is the main economic activity in the study zone. PDA 4 is known as the cotton-food zone of Benin with cashew and cotton representing the key production sectors (MAEP, 2016). The soybean sector has recently been selected by the Government as a priority sector in PDA 4 and since then is receiving a lot of attention. Most importantly, PDA 4 is identified as the leading pole for soybean development at the country-level as it provides alone close to half of the national soybean production with a high concentration in the Department of Borgou.

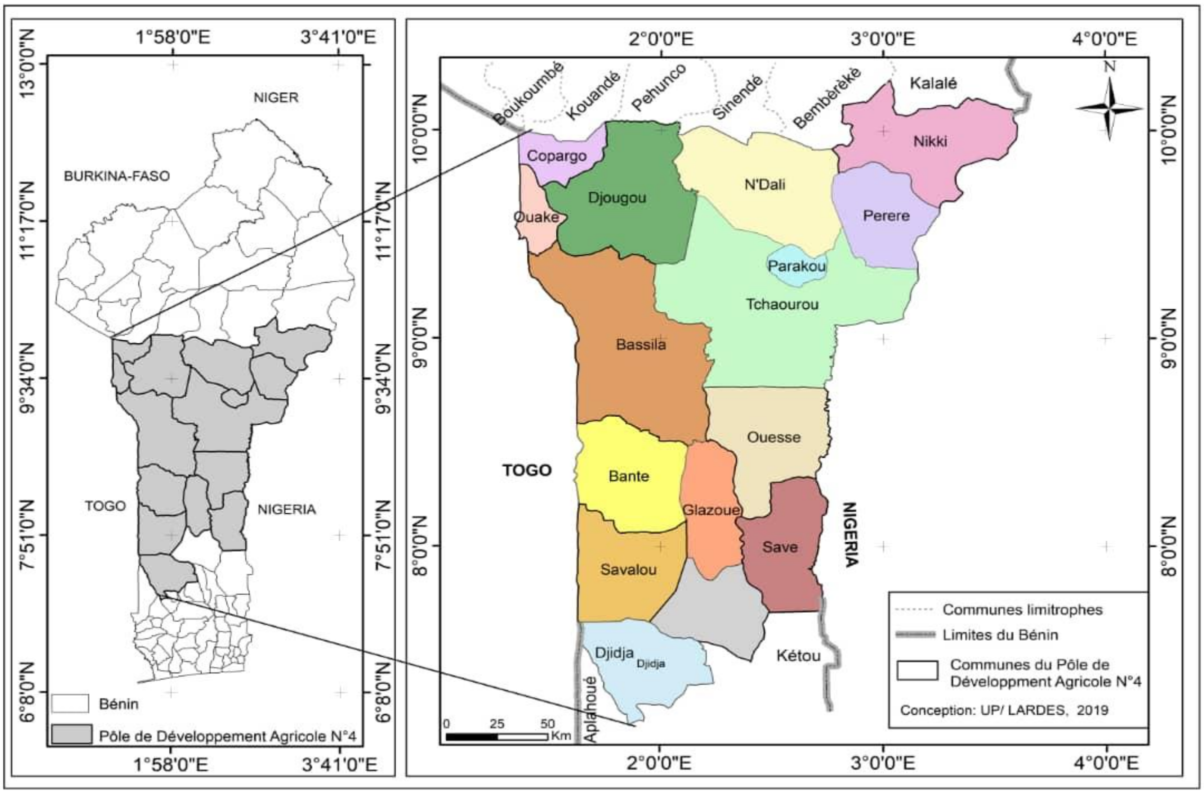


Figure 3: Study zone - PDA 4

3.2. Target population

In this study and to be able to capture the gendered impact of the intervention, we purposively focus on households that have couples where both the husband (male-farmer) and wife (female-farmer) have their own field and produce soybean on it. This methodological consideration could involve risks of fake partners and exclusion of single farmers, women or men, people who live in same-sex partnerships and households where male and female are married but only one of them is a farmer (or only one of them produces soybeans). The risk of fake partners is very minimal as we did a listing of the couples before disclosing the details of the intervention and proceed with the enrolment. Additionally, the intervention suggests that the couple shares some assets (homestead, fields, etc.) and it will be easy to find out fake partnerships should this happen. To minimize this risk, we also use a participatory and transparent approach to target beneficiaries by involving both organizations of producers and village leaders. The risk to exclusion of single farmers, women or men, nor people who live in same-sex partnerships, is minimal because of the socio-cultural settings of the research area which is rural Benin. First, it is unusual to find a single woman (unless she is a widow) leaving on her own. We might find some single men but then this will not allow us to explore the gender relationships. In the rural area, it is also common to see youth getting married very early and from there they become independent and have access to their own resources. When the boys are still single, they might have a plot of land, but they are related to the HH of their parents. Second, open same sex relationships in Benin is close to zero and when such relationships exist, they typically don't live together. While the number of households where male and female are married but only one of them is a farmer (or only one of them produces soybeans) might be not negligible, they do not allow us to explore the gender relationships especially because our main outcome of interest is not the take-up of soybean production. Last but not least we secure the PEP´s ethical review board approval.

3.3. Study design and power calculations

Our leading hypotheses are that 1) farmers who enjoy UNPS contract farming-based intervention will have better knowledge and higher productivity compared with their counterparts who receive no intervention, and 1) households where the female farmers were imposed as the direct/primary beneficiaries of the UNPS contract farming-based intervention will have better knowledge and higher productivity compared with their counterparts where the household decides who should be direct/primary beneficiaries. To test these hypotheses, we design a two-stage RCT, involving three groups: **Group 1**) a treated group in which the decision of who will be targeted (direct beneficiary) to receive the intervention is left to the husband (male-farmer) and the wife (female-farmer); **Group 2**) a treated group in which the female-farmer is imposed as the target who will receive the intervention; **Group 3**) a control group in which households do not receive any intervention. We assess the impact of the intervention by bundling Group 1 and Group 2 and comparing them to Group 3 (hypothesis 1). The comparison of Group 1 to Group 2 tells us whether female biased targeting leads to different outcomes, i.e., whether the household makes a choice that yields the same benefit than when this choice is female imposed (hypothesis 2).

We conduct the power calculations in three steps. First, we estimate the number of clusters required to compare group 1/2 to group 3 (first step of the randomization process – clustered RCT). Second, we estimate the number of clusters required to compare group 1 to group 2 (second level of the randomization process – individual RCT with blocking at cluster level). Third, we take the highest number of clusters suggested based on the previous two steps. Power calculations were done with Optimal Design Plus.

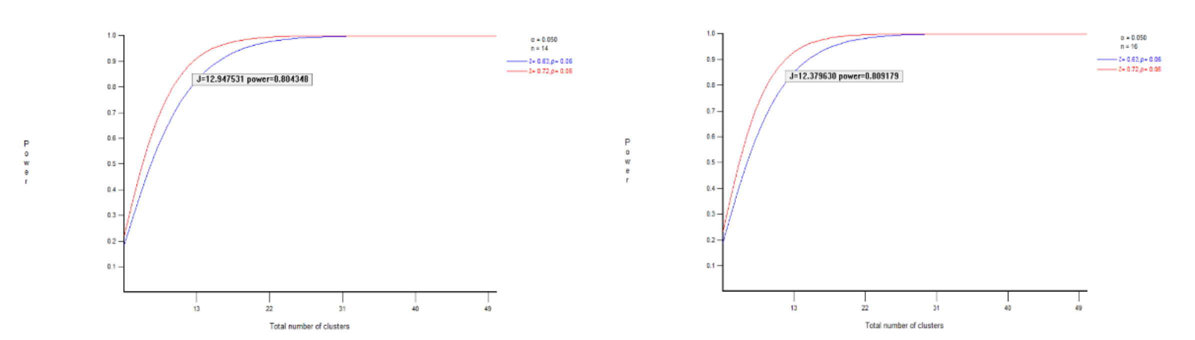
Step 1: Comparing group 1/2 to 3 (Clustered RCT)

The assumptions for the first step of power calculations are summarized as follows:

Table 1: Assumptions for power calculations (Step 1)

Item	Assumption	Justification
Number of eligible and registered HHs in each village	14 to 16	
Minimum Detectable Effect	0.63 to 0.72 (increases between 350 kg/ha to 400 kg/ha)	Outcome variable of interest is soy yield and average yield based on a recent study by Ogouniyi (2019) is about 1063 ± 550 kg/ha). The assumption is also made based on discussions with UNPS
ICC	0.06	Assumed based on a recent study by Ogouniyi (2019) who found ICCs of 0.01, 0.06 and 0.18 in different municipal areas in north Benin. Other studies on north Benin suggest ICC around 0.06.
Alpha Beta (power)	0.05 80%	

The series of Figure 4 illustrates the results of the power calculations:



14 Eligible HHs in each village 16 Eligible HHs in each village

Figure 4: Graphs of power calculation group 1/2 VS group 3

As evidenced by Figure 4, the number of villages required is about 14 villages (or 7 villages per group) with 14 or 16 HHs in each village.

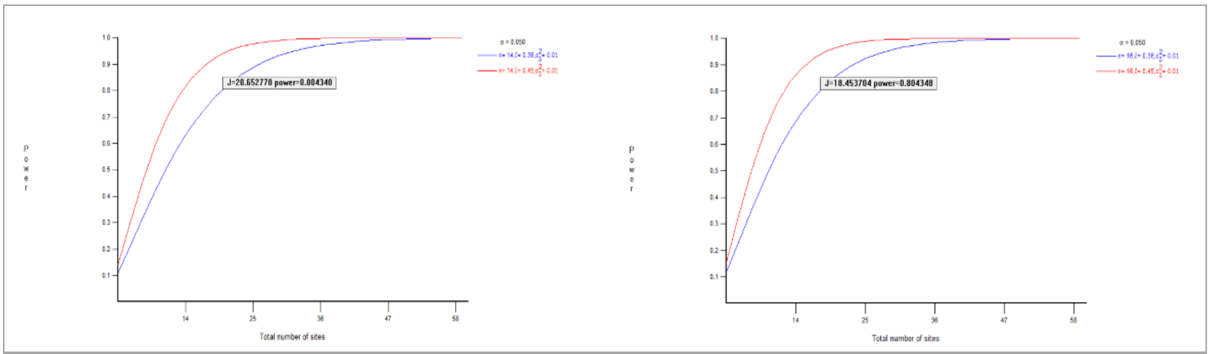
Step 2: Comparing group 1 to group 2 (individual level RCT)

We use a multi-sites or blocked design. This means that randomization is done within each village in the treatment Group 1/2. One option is to keep the 7 required villages obtained from the previous calculation and estimate the number of HHs to be selected in each village. Since we anticipate having a limited number of HHs in each evaluation villages, we compute the required number of villages with 14 to 16 HHs in each village. The following assumptions have been considered:

Table 2: Assumptions for power calculations (Step 2)

Item	Assumption	Justification
Number of eligible and registered HHs in each village	14 to 16	
Minimum Detectable Effect	0.36 to 0.45 (increases between 200 kg/ha to 250 kg/ha)	Same as for step 1
Effect-size variability	0.01	> 0 to assume random site effects
Explained variance by blocking	0	
ICC	0.06	
Alpha	0.05	
Beta (power)	80%	

The series of Figure 5 illustrates the results of the power calculations:



14 Eligible HHs in each village	16 Eligible HHs in each village

Figure 5: Graphs of power calculation group 1 to group 2

This figure suggests that we need about 19 sites (villages) with 16 HHs in each, implying a total of 360 HHs.

Step 3: Conclusion

Based on the previous calculations, the minimum sample required is as follows:

Table 3: Minimum sample required

Group	Number of villages	Number of HHs *Per village*	*Total HHs*
Group 1/2*	19	16	304
Group 3**	19	16	304
Total	38	16	608

* In each village, HHs will be assigned 50:50 to group 1 or group 2.
** As per the first step power calculations, we require a minimum of 7 Villages with 16 HHs each for Group 3.

NB: It is important to note that we have a constraint of about 300 treated HH from UNPS based on their available resources for the intervention. This constraint was considered for the power calculations. On the other hand, we expect that attrition rate will not exceed 15% (we anticipate 5%). We will increase the number of HH by 10%, implying 20 HHs per village. So, the total sample size is 760 HHs.

3.4. Sampling strategy

To increase our likelihood to detect MDEs, we first conducted a village paired-wise matching based on village-level climatic and soil condition data (please see appendix 1 for details). Second, we conducted a field visit to confirm 19 pairs of villages that meet our eligibility criteria. Third, we conducted a listing of eligible HHs in selected villages and the enrolment of eligible HHs for the study. The following figure summarizes the sampling strategy:

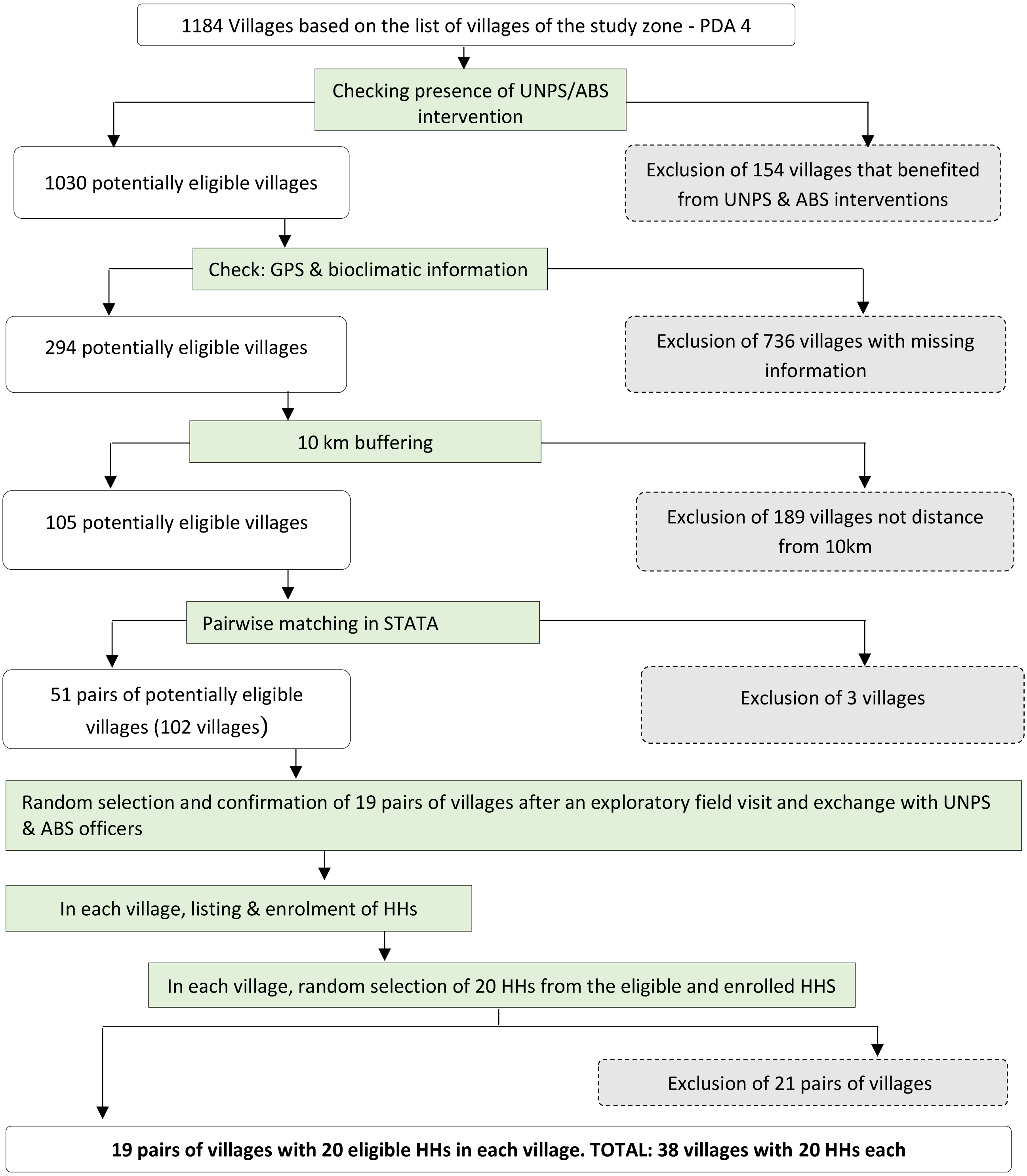


Figure 6: Illustration of the sampling process

3.5. Baseline survey

The baseline data collection was conducted between December 02 and 18, 2019, to collect before intervention information (i.e., reference was the rainy season 2019-20). A team of 19 well-experienced investigators was hired and trained for 4 days. A pre-test was also organized to vet the survey instrument that has three main parts:

- Household module: This module collects information at the household level on the location, the household structure, the main crops, importance of soybean and the assets owned. The respondent of this questionnaire is the head of the household.
- Male-farmer module: This module collects the male-farmer's information such as the socio-economic characteristics (age, education level, experience in agriculture, access to credit, etc.), knowledge, attitude and practices with respect to soybean production), soya production inputs (land, fertilizers, herbicides, etc.) and outputs for the rainy season 2019-20.
- Female-farmer module: This module collects same information like the male-farmer module but the respondent here is the female-farmer.

We used KoboCollect on Tablets for data collection. High-frequency checks were conducted to ensure the quality of the data.

3.6. Randomization

Following our evaluation design, randomization was conducted after the baseline survey in two steps. The first random assignment was done at the village-level. Within each pair of villages, we randomly assigned one village to the treatment group and the other to the pure control group through a public lottery. Due to logistical reasons, we invited paired villages to meet for the public lottery in three locations, depending on the geographical areas to minimize travel distance. Since the randomisation if done within each pair, village leaders were invited so that pairs were represented in the same public lottery. In that respect, this was not a stratified random assignment with strata corresponding to the geographical areas. In practice, we conveyed three public lottery meetings at three different locations (i.e., Save, N'Dali and Djougou). A map of the locations and the list of villages invited to each location is presented in Appendix 4 and Appendix 5, respectively.

Village heads of all the 38 villages were invited to attend the public lottery at their respective assigned location. The public lottery meetings were conducted by a member of the research team who acted as a facilitator. At the beginning of each meeting, the participants were introduced to each other. Then the facilitator recalled the baseline survey and explain among others, the objectives of the study, the details of the intervention, the evaluation design, the villages paired-wise matching, the purpose of the randomization, etc. After a round of questions and answers, the facilitator explained how the random assignment will be carried out, using blue (pure control) and green (treated) cards that village heads in the same village pair came forward and drew publicly. At the end of the draws, a summary of the results was presented by the facilitator. Then, the group of pure control villages and the one of treatment villages were briefed separately on the next steps. Figure 7 shows the map of the villages following their treatment status.

The second randomization is conducted at the household-level in each of the 19 villages assigned to the treatment group after the first randomization. Here, we aim at constructing one treatment group where the decision of who will be the beneficiary of the intervention is up to the couple and a second treatment group where the female is imposed as the beneficiary of the intervention. We conveyed a public lottery meeting in each village. The respondent household head, the male farmer (if different from the household head) of each household enrolled and interviewed at the baseline were invited to attend the public lottery meeting. The meetings were organised following the same general guidelines as for the first randomization. Figure 8 summarizes the randomization process.

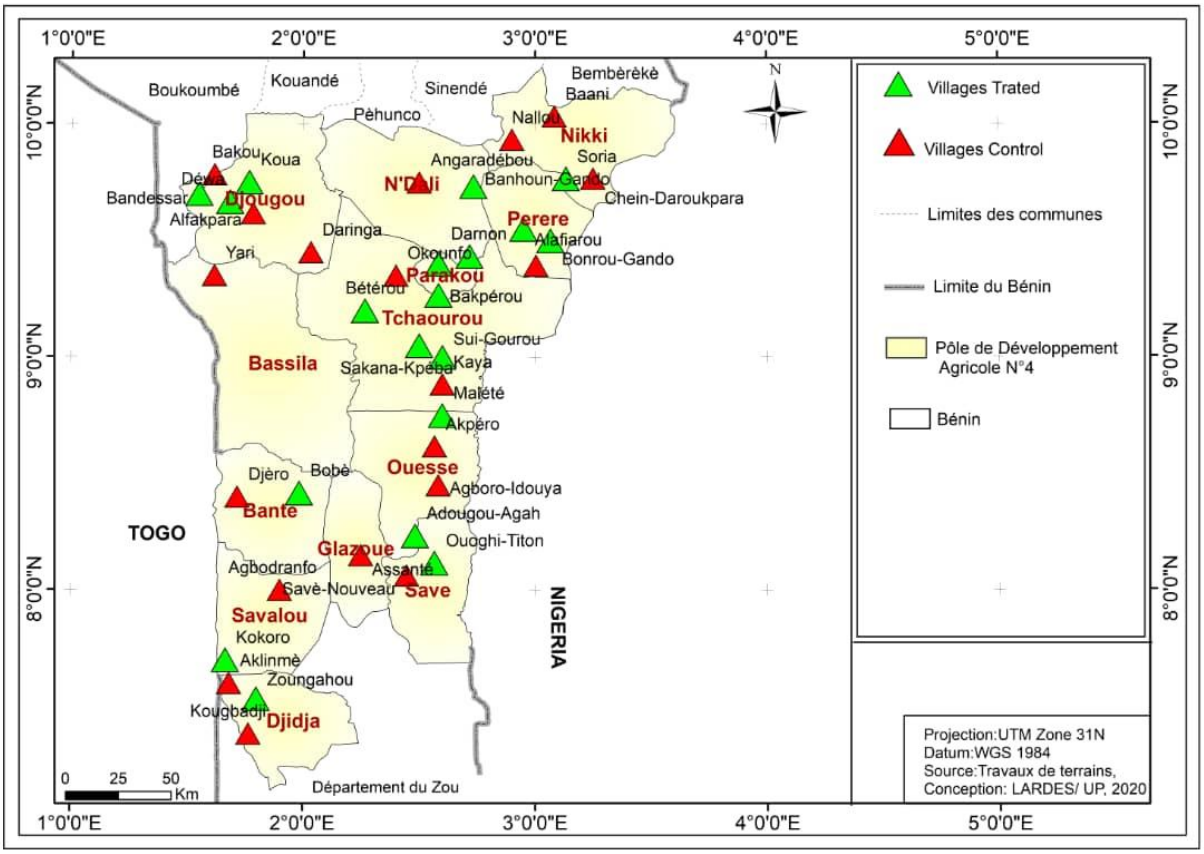


Figure 7: Map of the study villages after the village-level randomization

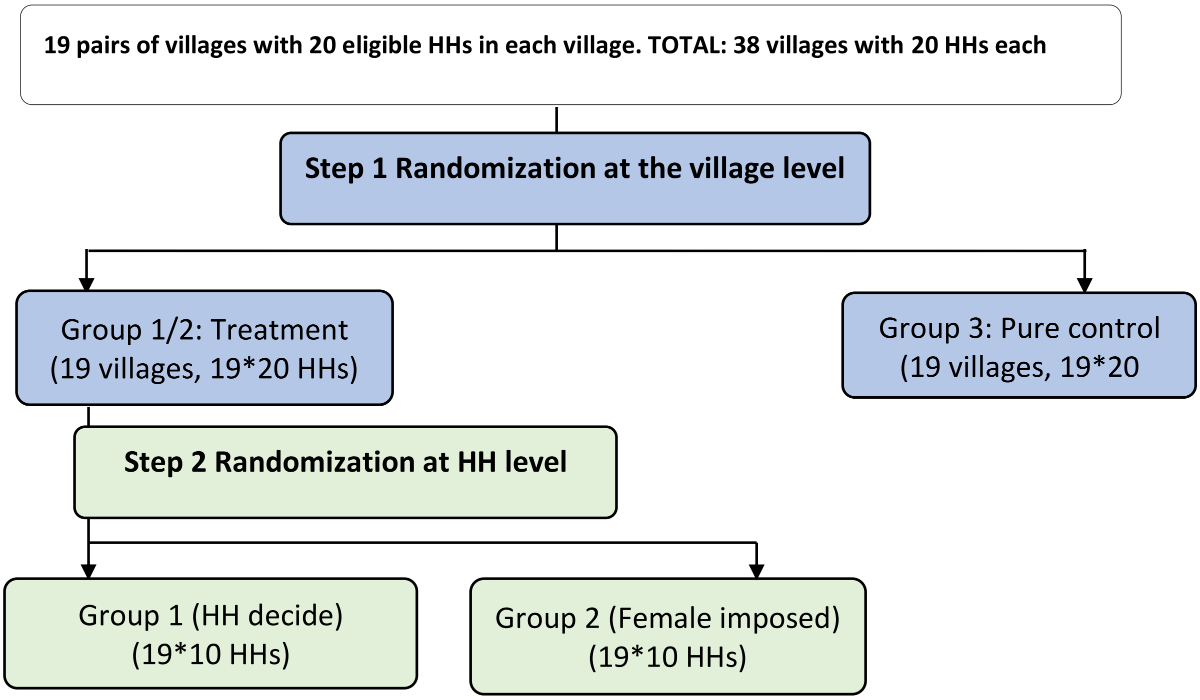


Figure 8: Illustration of the randomization process

3.7. Endline data collection

Endline data collection was conducted in the same study villages and on the study sample between December 13 and 24, 2020. Here also, a team of 30 well-experienced investigators was hired and trained for 4 days. A pre-test was also organized to vet the survey instrument that include the same modules used at baseline with some additions of questions on the sustainability of the intervention. At endline, we recorded a total attrition (whole household migrated outside the study zone or was not found, or either the male farmer or the female farmer in the household migrated outside the study zone or was not found) of about 7.24%. That attrition was also found to be random[1] and hence we have enough power to detect our hypothesized MDEs.

3.8. Empirical data analysis

We first used the baseline data to check balance tests at each of the two levels of random assignment (please refer to Appendix 4 for details). At the village-level, the balance tests suggest that both the pure control and the treatment groups are well balanced on the outcome of interest and most of the covariates. The control and treatment groups do differ as far as some household characteristics (i.e., numbers of radio, bicycle and motorbike), the socio-ethnic group of both the male and female respondents, the informal education for female respondents, the habit for male respondents to work with their partners, the person

[1] We also checked balance for non-attrited households and results remain consistent.

who decide on the size of the female farmer's plot of land, and the assessment of the availability of NPK are concerned. Yet, the differences are rather small in magnitudes. At the household-level, the balance tests indicate that both treatment groups are also well balanced on the outcome of interest and most of the covariates. Some differences could be observed here and there but they are rather small in magnitudes. We also used the baseline data to do ex-post power calculations. Results are summarized in Appendix 4.

Before the impact analysis, we used descriptive statistics to profile the characteristics of households as well as individual male and female famers in the different experimental groups. Our main outcome indicators[2] are the Knowledge Score (KS) and the productivity (P). For KS, we used a list[3] of 29 items/practices, ranging from land preparation to post harvest and storage. For each practice, we gave a score of 1 if the respondent knows the recommendation and 0 otherwise. KS is then computed as the sum of the individual item/practice score. P in our study refers to land productivity and is measured as the ratio of soybean production (i.e., the harvested output) to the land acreage under exploitation (i.e., the soybean farm/plot size). Each KS and P was measured and computed at the individual male and female farmer level but also at the household level as the mean value of male and female data.

To test our leading hypotheses, we used two model specifications: one at the village level (hereinafter referred to as Specification 1) to test hypothesis 1 and the other one at the household level (hereinafter referred to as Specification2) to test hypothesis 2. Relying on the exogenous variation created by the random assignments, we argue in each specification that the endline level of the outcome indicator is a function of the treatment status. Considering *k* outcome of interest (KS and P), *u* measurement units (male farmer, female farmer and household) and *n* specifications (1 and 2) and the following equation can be estimated:

$$Y_{kun} = \alpha_{kun} + \beta_{kun} T_{un} + e_{kun} \qquad \text{[Eq. 1]}$$

Where Y_{kun} stands for the endline level of the outcome variable of interest k measured on the unit u for the specification n, T is the treatment status of the measurement unit u in the specification n, α and β are coefficients to be estimated and e the error terms.

[2] We were not able to consider repayment as one of the outcome indicators due to the study timeline. Repayment was still on-going when we close the study and was up to 60% with good prospects to meet the 100% target.

[3] = Type of ploughing, 2= Type of soil, 3= Deep of sowing, 4= Type of sowing, 5= Distance between holes for sowing, 6= Number of grains per hole, 7= Number of plants after germination, 8= Type of varieties, 9= Sowing dates, 10= Type of fertilizers, 11= Dosage of TSP-NPK fertilizers, 12= Dosage of TSP-KCL/K2SO4 fertilizers, 13= knowledge of inoculum, 14= Dosage of inoculum, 15= Number of weeding, 16= Dates of first weeding, 17= Dates of second weeding, 18= Dates of third weeding, 19= Pre-germination herbicide, 20= Post-germination herbicide, 21= Dosage of Kalifor G, 22= Dosage of Faaba, 23= Usage of insecticides, 24= Type of insecticides, 25= Dates of harvest, 26= Method of harvest, 27= Method of threshing, 28= Method of seed storage/conservation, 29= Method of harvest storage/conservation.

To take into account common and unique traits of each specification, we added to Eq. 1 a set of socio-economic baseline characteristic (Z) that seems to be unbalanced, key production input availability (I), village pair-dummies and we also clustered the error terms at village level for specification 1. We added to Eq. 1 a set of socio-economic baseline characteristic (X) that seems to be unbalanced, village fixed-effects and we used robust standard errors for specification 2. In sum, we estimated the following models:

Specification 1 (Village level assignment)	$Y_{ku1} = \alpha_{ku1} + \beta_{ku1}T_{u1} + Z_{u1} + I_{u1} + Pairs\_Dummies + e_{ku1\_clustered\_village}$	[Eq. 2]
Specification 2 (HH level assignment)	$Y_{ku2} = \alpha_{ku2} + \beta_{ku2}T_{u2} + X_{u2} + I_{u2} + Village\_Dummies + e_{ku2\_robust}$	[Eq. 3]

In all the specifications, β coefficients estimated by using Ordinary Least Squares (OLS) regression reflect the the impact of the intervention (i.e., Intention to Treat – ITT).

4. Findings

4.1. Descriptive statistics of the respondents

4.1.1. Household-level socio-economic characteristics

The following table summarizes the descriptive statistics for the main household characteristics of households.

Table 4: Descriptive statistics of key households' characteristics

Variables		Mean	Sd. Dev.
Household size (# / HH)		12.76	7.52
Active household members (# / HH)		7.02	4.80
Total land owned (ha / HH)		11.03	9.5
Land acreage for soybean (ha / HH)		3.97	5.06
Crop production (yes / no)	Maize	.97	.14
	Cotton	.29	.45
	Rice	.23	.42
	Cassava	.82	.37
	Millet	.43	.49
Soybean as main crop contributing to	HH revenue (yes / no)	.53	.49
	HH food (yes / no)	.03	.17
	HH land management (yes / no)	.44	.49
Share out of 10 of soybean in	HH revenue	4.77	2.19
	HH food	1.28	1.30
Selected household assets	Radio	.702	.45
	Bike	.2	.40
	Motorcycle	.86	.34

Variables		Mean	Sd. Dev.
	Television	.23	.42
	Mobile phone	.89	.30
	Dwelling	.97	.16
Contribution to food expenditures	Male farmer	79.03	15.40
	Female farmer	19.46	14.22
	Other members	1.50	5.73
Contribution to Schooling expenditures	Male farmer	81.98	17.52
	Female farmer	16.68	16.12
	Other members	1.32	6.20
Contribution to health and hygiene expenditures	Male farmer	75.70	20.39
	Female farmer	23.05	19.36
	Other members	1.23	5.77
Contribution to clothing expenditures	Male farmer	62.37	23.37
	Female farmer	35.23	22.40
	Other members	2.39	8.06
Contribution to housing expenditures	Male farmer	91.70	13.00
	Female farmer	7.42	11.55
	Other members	.86	4.66

The statistics in Table 4 show that the average household has about 13 members and about half of them are involved in agricultural production as active members. The average total land owned by households is about 11 ha and up to 30% is allocated for soybean production. Most of the households produce maize and cassava. In terms of importance, soybean production is first perceived as a source of household income (53% of the respondents) and an important crop for in terms of land management (44% of the respondents). Less than 5% of the respondents mentioned soybean production as important for household food consumption. These figures are consistent with the reported shares of soybean in the household income and food that are about 50% and 13%, respectively. These figures suggest that soybean is mostly a cash-crop though it also contribute to a smaller extend to the household’s diet. Looking at selected households-owned assets, we find that most households have a dwelling (about 97%), a mobile phone (about 89%) and a motorbike (about 86%). The high rate of mobile phone ownership was an important asset to the implementation of the continuous technical support to farmers via phone calls. Statistics on households´ expenditures at endline only show that male farmers contribute to between 63% and 92% to the different expense items. Female farmers mostly contribute to clothing up to 35%.

4.1.2. Individual level socio-economic characteristics

The socio-economic characteristics of the respondents are summarized in the following table:

Table 5 Descriptive statistics of socio-economic characteristics

Variables		Male (N = 705)		Female (N = 705)	
		Mean	Std. Dev.	Mean	Std. Dev.
Age (year)		41.40	11.35	33.77	9.55
Socio-linguistic groups	Bariba (yes/no)	.27	.44	.28	.44
	Nago (yes/no)	.12	.33	.12	.32
	Idaasha (yes/no)	.001	.03	.001	.037
	Dendi (yes/no)	.001	.03	.001	.037
	Peulh (yes/no)	.035	.18	.038	.19
	Mahi-Fon (yes/no)	.167	.37	.171	.37
	Lokpa (yes/no)	.068	.25	.07	.26
	Gourmantch (yes/no)	.007	.08	.007	.083
	Yoruba (yes/no)	.012	.11	.00	.09
	Others (yes/no)	.29	.45	.29	.45
#Years of life together (year)		16.23	9.39	15.63	9.05
Male has another wife (yes/no)		.35	.47	.36	.48
Non-formal education (yes/no)		.41	.49	.94	.23
Formal education (yes/no)		.41	.49	.23	.42
#Years of education (year)		3.52	4.82	6.19	2.67
Professional training (yes/no)		.10	.30	.09	.29
Side activity (yes/no)		.32	.47	.47	.49
Main activity	Agriculture (yes / no)	.96	.19	.89	.31
	Livestock (yes / no)	.004	.06	.001	.03
	Craft (yes / no)	.005	.07	.025	.15
	Education (yes / no)	.002	.05	-	-
	Transport (yes / no)	.004	.06	-	-
	Trade (yes / no)	.007	.08	.062	.24
	Industry (yes / no)	-	-	.002	.053
	Hotel (yes / no)	-	-	.001	.03
	Other (yes / no)	.004	.06	-	-
#Years of experience in agriculture (year)		17.98	10.67	10.44	7.67
#Years of experience soy production (year)		6.05	3.73	4.15	2.72
Association membership (yes / no)		.27	.44	.11	.32
Soybean association membership (yes / no)		.11	.31	.06	.24
Access to credit (yes / no)		.11	.32	.02	.16
Distance between field and homestead (km)		5.14	4.31	4.64	4.17

On average, male farmers are about 8 years older than the female farmers. The most represented socio-linguistic groups in the sample is *Bariba.* Couples are together for about 15 to 16 years. Less than half of the households are polygamous. Differences between male and female respondents in terms of the length of the life together and whether the husband has another wife are very small and most likely because the interviews were conducted separately. Male farmers are more educated than female farmers either in terms of formal or non-formal (e.g., alphabetisation and koranic school). Male farmers have a longer experience in agriculture and in soybean production, they are more likely to belong to farmers associations and have more access to credit compared to the female farmers.

4.1.3. Experience of soybean-related support

We collected some data on the respondents' experience of soybean-related projects or any kind of support before UNPS intervention at baseline. The following table summarised the descriptive statistics:

Table 6: Descriptive statistics of the experience with soybean-related support at baseline

Variables	Male (N=705)		Female (N=705)	
	Mean	Std. dev.	Mean	Std. dev.
Ever enjoyed soy-related support (yes/no)	.11	.31	.03	.18
Enjoyed soy-related support in 2019 (yes/no)	.04	.21	.009	.09
Wish soy-related support in 2020 (yes/no)	.98	.12	.98	.13

The figures in this Table show that, at baseline, farmers have received very little support with respect to soybean production in the past. On the other hand, male farmers are more likely to have been the beneficiary of the support compared to the female farmers. With this low level of support, it was not a surprise to see that most of the respondents were willing to benefit from some support in the up-coming rainy season.

It is important to note that the take of the UNPS intervention was quite hight among the treatment households. Indeed, close to 90% of the targeted beneficiaries did participate in the group training. The 10% attrition observed was random either at the village-level or household level and explained by migration and few isolated cases where farmers were no more interested in the study. Among farmers who enjoyed the group training, take of the inputs package was almost 92%.

4.1.4. Knowledge of soybean production practices

Table 7 below shows the endline knowledge level of the respondents.

Table 7: Descriptive statistics of respondents' knowledge of the recommendations for soy production

	Male (N=760)		Female (N=760)	
	Mean	Std. Dev.	Mean	Std. Dev.
Knowledge score (#)	18.59	8.22	17.4	8.29
Know ALL (100%) of the best practices (yes / no)	.14	.35	.10	.31
Know 75% of the best practices (yes / no)	.27	.44	.25	.43
Know 50% of the best practices (yes / no)	.24	.43	.22	.41
Know 25% of the best practices (yes / no)	.30	.46	.40	.49
Know NONE (0%) of the best practices (yes / no)	.024	.15	.015	.12

The respondents have an average knowledge score between 17 and 19 at endline against 10 to 13 at baseline. Regardless of gender, most of the farmers know about 25% of the recommendations for optimal soybean production. Respectively 14% (against less than 1% at baseline) and 10% (against 0% at baseline) of male and female farmers know 100% of the best practices. These figures suggest some improvement in terms of best practices knowledge among farmers.

4.1.5. Attitude towards soybean production

Attitudes refer to beliefs, emotional, motivational, perceptual and cognitive, which positively or negatively influence the behaviour or practices of an individual. We asked the respondents whether they think that the soya production has some importance from nutritional, economic, social or environmental perspectives. Table 8 summarizes the perception of the respondents on the importance of soybean from the nutritional, economic, social and environmental standpoints.

Table 8: Descriptive statistics of the respondents' attitude towards soybean production

	Male (N = 705)		Female (N = 705)	
	Mean	Std. Dev.	Mean	Std. Dev.
Nutritional importance (yes/no)	.981	.13	.98	.12
Economic importance (yes/no)	.985	.11	.97	.16
Social importance (yes/no)	.828	.37	.83	.37
Environmental importance (yes/no)	.899	.30	.84	.36

Farmers have a pretty good perception of the nutritional economic, environmental and social importance of soybeans. The nutritional importance is linked with the fact that soybean is very rich in protein. The economic importance refers to the fact that soybean is more profitable than cotton and it represents on its own a source of savings. In terms of society, the importance of soybean production is driven by the fact that it helps to improve social relationships through group/joint selling of the harvests and the easy accessibility of soybean-related products such as the soybean cheese. With respect to environment, soybean production is believed to improve soil fertility/quality. The attitude figures are quite similar with those observed at baseline where we found that the respondents, although mostly untrained by then, have a good perception of the nutritional economic, environmental and social importance of soybeans.

4.1.6. Practices in relation with soybean production

We collected data on the respondents' practices in relation with soybean production, including some gender role information. The descriptive statistics are summarised in Table 9.

Table 9: Descriptive statistics of respondents' practices in relation with soybean production

	Male (N = 705)		Female (N = 705)	
	Mean	Std. Dev.	Mean	Std. Dev.
Work with partner (yes / no)	.73	.44	.95	.20
Discuss practices with partner (yes / no)	.90	.28	.89	.30
Give advice to partner (yes / no)	.87	.32	.81	.39
Receive advice from partner (yes / no)	.82	.38	.86	.34
Follow partner to his / her field (yes / no)	.79	.40	.87	.32
Partner follows to my field (yes / no)	.80	.39	.73	.44
I decide on labor allocation (yes / no)	.86	.34	.15	.35
I decide on the choice of plot of land (yes / no)	.87	.33	.14	.34
I decide on the size of the plot of land (yes / no)	.87	.33	.18	.39
I decide on the purchase of inputs (yes / no)	.87	.32	.21	.41
I decide on the purchase of equipment (yes / no)	.87	.33	.16	.37

The statistics suggest that mutual aid is a common practice in most of the households. On the other hand, most of the respondents mentioned that they discuss production-related issues with their partner. The statistics for male and female respondents are quite consistent and show that beyond the discussions, male farmers tend to give more advise to their partner than they receive while female farmers tend to give less advise to their partner than they receive. On average, a male farmer is slightly less likely to follow his partner to her fields but is more slightly likely have his partner coming to his field. Talking about resources for production, the decisions are mostly taken by the male farmers who happen to be in most cases the household head. It is important to note that the self-reports of male and female farmers do not match in all the cases. Differences are however are very small in magnitude and most likely because the interviewed were done separately. These figures are quite consistent with the baseline statistics.

4.1.7. Soybean production

Table 10 presents some descriptive statistics of some variables related to the production system:

Table 10: Descriptive statistics of some soybean production-related variables.

Variables	Male (N = 705)		Female (N = 705)	
	Mean	Std. Dev.	Mean	Std. Dev.
Yield (kg / ha)	818.93	386.04	785.10	347.59
Loose soil (yes / no)	.65	.476	.66	.47
Quantity of seeds (kg / ha)	47.28	222.20	15.61	24.47
Quantity of NPK fertilizer (kg / ha)	4.60	35.15	1.65	13.99
Quantity of urea fertilizer (kg / ha)	2.62	24.67	.52	5.67
Quantity of inoculum (unit / ha)	.34	2.38	.33	.76
Availability of seed in the village (yes / no)	.86	.34	.85	.35
Availability of NPK in the village (yes / no)	.12	.33	.11	.31
Availability of urea in the village (yes / no)	.14	.35	.13	.34
Availability of inoculum in the village (yes / no)	.07	.26	.08	.27

On average, male farmers have slightly higher yield than female farmers. Male farmers tend to use more inputs (seeds and fertilizers). Statistics also show that both fertilizers and inoculum are barely available in the study area. Again, this constraint was not addressed by the intervention due to the Covid-19 pandemic.

4.2. Impact analysis

As described in the methodology, we test our leading hypotheses by comparing on the one hand Group 1/2 to Group 3 (hypothesis 1 or specification 1) and, on the other hand, Group 1 to Group 2 (hypothesis 2 or specification 2).

4.2.1. Impact of the intervention on farmers´ knowledge and soybean productivity

This analysis refers to the specification 1. We test here whether the UNPS contract farming-based intervention improved farmers´ knowledge and soybean productivity. Table 11 presents the impact estimates.

Table 11: ITT Impact estimates following specification 1

	Y = Knowledge (score)			Y = Productivity (kg/ha)		
	Male	Female	Household	Male	Female	Household
Treatment [a] (Yes/no)	9.51 *** (.99)	9.84 *** (.90)	9.74 *** (.97)	274.91 *** (45.33)	402.5 *** (35.22)	294.35 *** (35.50)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs availability in the village [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes
Control group mean	13.93 (.40)	(12.80) (.39)	(13.37) (.38)	669.59 (23.49)	669.59 (23.49)	522.63 (18.00)
# Observations	705	705	705	647	495	668

*[a] Code as 0 = control and 1 = treated. [b] Baseline socio-economic characteristics include Cotton production, ownership of radio, ownership of a bike, ownership of motorcycle as asset, soybean association membership, work on the soybean plot of the wife, work on the soybean plot of the husband, socio-linguistic groups, seed availability in the village. [c] NPK availability in the village, urea availability in the village and nature of the soybean field soil. Error terms are clustered at the village level. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.*

The results of the regression models clearly highlight that UNPS intervention has a positive and statistically (p < .01) significant impact on the knowledge score of both male and female farmers. The size of the estimate is 9.51 score for male farmers and 9.84 score for female farmers. These figures suggest that the UNPS training capacity component is effective in improving farmers´ knowledge. The above presented descriptive statistics on knowledge however show that 14% (against less than 1% at baseline) and 10% (against 0% at baseline) of male and female farmers, respectively, know 100% of the best practices. This highlight that there is still room for improvement and further UNPS support might still be useful. In addition to the positive impact on knowledge, we also find positive and statistically (p < .01) significant impact on soybean productivity for both male and female farmers. Male and female farmers who enjoy the UNPS intervention increased their productivity by almost 275 kg/ha and 405 kg/ha, respectively. The first explanation could be that thanks to the capacity building and the partial inputs package, farmers can potentially increase their productivity. As both male and female farmers benefited from the intervention, the household average productivity also increased. It is important to note that the magnitude of the impact on female farmers is almost two-fold the impact on male farmers. This is an interesting finding that we further explore thanks to the specification 2.

4.2.2. Impact of the targeting mechanisms on farmers´ knowledge and soybean productivity

This analysis refers to the specification 2. Here, we test whether the UNPS targeting mechanism improved farmers´ knowledge and soybean productivity. Table 12 presents the impact estimates.

Table 12: ITT Impact estimates following specification 2

	Y = Knowledge (score)			Y = Productivity (kg/ha)		
	Male	Female	Household	Male	Female	Household
Treatment [a] (Female imposed/HH choice)	-1.40 *** (.53)	1.74 *** (.60)	.27 (.53)	-325.94 *** (25.44)	144.01 *** (31.35)	33.09 (26.12)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs availability in the village [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes
Control group mean	23.94 (.44)	21.10 (.51)	22.52 (.43)	1125.17 (23.55)	879.24 (18.93)	823.46 (21.48)
# Observations	355	355	355	330	271	345

*[a] Coded as 1 = Female imposed and 0 =HH choice. [b] Baseline socio-economic characteristics include Cotton production, ownership of radio, ownership of a bike, ownership of motorcycle as asset, soybean association membership, work on the soybean plot of the wife, work on the soybean plot of the husband, socio-linguistic groups, seed availability in the village. [c] NPK availability in the village, urea availability in the village and nature of the soybean field soil. Error terms are clustered at the village level. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.*

The results show a differentiated impact on male and female farmers. When the female farmer is imposed as the direct beneficiary, we find that her knowledge score does increase by about 2 points (scale 0 to 29). In contrast, the knowledge score of the male tends to decrease by about 1.5 point. The household average knowledge score does increase by less than 0.5 point and remains statistically non-significant. This suggest that a female farmers-biased targeting will likely improve the knowledge of female farmers but adversely affects the knowledge score of male farmers and has not significant impact on the household knowledge score. This result can be explained by the fact that the gender role or dynamics within the household did not change much over the intervention life cycle as discussed above under the practice session. We also find that when households are given the choice, the male farmer is nominated as the primary beneficiary in close to 86% of the cases (Table 13). We discussed more these result in paragraph 4.2.3.

Table 13: Choices of the primary beneficiary of the intervention

Treatment group	Gender	N	Frequency
Female farmers imposed	Male	.	.
	Female	179	100%
	Total	179	100%
Household´s choice	Male	151	85.79
	Female	25	14.21
	Total	176	100

4.2.3. Sustainability of the intervention under specification 1

In addition to our outcome of interest, we measure at endline the likelihoods of both the male and female farmers to plan soybean in the next rainy season under several hypothetical scenarios. Table 14 summarized the results.

Table 14: Farmers plans to plant soybean in the next rainy season under hypothetical scenarios in specification 1

	Likelihood to plan soybean in the next rainy season if. . .					
	Group training	Follow-up via phone calls	Free inputs	Inputs on credit	Access to the market	Group organization
Male farmers (N = 750)						
Treatment (Yes / No) [a]	- .02 (.07)	-.06 (.06)	-.09 (.07)	-.10 (.07)	-.10 * (.05)	-.10 * (.06)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs availability [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes
Female farmers						
Treatment 1 (Yes / No) [a]	.13 * (.08)	.11 (.07)	-.02 (.10)	-.01 (.09)	.07 (.06)	.07 (.06)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs availability in the village [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes

*[a] Code as 0 = control and 1 = treated. [b] Baseline socio-economic characteristics include Cotton production, ownership of radio, ownership of a bike, ownership of motorcycle as asset, soybean association membership, work on the soybean plot of the wife, work on the soybean plot of the husband, socio-linguistic groups, seed availability in the village. [c] NPK availability in the village, urea availability in the village and nature of the soybean field soil. Error terms are clustered at the village level. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.*

We find that most of the farmers look forward to planning soybean again regardless the treatment status. This shows that soybean production is gaining a lot of interest among farmers. There is no statistically significant difference in terms of farmers´ likelihood to plant soybean in the next rainy season across most of the scenarios, even where farmers have to pay a cash to receive inputs. For male farmers, those in households who enjoyed UNPS intervention are 10 percentage points less likely to plant soybean in the next season if there were either offered access to the market support of membership in group organization. This result could be explained that UNPS did not implement the market intervention as it should be but also farmers were not systematically organized in groups to experience the advantage of the two scenarios. Additionally, with market access, many farmers experienced that price on the market was still going up and did not want to lock themselves in a circle where UNPS could link them up with some contracts who will have a fixed price. For female farmers, those in households who enjoyed UNPS intervention are 13 percentage points less likely to plant soybean in the next season if there were group training offered. This can be explained by the social and cultural context where female farmers knows that their participation in group training will depend on their husband. These results are consistent with the above impact estimates and we discuss this more in paragraph 4.2.4.

4.2.4. Sustainability of the intervention under specification 2

We also measure at endline the likelihoods of both the male and female farmers to plan soybean in the next rainy season under several hypothetical scenarios in relation with the specification 2 of our experimental design. Table 15 summarized the results.

Here, we find also that most of the farmers look forward to planning soybean again. For male farmers, there is no statistically significant difference in terms of farmers´ likelihood to plant soybean in the next rainy season across all the scenarios. However, for female farmers, those in households where the female farmer was imposed are 18, 17 and 11 percentage points more likely to plan soybean if they were offered group training, follow-up via phone calls, free inputs, respectively. This result suggests that the intervention has been very beneficial for women but contrast with the finding that the gain did not translate into improvements in household knowledge and productivity.

Table 15: Farmers plans to plant soybean in the next rainy season under hypothetical scenarios in specification 2

	Confident to plan soybean in the next rainy season if. . .					
	Group training	**Follow-up via phone calls**	**Free inputs**	**Inputs on credit**	**Access to the market**	**Group organization**
Man (N= 355)						
Treatment (Female / HH choice) [a]	-.05 (.04)	-.01 (.04)	-.04 (.03)	-.04 (.02)	-.01 (.03)	-.00 (0.3)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes
Women (N= 355)						
Treatment (Female / HH choice) [a]	.18 *** (.06)	.17 *** (.06)	.11 ** (.05)	.05 (.05)	.05 (.05)	.04 (.05)
Socio-economic characteristics [b]	Yes	Yes	Yes	Yes	Yes	Yes
Inputs [c]	Yes	Yes	Yes	Yes	Yes	Yes
Village pairs dummies	Yes	Yes	Yes	Yes	Yes	Yes

*[a] Coded as 1 = Female imposed and 0 =HH choice. [b] Baseline socio-economic characteristics include Cotton production, ownership of radio, ownership of a bike, ownership of motorcycle as asset, soybean association membership, work on the soybean plot of the wife, work on the soybean plot of the husband, socio-linguistic groups, seed availability in the village. [c] NPK availability in the village, urea availability in the village and nature of the soybean field soil. Error terms are clustered at the village level. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.*

4.2.5. Connecting the dots of the theory of change

Our ToC suggests two main impact pathways. First, training farmers on best practices for soybean production would help to improve awareness and knowledge among smallholder farmers and increase their likelihood to adopt better farming practices. Improvements in both knowledge and farm practices coupled with timely delivery of quality inputs would result in positive effects on productivity. Second, the intervention targeting mechanism (HH choice vs female farmer biased) can potentially generate intra household knowledge spillovers through the gender dynamics within the household.

Our quantitative findings suggest that the UNPS intervention delivered as expected through the first impact pathway. Training, continuous technical support via phone calls and provision of quality inputs in time lead to a positive impact on the knowledge score of both male and female farmers. Furthermore, we observe that male farmers tend to perform better than their counterpart female famers and this could be explained by the fact that male farmers have more experience and thus more skills and have a lower capacity building requirement.

On the other hand, the household production resources are first used by the male farmer who can also enjoy the female farmer labor in his field.

Regarding the second impact pathway, the UNPS intervention did improve knowledge and productive of female farmers but fails to improve male farmers´ knowledge and productivity, resulting in no impact at the household level. As discussed above, this can be explained by the fact that the gender role or dynamics within the household did not change much over the intervention life cycle as discussed above under the practice session. When households are given the choice, the male farmer is nominated as the primary beneficiary in close to 86% of the cases. He continuous to be the major contributor to the household expenses and the main decision-maker over resources. Another extreme explanation is that although female participate in the training and gain new knowledge, they have yet to be acknowledged and listen as knowledgeable person by male farmers. Imposing the female could already be a potential source of conflicts within the households. The fact that women could not take on more household expenditures does not also help them to weigh in more in the discussions and household decisions. All this highlights that our ToC might have a weak link in the sense that there was not action to communicate and engage with male farmers in cases where the female farmers where imposed.

5. DISCUSSION AND CONCLUSION

5.1. Discussion of the results

It is broadly acknowledged that education plays a key role in agricultural production. According to Becker, 1964 and Schultz, 1961, education can help farmers choose more efficient means of production by adopting new techniques within the limits of their resources. Lele (1990) argued that the improvement of farm human capital based on farmer's education is crucial to enhance agricultural productivity. According to Welch (1970), there are two channels through which education can influence production: the worker effect and the allocative effect. The worker effect refers to the situation where education enables farmers to obtain better yields with the available productive resources. It is the own value of the marginal product of education which reflects an increasing in output per unit change in education, holding other factors constant (Lee et al., 2017, Oduro-Ofori *et al.,* 2014). The allocative effect can be defined as the effect of education on the ability of farmer to choose and allocate resources efficiently. Lee *et al.,* (2017) identify two allocative effect namely input allocation effect and input selection-effect. They define the allocation-effect as the effect of allocating three productive resources (purchased input, farm supplied input and education) efficiently among competing uses and input selection effect reflect the effect of selecting the right amount of purchased input. Ogouniyi Adimi *et al.,* (2017) also showed that education has a significant effect on the quality of farming production management. Oduro-Ofori *et al.,* (2014) observed that farmers have access to information about cost and characteristic of input with allocative effect. The access to information may help farmer in the adoption of technology and input change. (Pudasaini, 1983) describes three (03) ways by which the productive effect of education act: the improvement in farmer's skills, the enhancement of farmer's ability to obtain, understand and use new agricultural input and the improvement in overall managerial capacity.

Several studies analysed the effect of education on agricultural production. They can be classified into two groups namely non-experimental and experimental study. The non-experimental studies use variables such as the level of education, access to education and agricultural extension services to analyse the effect of education on productivity (Ferreira, 2018; Asadullah and Rahman, 2009; Oduro-Ofori et al., 2014; Ogouniyi and al, 2017, Paltasinghl and Goyari, 2018; Alene and Manyong, 2007, Yir-Hueih, 2017, Koffi Tessio and al, 2008). These studies show through a regression model or stochastic production frontier and instrumental variables that education has positive, negative or no effect on production. Non-experimental research despite it is relatively inexpensive and easy to perform, the main limit of the approach is that it's not well support testing for cause-and-effect relation. Then, the non-experimental studies cannot demonstrate the real cause and effect relationship between education and agricultural productivity. Based on experimental design, Okpachu et al. (2014); Davis *et al.*, (2010) and Ahmad et al., (2007) show that the participation to adult education programme, farmers' field school and agricultural training affect positively yield, and income and reduce animals' disease and mortality at farm level. The agricultural training program includes agricultural, livestock, leadership skills and enterprises development. These training programs aim to improve crop and livestock production. This is evidenced by our results as improvements in knowledge led to increases in productivity. This was also made possible thanks to the provision of inputs on credit. Yet, the results are gender differentiated, depending on the targeting mechanism.

Is it well established that women have less productivity than men and the gender gap in agricultural productivity varies around 8% and 46% (Aguilar *et al.,* 2014, Ali *et al.,* 2016, Un Women *et al.,* 2019). This difference is mainly due to the reduced access of women to productive resources, extension services in education and credit. Nevertheless, according to Akter *et al.* (2016), the contribution of women in agricultural labour is estimate at 50%. Except for land preparation, they are involved in all crop production activities (Akter *et al.,* 2020). However, women have less productivity than men. Indeed, gender gap in agricultural productivity varies around 8% and 46% (Aguilar *et al.*, 2014, Ali *et al.,* 2016, Un Women *et al.*, 2019). The gender difference in agricultural productivity is mainly due to women's lower access to productive resources, education extension and credit services. Regasa *et al.,* (2013), analyse the gender differences in access to extension services and agricultural productivity and show that female heads household have less access to extension service through various channels than men. In addition, they noted that the adoption of improved seed and fertilizer is positively influenced by access to agricultural extension services. However, access to agricultural extension can have no effect or affect negatively crop productivity. Among factor that limit women access to extension services, Akter *et al.,* (2020) pointed the socio-cultural barriers related to women's mobility, gender bias in distribution and delivery of planting materials (e.g., seeds and agricultural equipment and tools), the low percentage of women extension officer. FAO, (2011) reported that if women had the same access to productive resources as men, they could increase yield on their farms by 20-30% which could enhance agricultural production by 2.5-4% and reduce number of hungry people in the world by 12-17%. Furthermore, women's needs have frequently been neglected by programs that focuses on productivity increases (Doss, 2018).

We show that women benefit more from training if there are the direct beneficiary but this can have adverse effect on male farmers and a null effect on the household. Our study further suggests that women empowerment intervention like training would have mixed results if male farmers are not simultaneously engaged. This is mainly driven by the socio-economic settings of the study where production decisions are mostly taken by the male farmers who happen to be in most cases the household head (Doubogan, 2016). Male farmers also have larger plots, more plots than female farmers, record slightly higher yield and contribute more the household expenditures.

5.2. Conclusion and recommendation

We tested the impact of the UNPS intervention and the targeting mechanism on male and female farmers knowledge and productivity. Designed an experiment, involving two stage random assignments – one at the village level and the other one at the individual level, and three groups: Group 1) a treated group in which the decision of who will be targeted (direct beneficiary) to receive the intervention is left to the husband (male-farmer) and the wife (female-farmer); Group 2) a treated group in which the female-farmer is imposed as the target who will receive the intervention; Group 3) a control group in which households do not receive any intervention.

Our baseline data suggest that households involved in the study have an average size of 13 members, including 7 active people. Most of the households produce staple food like maze, cassava and yam. Soybean is mostly produced as a cash-crop but also contribute to a smaller extend to the household diet. The respondents have received very little support with respect to soybean production. Most of them know about 25% only of the recommendations/best practices for optimal soybean production. Although the knowledge level is quite low, farmers have a very good perception of the nutritional economic, environmental and social importance of soybeans. The two random assignments balanced groups. Our econometric analysis shows that the UNPS intervention has a positive and statistically ($p < .01$) significant impact on the knowledge score of both male and female farmers. The size of the estimate is 9.51 score for male farmers and 9.84 score for female farmers. We also find positive and statistically ($p < .01$) significant impact on soybean productivity for both male and female farmers. Male and female farmers who enjoy the UNPS intervention increased their productivity by almost 275 kg/ha and 405 kg/ha, respectively. Despite these positive results, there is still room to improve farmers´ knowledge with further expectations of productivity gains.

The intervention targeting mechanism has gender-differentiated impact. When the female farmer is imposed as the direct beneficiary, we find that her knowledge score does increase while the knowledge score of the male decreases. The household average knowledge score does increase slightly but remains statistically non-significant. We find similar pattern as far as the productivity is concerned. Additionally, we show that soybean production is gaining a lot of interest among farmers as most of the respondent farmers look forward to planning soybean again regardless the treatment status. There is no statistically significant difference in terms of farmers´ likelihood to plant soybean in the next rainy season across most of the scenarios. Yet, it is important to highlight that male farmers in households who enjoyed UNPS intervention are 10 percentage points less likely to plant soybean in the next season if there were either offered access to the market support of membership in group organization. Female farmers in households who enjoyed UNPS intervention are 13 percentage points less likely to plant soybean in the next season if there were group training offered. Nevertheless, female farmers in households where the female farmer was imposed are 18, 17 and 11 percentage points more likely to plan soybean if they were offered group training, follow-up via phone calls, free inputs, respectively.

As anticipated in our ToC, we show that training farmers on best practices for soybean production would help to improve awareness and knowledge among smallholder farmers and increase their likelihood to adopt better farming practices. Improvements in both knowledge and farm practices coupled with timely delivery of quality inputs would result in positive effects on productivity. Our results contrast with the expectation that the intervention targeting mechanism (HH choice vs female farmer biased) can potentially generate intra household knowledge spillovers through the gender dynamics within the household. This is driven by the socio-economic settings of the study where production decisions are mostly taken by the male farmers who happen to be in most cases the household head who have larger plots, more plots than female farmers, record slightly higher yield and contribute more the household expenditures.

Based on our findings, we recommend UNPS to scale up the intervention. As far as the targeting mechanism is concerned, there will be need to engage with male farmers. This could be through sensibilisation activities. Future research could explore the impact of the female farmers-biased targeting approach with additional women empowerment components. The provision of continuous technical support via phone calls also pave the way to testing how information and communication technologies can be used to improve or replace traditional in person visits.

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APPENDIX

Appendix 1: Paired-wise matching

We start the sampling with a list of 1184 villages of ATDA4 and exclude those that are not free of UNPS and ABS interventions. We also drop all villages without GPS or Bioclimatic (rainfall, temperature and soil condition) information. We then do the 10km buffering to obtain a short list of 105 villages. The table below provides some details of the village selection process for paired-wise matching:

Table 1.1: Statistics of the village selection process

Causes de suppression de village	Nombre de Villages	Proportion (%)
Absence de coordonnées géographiques	681	66.12
Valeurs nulle "0" pour Prec 1 et bio 14	7	0.68
Code manquant pour PHASE 1	8	0.78
Coordonnées géographiques équivalentes (entre villages d'identifiants différents) *	40	3.88
Distance au plus proche voisin < 10 km	189	18.35
Total	*925*	*89.81*
Villages retenus	**105**	**10.19**
Total general	1030	100

**74 villages concernés. Pour optimiser la taille de l'échantillon, un choix raisonné (degré de ruralité) de 1 village sur 2 ou 3 possédants les mêmes attributs géographiques a été opéré.*

We run the paired-wise matching on the 105 villages and obtain 51 pairs of villages presented in the following figure:

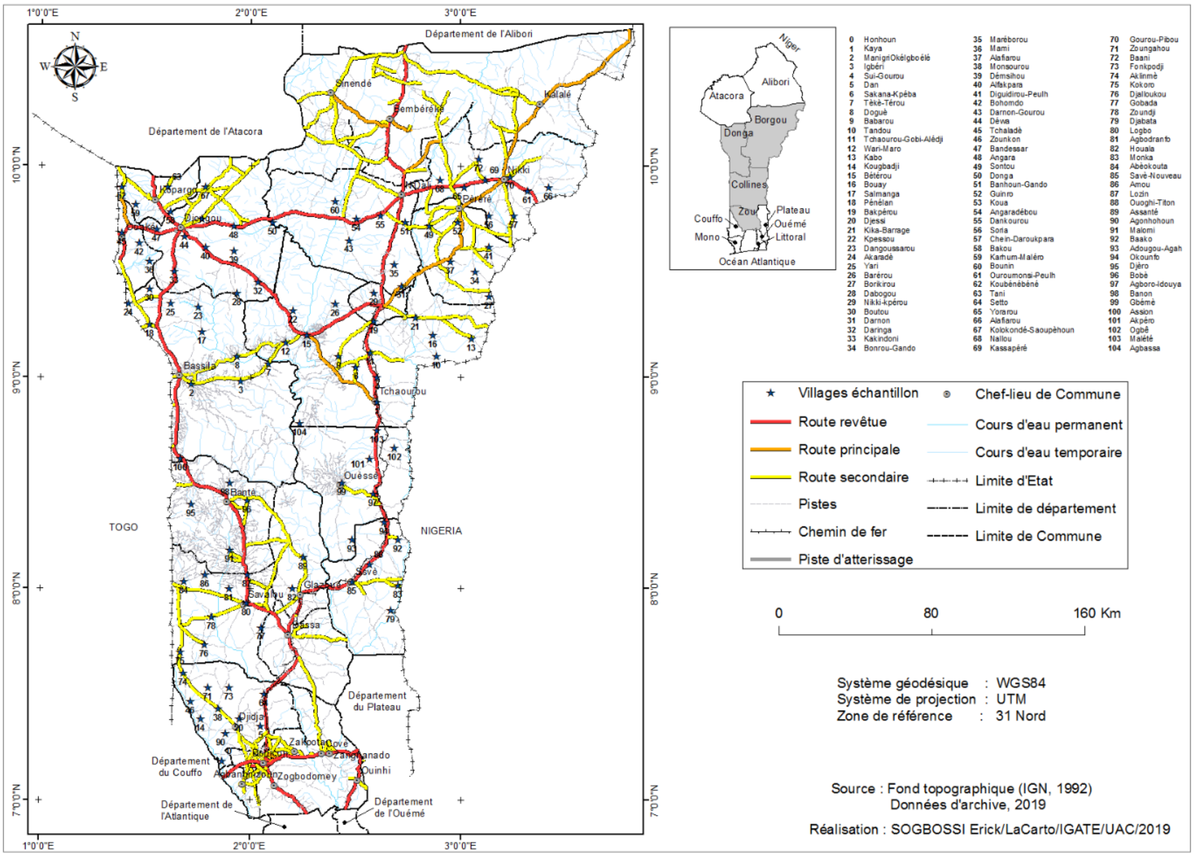


Figure 1.1: Map of the 51 pairs of villages after paired-wise matching

Field visit to confirm 19 pairs of villages

We draw randomly 19 pairs of villages from the 51 pairs to confirm that they meet our eligibility criteria. The village eligibility criteria for the study include: production of soybeans during the past crop year (2019-2020); not be on the list of villages which are currently benefiting or which have benefited in the past from the capacity building activities led by UNPS or ABS in relation with soybean production; be on the list of villages for UNPS expansion plan; have at least 16 eligible households - in which the man and woman who are in a relationship (living together) have produced soybeans during the past crop year (2019-2020): and be at least 10 km from the nearest eligible village. If a village is found to be non-eligible, the pair was replaced. Figure 5 shows the map of 19 confirmed pairs.

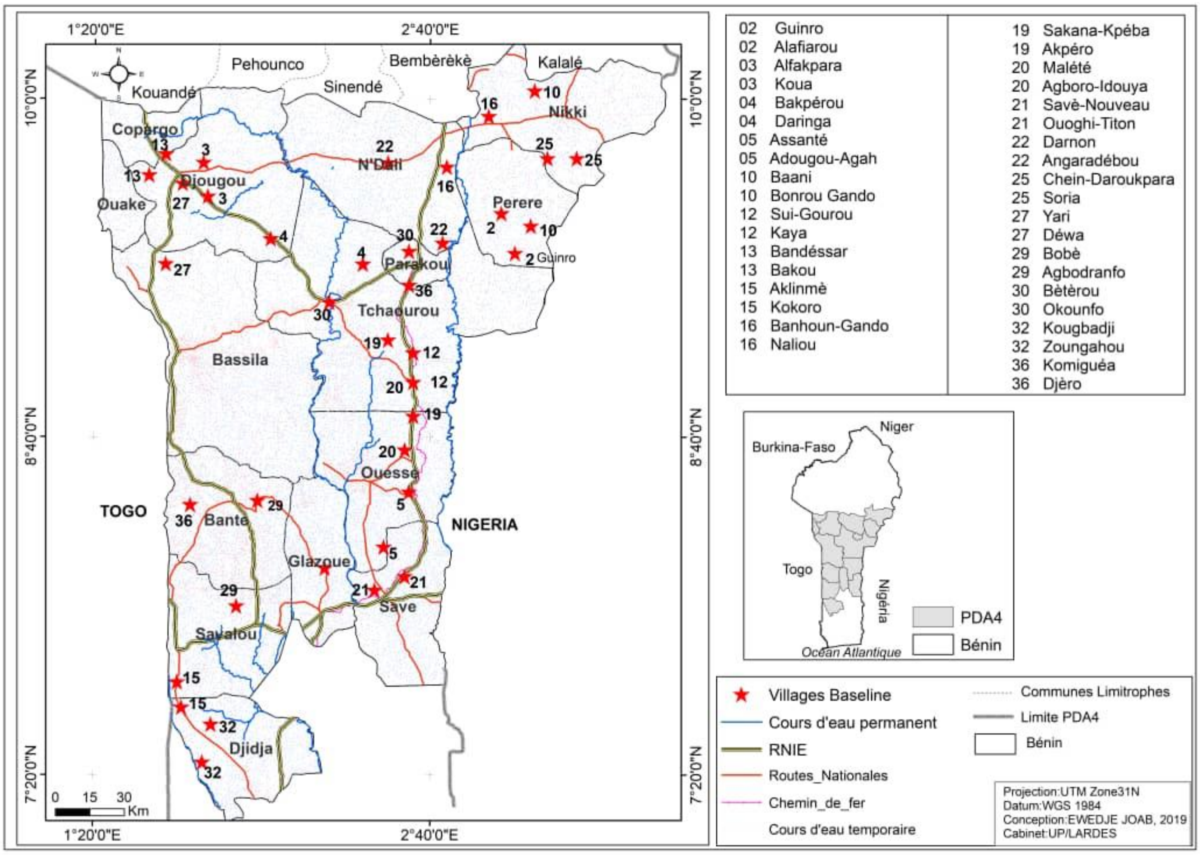


Figure 1.2: Map of the 19 confirmed pairs of villages

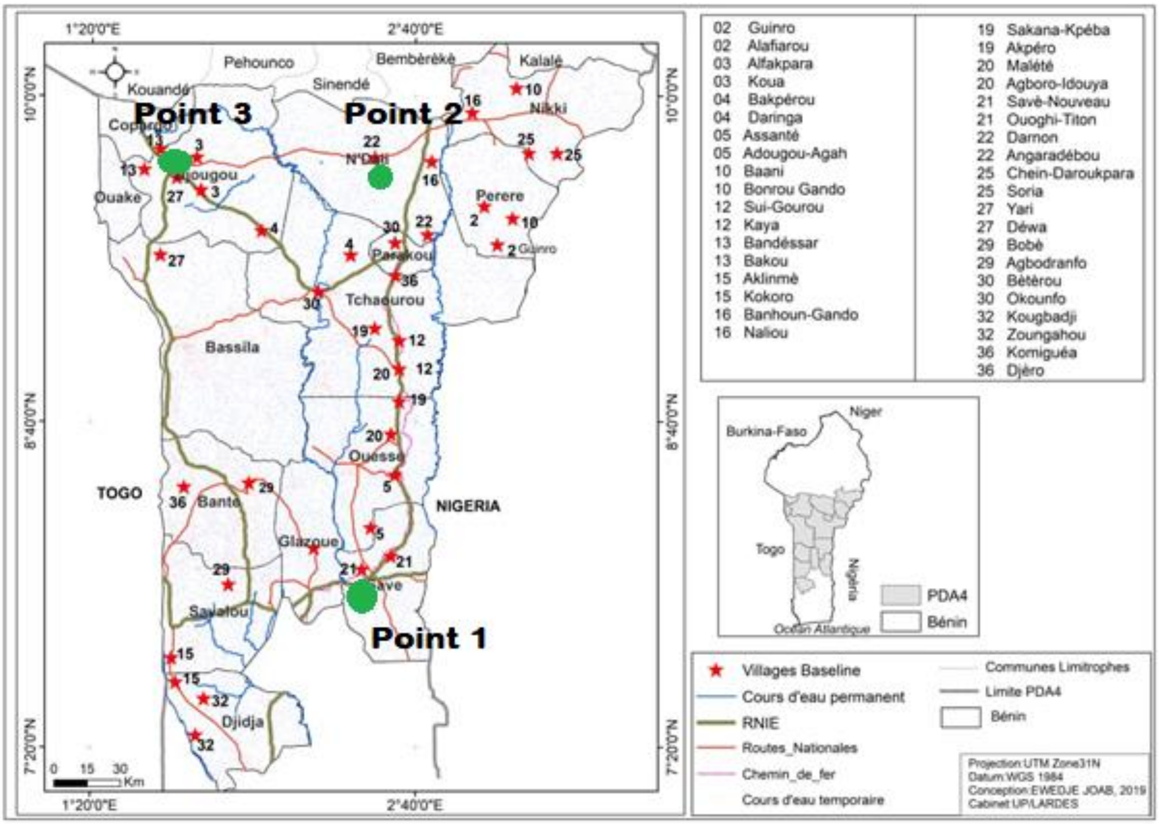
Listing of eligible HHs in selected villages

In each confirmed village, we conducted a listing of eligible HHs. HHs eligibility criteria are: being a household in which the man and woman who are in a relationship (living together) have produced soy during the past crop year (2019-2020); have never benefited from the capacity building of UNPS, the ABS or other partners; have plans to produce soybean production during the 2020-2021 crop year on at least 0.25 ha; be willing and available to participate in project activities as a treated or control household.

Enrolment of eligible HHs for the study

At the end of the listing activity, eligible households are given the chance to enrol themselves to participate in the study. In that respect, households are given detailed information about the study, including the description of the intervention and the possibility of ending up in one of the treated groups or in the control group.

Appendix 2: Map of the location of public lottery meetings



Appendix 3: Repartition of the pairs following the locations of public lottery meetings

Pairs	Département	Commune	Arrondissement	Villages	Point de Regroupement
5	COLLINES	GLAZOUE	ASSANTE	Assanté	1
5	COLLINES	OUESSE	OUESSE	Adougou-Agah	
15	ZOU	DJIDJA	HOUTO	Aklinmè	
15	COLLINES	SAVALOU	LEMA	Kokoro	
20	COLLINES	OUESSE	TOUI	Malété	
20	COLLINES	OUESSE	CHALLA-OGOÏ	Agboro-Idouya	
21	COLLINES	SAVE	PLATEAU	Savè-Nouveau	
21	COLLINES	SAVE	SAKIN	Ouoghi-Titon	
29	COLLINES	BANTE	BOBE	Bobè	
29	COLLINES	SAVALOU	OUESSE	Agbodranfo	
32	ZOU	DJIDJA	MONSOUROU	Kougbadji	
32	ZOU	DJIDJA	AGOUNA	Zoungahou	
3	DONGA	DJOUGOU	BARIENOU	Koua	3
3	DONGA	DJOUGOU	SEROU	Alfakpara	
13	DONGA	DJOUGOU	BAREI	Bandessar	
13	DONGA	DJOUGOU	ONKLOU	Bakou	
27	DONGA	DJOUGOU	SEROU	Déwa	
27	DONGA	BASSILA	PENESSOULOU	Yari	
2	BORGOU	PERERE	KPEBIE	Guinro	2
2	BORGOU	PERERE	SONTOU	Alafiarou	
4	BORGOU	PARAKOU	1er Arrondissement	Bakpérou	
4	DONGA	DJOUGOU	ONKLOU	Daringa	
10	BORGOU	PERERE	SONTOU	Bonrou-Gando	
10	BORGOU	NIKKI	SEREKALE	Baani	
12	BORGOU	TCHAOUROU	KIKA	Sui-Gourou	
12	BORGOU	TCHAOUROU	SANSON	Kaya	
16	BORGOU	N'DALI	N'DALI	Banhoun-Gando	
16	BORGOU	NIKKI	BIRO	Nallou	
19	BORGOU	TCHAOUROU	TCHATCHOU	Sakana-Kpéba	
19	COLLINES	OUESSE	IKEMON	Akpéro	
22	BORGOU	N'DALI	GBEGOUROU	Darnon	
22	BORGOU	N'DALI	BORI	Angaradébou	
25	BORGOU	PERERE	PERERE	Soria	
25	BORGOU	NIKKI	SUYA	Chein-Daroukpara	
35	BORGOU	TCHAOUROU	BETEROU	Bétérou	
35	COLLINES	SAVE	KABOUA	Okounfo	
36	BORGOU	PARAKOU	3e Arrondissement	Nikkikpérou	
36	COLLINES	BANTE	PIRA	Djèro	

Appendix 4: Balance tests

We conduct balance test at the cluster level (for the first random assignment) and at the household/individual level (for the second random assignment). Using the details baseline information, we test the balance of groups on the main outcome of interest (yield – land productivity) but also on a large range of covariates. The following Table summarises the balance tests statistics for the first randomization. Here we use village average information (individual-level data averaged at the village-level).

Table 4.1: Balance tests following the village-level randomization

		Full sample (N=38)	Control (N=19)	Treatment (N=19)	Difference [a]
Outcome variable					
Yield (kg/ha)	Male respondent	827.16 (28.70)	816.39 (43.37)	837.94 (38.63)	21.54 (58.08)
	Female respondent	796.23 (28.97)	773.02 (44.91)	819.44 (37.07)	-46.41 (58.23)
Covariates - Household level characteristics					
Household size (#/HH)		12.71 (.51)	12.17 (.52)	13.26 (.88)	-1.09 (1.02)
Active household members (#/HH)		7.04 (.31)	6.91 (.33)	7.17 (.54)	-.26 (.64)
Crop production (yes/no)	Maize	.97 (.006)	.97 (.008)	.98 (.008)	-.01 (.012)
	Cotton	.30 (.04)	.35 (.07)	.24 (.05)	.11** (.09)
	Rice	.23 (.03)	.25 (.04)	.20 (.05)	.04 (.07)
	Cassava	.81 (.02)	.83 (.03)	.79 (.04)	.03 (.05)
	Yam	.85 (.03)	.86 (.05)	.84 (.04)	.02 (.06)
	Mil	.45 (.05)	.46 (.07)	.44 (.08)	.02 (.11)
Soybean as main crop contributing to	HH revenue (yes/no)	.55 (.04)	.53 (.06)	.56 (.07)	-.02 (.09)
	HH food (yes/no)	.02 (.008)	.03 (.01)	.02 (.007)	.01 (.01)
	HH land use (yes/no)	.44 (.04)	.44 (.06)	.45 (.06)	-.007 (.09)
Share out of 10 of soybean in	HH revenue	4.79 (.25)	4.80 (.37)	4.78 (.35)	.02 (.51)
	HH food	1.25 (.13)	1.37 (.17)	1.13 (.20)	.24 (.27)
Total land owned (ha/HH)		10.92 (.79)	11.50 (.96)	10.35 (1.28)	1.14 (1.60)
Land acreage for soybean (ha/HH)		3.96 (.42)	4.19 (.71)	3.72 (.46)	.47 (.84)
HH assets ownership (#/HH)	Radio	.90 (.05)	.83 (.07)	.97 (.09)	-.13* (.11)
	TV	.25 (.03)	.24 (.04)	.27 (.06)	-.03 (.07)
	Bicycle	.30 (.04)	.19 (.05)	.40 (.07)	-.20** (.09)
	Tricycle	.03 (.009)	.03 (.01)	.03 (.01)	0 (.01)
	Car	.01 (.005)	.01 (.006)	.02 (.009)	-.01 (.01)
	Motorbike	1.33 (.06)	1.21 (.08)	1.44 (.10)	-.22* (.13)
	Poultry	21.79 (1.78)	22.00 (2.45)	21.58 (2.65)	.42 (3.61)
	Small ruminant	5.42 (.65)	5.73 (.92)	5.11 (.94)	.61 (1.31)
	Gros ruminant	1.37 (.30)	1.45 (.50)	1.3 (.37)	.15 (.62)
	House	1.98 (.16)	1.97 (.24)	1.98 (.22)	-.002 (.332)
	Hoe	6.05 (.38)	5.99 (.49)	6.10 (.58)	-.11 (.77)
	Ploughing machine	.10 (.03)	.15 (.06)	.05 (.02)	.10 (.06)
	Charette	.02 (.009)	.03 (.01)	.005 (.005)	.03 (.01)
	Storage building	.34 (.04)	.34 (.06)	.35 (.07)	-.005 (.09)
	Sprayer	1.13 (.08)	1.09 (.12)	1.16 (.12)	-.06 (.17)
Covariates - Individual level socio-economic characteristics					
Age (year)	Male respondent	41.32 (.62)	41.49 (.97)	41.16 (.80)	.32 (1.26)
	Female respondent	33.65 (.67)	34.11 (.97)	33.19 (.95)	.92 (1.36)
Bariba socio-ethnic group (yes/no)	Male respondent	.30 (.07)	.15 (.08)	.45 (.10)	-.29** (.13)
	Female respondent	.30 (.07)	.16 (.08)	.44 (.10)	-.27** (.13)
#Years of life together (year)	Male respondent	16.00 (.58)	16.29 (.82)	15.71 (.84)	.57 (1.17)
	Female respondent	15.44 (.54)	15.76 (.78)	15.12 (.77)	.63 (1.10)
	Male respondent	.34 (.02)	.34 (.03)	.35 (.03)	-.01 (.05)

		Full sample (N=38)	Control (N=19)	Treatment (N=19)	Difference [a]
Male as another wife (yes/no)	Female respondent	.35 (.03)	.34 (.04)	.36 (.04)	-.01 (.06)
Formal education (yes/no)	Male respondent	.40 (.04)	.38 (.06)	.42 (.05)	-.03 (.08)
	Female respondent	.22 (.03)	.24 (.05)	.21 (.05)	.03 (.07)
#Years of education (year)	Male respondent	3.46 (.38)	3.15 (.52)	3.77 (.56)	-.61 (.77)
	Female respondent	1.42 (.22)	1.5 (.30)	1.34 (.33)	.15 (.44)
Informal education (yes/no)	Male respondent	.32 (.03)	.33 (.05)	.32 (.06)	.01 (.07)
	Female respondent	.07 (.01)	.10 (.03)	.03 (.01)	.06* (.03)
Professional training (yes/no)	Male respondent	.09 (.02)	.08 (.02)	.10 (.04)	-.01 (.04)
	Female respondent	.09 (.02)	.06 (.01)	.11 (.03)	-.05 (.03)
Agriculture as main activity (yes/no)	Male respondent	.97 (.008)	.97 (.01)	.96 (.01)	.007 (.017)
	Female respondent	.90 (.01)	.90 (.02)	.90 (.02)	.002 (.035)
#Years of experience in agriculture (year)	Male respondent	17.91 (.75)	18.25 (1.28)	17.58 (.83)	.66 (1.53)
	Female respondent	10.37 (.61)	10.99 (.99)	9.76 (.73)	1.23 (1.23)
#Years of experience soy production (year)	Male respondent	6.13 (.30)	5.70 (.31)	6.57 (.51)	-.86 (.60)
	Female respondent	4.21 (.23)	4.24 (.26)	4.18 (.38)	.05 (.46)
Side activity (yes/no)	Male respondent	.32 (.03)	.34 (.04)	.31 (.05)	.03 (.07)
	Female respondent	.48 (.03)	.43 (.04)	.53 (.05)	-.09 (.07)
Association membership (yes/no)	Male respondent	.28 (.04)	.25 (.06)	.31 (.06)	-.05 (.09)
	Female respondent	.12 (.03)	.09 (.03)	.16 (.05)	-.07 (.06)
Soybean association membership (yes/no)	Male respondent	.12 (.03)	.10 (.04)	.15 (.05)	-.05* (.07)
	Female respondent	.07 (.02)	.05 (.02)	.10 (.05)	-.04 (.05)
Access to credit (yes/no)	Male respondent	.11 (.02)	.12 (.03)	.10 (.02)	.01 (.04)
	Female respondent	.025 (.007)	.03 (.01)	.02 (.009)	.01 (.01)
Distance between field and homestead (km)	Male respondent	5.21 (.41)	4.79 (.56)	5.63 (.60)	-.83 (.82)
	Female respondent	4.72 (.40)	4.33 (.53)	5.10 (.59)	-.77 (.80)
Covariates - Individual level experience of soybean production-related support					
Ever enjoyed soy-related support (yes/no)	Male respondent	.10 (.03)	.08 (.02)	.13 (.05)	-.04 (.06)
	Female respondent	.03 (.01)	.02 (.01)	.03 (.02)	-.01 (.02)
Enjoyed soy-related support in 2019 (yes/no)	Male respondent	.04 (.01)	.02 (.01)	.06 (.02)	-.04 (.03)
	Female respondent	.009 (.003)	.007 (.004)	.01 (.006)	-.002 (.007)
Wish soy-related support in 2020 (yes/no)	Male respondent	.99 (.003)	.99 (.005)	.99(.003)	-.002 (.006)
	Female respondent	.98 (.005)	.98 (.01)	.99 (.003)	-.010 (.01)
Covariates - Individual level knowledge (on best practice for soybean production)					
Knowledge score (#)	Male respondent	12.19 (.78)	11.28 (1.04)	13.09 (1.14)	-1.81 (1.55)
	Female respondent	10.75 (.69)	9.85 (.95)	11.65 (.99)	-1.80 (1.37)
Know ALL (100%) of the best practices (yes/no)	Male respondent	.001 (.001)	.002 (.002)	0(0)	.002 (.002)
	Female respondent	0	0	0	0
Know 75% of the best practices (yes/no)	Male respondent	.11 (.04)	.08 (.05)	.15 (.06)	-.06 (.08)
	Female respondent	.05 (.02)	.04 (.03)	.07 (.03)	-.02 (.04)
Know 50% of the best practices (yes/no)	Male respondent	.26 (.05)	.20 (.07)	.32 (.08)	-.12 (.11)
	Female respondent	.21 (.05)	.16 (.07)	.26 (.08)	-.09 (.10)
Know 25% of the best practices (yes/no)	Male respondent	.81 (.03)	.78 (.05)	.85 (.05)	-.060(.07)
	Female respondent	.70 (.04)	.65 (.06)	.74 (.05)	-.09 (.09)
Know NONE (0%) of the best practices (yes/no)	Male respondent	.01 (.006)	.01 (.009)	.007 (.007)	.007 (.01)
	Female respondent	.01 (.006)	.02 (.01)	.007 (.004)	.01 (.01)
Covariates - Individual level attitude towards soybean production					
Nutritional importance (yes/no)	Male respondent	.97 (.01)	.97 (.009)	.97 (.01)	-.002 (.02)
	Female respondent	.96 (.01)	.96 (.01)	.96 (.02)	.005 (.02)
Economic importance (yes/no)	Male respondent	.98 (.006)	.98 (.01)	.99 (.004)	-.01 (.01)
	Female respondent	.99 (.002)	.99 (.003)	.98 (.004)	.005 (.006)
Social importance (yes/no)	Male respondent	.84 (.03)	.83 (.05)	.84 (.05)	-.007 (.07)
	Female respondent	.77 (.04)	.76 (.06)	.78 (.05)	-.01 (.08)
Environmental importance (yes/no)	Male respondent	.95 (.01)	.93 (.02)	.96 (.01)	-.02 (.02)
	Female respondent	.90 (.02)	.90 (.03)	.91 (.03)	-.002 (.05)
Covariates - Individual level practice in relation with soybean production					
Work with partner (yes/no)	Male respondent	.84 (.04)	.91 (.02)	.77 (.07)	.13* (.07)
	Female respondent	.97 (.007)	.97 (.007)	.96 (.01)	.01 (.01)

		Full sample (N=38)	Control (N=19)	Treatment (N=19)	Difference [a]
Discuss practices with partner (yes/no)	Male respondent	.86 (.02)	.86 (.04)	.87 (.02)	-.01 (.05)
	Female respondent	.87 (.02)	.86 (.03)	.88 (.03)	-.02 (.05)
Give advice to partner (yes/no)	Male respondent	.91 (.02)	.92 (.03)	.90 (.02)	.01 (.04)
	Female respondent	.76 (.03)	.77 (.05)	.75 (.05)	.02 (.07)
Receive advice from partner (yes/no)	Male respondent	.77 (.03)	.78 (.05)	.76 (.04)	.02 (.07)
	Female respondent	.91 (.01)	.92 (.02)	.90 (.02)	.02 (.03)
Follow partner to his/her field (yes/no)	Male respondent	.83 (.02)	.82 (.04)	.84 (.03)	-.01 (.05)
	Female respondent	.89 (.02)	.88 (.04)	.9 (.03)	-.01 (.05)
Partner follows to my field (yes/no)	Male respondent	.83 (.03)	.84 (.04)	.82 (.05)	.01 (.07)
	Female respondent	.38 (.05)	.38 (.07)	.38 (.08)	-.002 (.11)
I decide on labor allocation (yes/no)	Male respondent	.89 (.02)	.9 (.03)	.88 (.04)	.01 (.05)
	Female respondent	.24 (.03)	.21 (.04)	.27 (.05)	-.05 (.07)
I decide on the choice of plot of land (yes/no)	Male respondent	.90 (.02)	.90 (.02)	.89 (.04)	.007 (.05)
	Female respondent	.21 (.03)	.21 (.05)	.21 (.05)	-.005 (.07)
I decide on the size of the plot of land (yes/no)	Male respondent	.90 (.02)	.90 (.03)	.89 (.04)	.01 (.05)
	Female respondent	.29 (.04)	.24 (.05)	.34 (.06)	-.10** (.08)
I decide on the purchase of inputs (yes/no)	Male respondent	.9 (.02)	.9 (.03)	.9 (.04)	0 (.05)
	Female respondent	.21 (.03)	.21 (.04)	.22 (.05)	-.01 (.07)
I decide on the purchase of equipment (yes/no)	Male respondent	.90 (.02)	.91 (.03)	.88 (.04)	.02 (.05)
	Female respondent	.13 (.02)	.12 (.03)	.14 (.04)	-.01 (.05)
Covariates - Individual level soybean production information					
Total land owned (ha)	Male respondent	7.37 (.71)	8.13 (1.00)	6.61 ()	1.51 (1.43)
	Female respondent	1.37 (.15)	1.39 (.22)	1.36 (.21)	.03 (.31)
% of respondents with several soybean plots	Male respondent	.12 (.02)	.08 (.02)	.15 (.04)	-.06 (.05)
	Female respondent	.06 (.04)	.06 (.05)	.06 (.05)	0(.07)
Size of main soybean plot in 2019 (ha)	Male respondent	2.83 (.34)	3.21 (.61)	2.45 (.31)	.75 (.68)
	Female respondent	.85 (.06)	.83 (.08)	.87 (.08)	-.04 (.12)
Practice of monoculture for soybean (yes/no)	Male respondent	.95 (.02)	.97 (.008)	.92 (.05)	.05 (.05)
	Female respondent	.95 (.02)	.98 (.006)	.92(.052)	.05 (.05)
Loose soil (yes/no)	Male respondent	.66 (.04)	.62 (.06)	.71 (.05)	-.08 (.08)
	Female respondent	.67 (.04)	.6 (.06)	.74 (.05)	-.14* (.08)
Quantity of seeds (kg/ha)	Male respondent	33.75 (2.3)	30.29 (2.68)	37.22 (3.64)	-6.92 (4.52)
	Female respondent	43.26 (4.23)	41.50 (6.98)	45.02 (4.95)	-3.52 (8.56)
Quantity of NPK fertilizer (kg/ha)	Male respondent	2.01 (.81)	2.15 (1.3)	1.87 (1.02)	.28 (1.65)
	Female respondent	.05 (.03)	.09 (.06)	.02 (.01)	.06 (.07)
Quantity of urea fertilizer (kg/ha)	Male respondent	.58 (.25)	.5 (.34)	.58 (.39)	-.01 (.52)
	Female respondent	.72 (.33)	1.26 (.64)	.19 (.14)	1.07 (.65)
Quantity of inoculum (unit/ha)	Male respondent	.23 (.07)	.20 (.10)	.26 (.11)	-.05 (.15)
	Female respondent	.37 (.11)	.27 (.12)	.47 (.19)	-.20 (.23)
Availability of seed in the village (yes/no)	Male respondent	.87 (04)	.84 (.06)	.90 (.04)	-.05 (.08)
	Female respondent	.86 (.04)	.82 (.06)	.90 (.05)	-.08 (.08)
Timely access to seed in the village (yes/no)	Male respondent	.87 (.04)	.85 (.06)	.9(.05)	-.04 (.08)
	Female respondent	.86 (.06)	.84 (.05)	.88 (.04)	-.04 (.08)
Availability of NPK in the village (yes/no)	Male respondent	.13 (.03)	.09 (.04)	.16 (.06)	-.06** (.07)
	Female respondent	.10 (.03)	.07 (.03)	.13 (.06)	-.06** (.07)
Timely access to NPK in the village (yes/no)	Male respondent	.9 (.1)	1 (0)	.8 (.2)	.2 (.2)
	Female respondent	.81 (.13)	.7 (.2)	1 (0)	-.3 (.26)
Availability of urea in the village (yes/no)	Male respondent	.14 (.04)	.13 (.05)	.15 (.06)	-.01 (.08)
	Female respondent	.13 (.04)	.13 (.05)	.13 (.06)	-.005 (.08)
Timely access to urea in the village (yes/no)	Male respondent	.80 (.09)	.88 (.11)	.75 (.14)	.13 (.19)
	Female respondent	.83 (.03)	1 (0)	.5 (.5)	.5 (.30)
Availability of inoculum in the village (yes/no)	Male respondent	.08 (.16)	.06 (.05)	.10 (.05)	-.03 (.07)
	Female respondent	.08 (.03)	.07 (.05)	.10 (.05)	-.03 (.07)
Timely access to inoculum in the village (yes/no)	Male respondent	.09 (.03)	.08 (.05)	.09 (.05)	-.01 (.07)
	Female respondent	.07 (.03)	.06 (.05)	.07 (.04)	-.01 (.07)
Covariates - Individual level risk attitude					
Risk score	Male respondent	605.69 (24.93)	632.02 (35.51)	579.36 (34.89)	52.65 (49.78)
	Female respondent	538.31 (23.13)	558.07 (29.73)	518.55 (35.68)	39.52 (46.44)

[a]: P-values are from regression estimates with village pair dummies. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.
Source: Own estimates

The statistics of this table suggest that both the pure control and the treatment groups are well balanced on the outcome of interest and most of the covariates. The control and treatment groups do differ as far as some household characteristics (i.e. numbers of radio, bicycle and motorbike), the socio-ethnic group of both the male and female respondents, the informal education for female respondents, the habit for male respondents to work with their partners, the person who decide on the size of the female farmer's plot of land, and the assessment of the availability of NPK are concerned. Yet, the differences are rather small in magnitudes. The following table summarises the balance tests statistics for the second randomization.

Table 4.1: Balance tests following the household-level randomization

		Full sample (N=380)	HH Decide (N=190)	Woman imposed (N=190)	Difference [a]
Outcome variable					
Yield (kg/ha)	Male respondent	837.94 (14.29)	838.75 (20.14)	837.13 (20.34)	1.62 (28.63)
	Female respondent	819.44 (13.97)	817.15 (19.53)	821.73 (20.03)	-4.57 (27.98)
Covariates - Household level characteristics					
Household size (#/HH)		13.26 (.43)	13.25 (.60)	13.27 (.64)	-.02 (.87)
Active household members (#/HH)		7.17 (.25)	6.93 (.32)	7.42 (.40)	-.49 (.51)
Crop production (yes/no)	Maize	.98 (.006)	.98 (.009)	.98 (.009)	0 (.01)
	Cotton	.24 (.02)	.26 (.03)	.22 (.03)	.03 (.04)
	Rice	.20 (.02)	.22 (.03)	.18 (.02)	.03 (.04)
	Cassava	.79 (.02)	.77 (.03)	.81 (.02)	-.04 (.04)
	Yam	.84 (.01)	.85 (.02)	.83 (.02)	.02 (.03)
	Mil	.44 (.02)	.44 (.03)	.44 (.03)	0.001 (.05)
Soybean as main crop contributing to	HH revenue (yes/no)	.56 (.02)	.53 (.03)	.58 (.03)	-.05 (.05)
	HH food (yes/no)	.02 (.007)	.02 (.01)	.02 (.01)	-.005 (.01)
	HH land use (yes/no)	.45 (.02)	.42 (.03)	.47 (.03)	-.05 (.05)
Share out of 10 of soybean in	HH revenue	4.78 (.11)	4.71 (.16)	4.85 (.15)	-.13 (.22)
	HH food	1.13 (.06)	1.08 (.08)	1.18 (.10)	-.1 (.13)
Total land owned (ha/HH)		10.35 (.48)	10.77 (.75)	9.94 (.62)	.82 (.97)
Land acreage for soybean (ha/HH)		3.72 (.17)	3.62 (.23)	3.82 (.25)	-.20 (.34)
HH assets ownership (#/HH)	Radio	.97 (.04)	1.03 (.06)	.90 (.05)	.13* (.08)
	TV	.27 (.02)	.27 (.04)	.27 (.03)	0(.05)
	Bicycle	.40 (.05)	.48 (07)	.32 (.06)	.16 (.10)
	Tricycle	.03 (.008)	.02 (.01)	.03 (.01)	-.01 (.01)
	Car	.02 (.007)	.02 (.01)	.02 (.01)	0(.01)
	Motorbike	1.44 (.08)	1.41 (.07)	1.47 (.15)	-.06 (.17)
	Poultry	21.58 (1.50)	23.45 (2.42)	19.71 (1.76)	3.74 (2.99)
	Small ruminant	5.11 (.46)	5.68 (.70)	4.54 (.61)	1.14 (.93)
	Gros ruminant	1.3 (.22)	1.23 (.25)	1.36 (.38)	-.13 (.46)
	House	1.98 (.22)	1.96 (.11)	2 (.12)	-.03 (.16)
	Hoe	6.10 (.26)	6.08 (.34)	6.12 (.40)	-.03 (.53)
	Ploughing machine	.05 (.01)	.06 (.02)	.04 (.01)	.02 (.02)
	Charette	.005 (.003)	.01 (.007)	0	.010 (.007)
	Storage building	.35 (.02)	.34 (.04)	.35 (.04)	-.005 (.05)
	Sprayer	1.16 (.05)	1.16 (.07)	1.15 (.07)	.01 (.10)
Covariates - Individual level socio-economic characteristics					
Age (year)	Male respondent	41.16 (.80)	40.94 (.77)	41.38 (.86)	-.44 (1.16)
	Female respondent	33.19 (.48)	33.25 (.65)	33.13 (.70)	.12 (.96)
Bariba socio-ethnic group (yes/no)	Male respondent	.45 (.02)	.44 (.03)	.45 (.03)	-.005 (.05)
	Female respondent	.44 (.02)	.44 (.03)	.44 (.03)	-.005 (.05)
#Years of life together (year)	Male respondent	15.71 (.48)	15.55 (.65)	15.87 (.70)	-.32 (.96)
	Female respondent	15.12 (.46)	15.1 (.64)	15.15 (.67)	-.05 (.93)

		Full sample (N=380)	HH Decide (N=190)	Woman imposed (N=190)	Difference [a]
Male as another wife (yes/no)	Male respondent	.35 (.02)	.33 (.03)	.37 (.03)	-.04 (.04)
	Female respondent	.36 (.24)	.34 (.03)	.37 (.03)	-.03 (.04)
Formal education (yes/no)	Male respondent	.42 (.02)	.38 (.03)	.46 (.03)	-.08** (.05)
	Female respondent	.21 (.02)	.18 (.02)	.23 (.03)	-.04 (.04)
#Years of education (year)	Male respondent	3.77 (.25)	3.33 (.36)	4.21 (.36)	-.88* (.51)
	Female respondent	1.34 (.14)	1.2 (.20)	1.48 (.21)	-.28 (.29)
Informal education (yes/no)	Male respondent	.32 (.02)	.33 (.03)	.31 (.03)	.02 (.05)
	Female respondent	.03 (.01)	.05 (.01)	.02 (.01)	.03 (.02)
Professional training (yes/no)	Male respondent	.10 (.01)	.08 (.02)	.11 (.02)	-.02 (.03)
	Female respondent	.11 (.01)	.11 (.02)	.12 (.02)	-.01 (.03)
Agriculture as main activity (yes/no)	Male respondent	.96 (.01)	.97 (.01)	.95 (.01)	.02 (.01)
	Female respondent	.90 (.01)	.90 (.02)	.90 (.02)	0 (.03)
#Years of experience in agriculture (year)	Male respondent	17.58 (.83)	18.25 (.76)	16.91 (.70)	1.34 (1.04)
	Female respondent	9.76 (.38)	9.88 (.54)	9.64 (.54)	.24 (.77)
#Years of experience soy production (year)	Male respondent	6.57 (.21)	6.71 (.32)	6.42 (.27)	.28 (.42)
	Female respondent	4.18 (.14)	4.30 (.21)	4.06 (.18)	.23 (.29)
Side activity (yes/no)	Male respondent	.31 (.02)	.29 (.03)	.32 (.03)	-.03 (.04)
	Female respondent	.53 (.02)	.48 (.03)	.58 (.03)	-.1 (.05)
Association membership (yes/no)	Male respondent	.31 (.02)	.35 (.03)	.27 (.03)	.07 (.04)
	Female respondent	.16 (.01)	.18 (.02)	.13 (.02)	.05 (.03)
Soybean association membership (yes/no)	Male respondent	.15 (.01)	.18 (.02)	.11 (.02)	.06* (.03)
	Female respondent	.10 (.01)	.12 (.02)	.07 (.10)	.04 (.03)
Access to credit (yes/no)	Male respondent	.10 (.01)	.13 (.02)	.07 (.01)	.05** (.03)
	Female respondent	.01 (.006)	.02 (.01)	.01 (.007)	.01* (.01)
Distance between field and homestead (km)	Male respondent	5.63 (.25)	6.13 (.39)	5.12 (.30)	1.01** (.49)
	Female respondent	5.10 (.24)	5.56 (.38)	4.64 (.28)	.91** (.48)
Covariates - Individual level experience of soybean production-related support					
Ever enjoyed soy-related support (yes/no)	Male respondent	.13 (.05)	.12 (.02)	.14 (.02)	-.02 (.03)
	Female respondent	.03 (.01)	.04 (.01)	.03 (.01)	.005 (.02)
Enjoyed soy-related support in 2019 (yes/no)	Male respondent	.06 (.01)	.04 (.01)	.08 (.02)	-.04 (.13)
	Female respondent	.01 (.005)	.005 (.005)	.01 (.009)	-.01 (.01)
Wish soy-related support in 2020 (yes/no)	Male respondent	.99(.003)	.99 (.005)	.99 (.005)	0 (.007)
	Female respondent	.99 (.003)	.98 (.007)	1 (0)	-.02 (.007)
Covariates - Individual level knowledge (on best practice for soybean production)					
Knowledge score (#)	Male respondent	13.09 (.28)	13.11 (.40)	13.07 (.40)	.03 (.57)
	Female respondent	11.66 (.28)	11.73 (.38)	11.58 (.41)	.14 (.57)
Know ALL (100%) of the best practices (yes/no)	Male respondent	0	0	0	0
	Female respondent	0	0	0	0
Know 75% of the best practices (yes/no)	Male respondent	.15 (.01)	.15 (.02)	.14 (.02)	.005 (.03)
	Female respondent	.07 (.01)	.06 (.01)	.07 (.01)	-.01 (.02)
Know 50% of the best practices (yes/no)	Male respondent	.32 (.02)	.32 (.03)	.33 (.03)	-.01 (.04)
	Female respondent	.26 (.02)	.25 (.03)	.26 (.03)	-.01 (.04)
Know 25% of the best practices (yes/no)	Male respondent	.85 (.01)	.84 (.02)	.85 (.02)	-.005 (.03)
	Female respondent	.74 (.02)	.76 (.03)	.73 (.03)	.03 (.04)
Know NONE (0%) of the best practices (yes/no)	Male respondent	.007 (.007)	.005 (.005)	.01 (.007)	-.005 (.009)
	Female respondent	.007 (.004)	.005 (.005)	.01 (.007)	-.005 (.009)
Covariates - Individual level attitude towards soybean production					
Nutritional importance (yes/no)	Male respondent	.97 (.007)	.97 (.01)	.97 (.01)	.005 (.01)
	Female respondent	.96 (.009)	.95 (.01)	.96 (.01)	-.01 (.01)
Economic importance (yes/no)	Male respondent	.99 (.004)	.98 (.007)	.99 (.005)	-.005 (.009)
	Female respondent	.98 (.005)	.99 (.005)	.98 (.009)	.01 (.01)
Social importance (yes/no)	Male respondent	.84 (.01)	.84 (.02)	.84 (.02)	0 (.03)
	Female respondent	.78 (.02)	.79 (.02)	.77 (.03)	.02 (.04)
Environmental importance (yes/no)	Male respondent	.96 (.009)	.98 (.009)	.94 (.01)	.03* (.01)
	Female respondent	.91 (.01)	.93 (.01)	.88 (.02)	.04 (.02)
Covariates - Individual level practice in relation with soybean production					
Work with partner (yes/no)	Male respondent	.77 (.02)	.79 (.02)	.76 (.03)	.03 (.04)
	Female respondent	.96 (.009)	.97 (.01)	.95 (.01)	.01 (.01)

		Full sample (N=380)	HH Decide (N=190)	Woman imposed (N=190)	Difference [a]
Discuss practices with partner (yes/no)	Male respondent	.87 (.01)	.85 (.02)	.9 (.02)	-.04 (.03)
	Female respondent	.88 (.01)	.88 (.02)	.88 (.02)	0(.03)
Give advice to partner (yes/no)	Male respondent	.90 (.01)	.88 (.02)	.91 (.02)	-.02 (.03)
	Female respondent	.75 (.02)	.73 (.03)	.76 (.03)	-.03 (.04)
Receive advice from partner (yes/no)	Male respondent	.76 (.02)	.73 (.03)	.78 (.02)	-.05 (.04)
	Female respondent	.90 (.01)	.89 (.02)	.91 (.02)	-.02 (.03)
Follow partner to his/her field (yes/no)	Male respondent	.84 (.01)	.84 (.02)	.84 (.02)	0 (.03)
	Female respondent	.9 (.01)	.87 (.02)	.92 (.01)	-.04 (.03)
Partner follows to my field (yes/no)	Male respondent	.82 (.02)	.83 (.02)	.82 (.02)	.009 (.04)
	Female respondent	.38 (.02)	.38 (.03)	.38 (.03)	.005 (.05)
I decide on labor allocation (yes/no)	Male respondent	.88 (.01)	.87 (.02)	.88 (.02)	-.005 (.03)
	Female respondent	.27 (.02)	.23 (.03)	.32 (.03)	-.08* (.04)
I decide on the choice of plot of land (yes/no)	Male respondent	.89 (.01)	.88 (.02)	.90 (.02)	-.01 (.89)
	Female respondent	.21 (.02)	.22 (.03)	.21 (.02)	.005 (.04)
I decide on the size of the plot of land (yes/no)	Male respondent	.89 (.01)	.88 (.02)	.90 (.02)	-.02 (.03)
	Female respondent	.34 (.02)	.33 (.03)	.36 (.03)	(.04)
I decide on the purchase of inputs (yes/no)	Male respondent	.9 (.01)	.89 (.02)	.90 (.02)	-.01 (.03)
	Female respondent	.22 (.02)	.22 (.03)	.22 (.03)	.005 (.04)
I decide on the purchase of equipment (yes/no)	Male respondent	.88 (.01)	.87 (.02)	.9 (.02)	-.02 (.03)
	Female respondent	.14 (.01)	.13 (.02)	.15 (.02)	-.02 (.03)
Covariates - Individual level soybean production information					
Total land owned (ha)	Male respondent	6.61 (.37)	6.85 (.50)	6.38 (.55)	.47 (.75)
	Female respondent	1.36 (.06)	1.38 (.09)	1.34 ()	.04 (.13)
% of respondents with several soybean plots	Male respondent	.15 (.01)	.16 (.02)	.14 (.02)	.02 (.03)
	Female respondent	.06 (.01)	.06 (.01)	.06 (.01)	0 (.02)
Size of main soybean plot in 2019 (ha)	Male respondent	2.45 (.12)	2.36 (.18)	2.54 (.18)	-.18 (.25)
	Female respondent	.87 (.03)	.86 (.04)	.87 (.04)	-.007 (.06)
Practice of monoculture for soybean (yes/no)	Male respondent	.92 (.01)	.93 (.25)	.92 (.26)	.005 (.02)
	Female respondent	.92(.01)	.92 (.01)	.93 (.01)	-.005 (.02)
Loose soil (yes/no)	Male respondent	.71 (.02)	.69 (.03)	.73 (.03)	-.03 (.04)
	Female respondent	.74 (.02)	.70 (.03)	.77 (.03)	-.07 (.04)
Quantity of seeds (kg/ha)	Male respondent	37.22 (1.20)	37.01 (1.79)	37.42 (1.62)	-.41 (2.41)
	Female respondent	45.02 (2.92)	46.09 (5.46)	43.95 (2.10)	2.14 (5.85)
Quantity of NPK fertilizer (kg/ha)	Male respondent	1.87 (.57)	1.11 (.55)	2.63 (1.0)	-1.52 (1.14)
	Female respondent	.02 (.009)	.01 (.007)	.03 (.01)	-.02 (.01)
Quantity of urea fertilizer (kg/ha)	Male respondent	.58 (.24)	.70 (.36)	.46 (.32)	.23 (.49)
	Female respondent	.19 (.14)	.10 (.10)	.27 (.26)	-.16 (.28)
Quantity of inoculum (unit/ha)	Male respondent	.26 (.03)	.34 (.06)	.18 (.04)	.16** (.07)
	Female respondent	.47 (.17)	.62 (.30)	.33 (.17)	.29 (.34)
Availability of seed in the village (yes/no)	Male respondent	.90 (.01)	.89 (.02)	.91 (.02)	-.02 (.03)
	Female respondent	.90 (.01)	.9 (.02)	.9 (.02)	0 (.03)
Timely access to seed in the village (yes/no)	Male respondent	.9(.01)	.89 (.02)	.91 (.02)	-.02 (.03)
	Female respondent	.88 (.01)	.89 (.02)	.87 (.02)	.01 (.03)
Availability of NPK in the village (yes/no)	Male respondent	.16 (.06)	.16 (.02)	.16 (.02)	.005 (.03)
	Female respondent	.13 (.01)	.15 (.02)	.12 (.02)	.02 (.03)
Timely access to NPK in the village (yes/no)	Male respondent	.95 (.05)	1	.92 (.07)	.07 (.11)
	Female respondent	1 (0)	1	1	0
Availability of urea in the village (yes/no)	Male respondent	.15 (.01)	.17 (.02)	.13 (.02)	.04 (.03)
	Female respondent	.13 (.01)	.15 (.02)	.12 (.02)	.03 (.03)
Timely access to urea in the village (yes/no)	Male respondent	.83 (.11)	.83 (.16)	.83 (.16)	0 (.23)
	Female respondent	.8 (.2)	,5 (0.5)	1 (0)	-.5 (.37)
Availability of inoculum in the village (yes/no)	Male respondent	.10 (.01)	.13 (.02)	.08 (.02)	.04 (.03)
	Female respondent	.10 (.01)	.12 (.02)	.07 (.01)	.04 (.03)
Timely access to inoculum in the village (yes/no)	Male respondent	.09 (.15)	.11 (.02)	.07 (.01)	.03 (.03)
	Female respondent	.07 (.01)	.08 (.02)	.06 (.01)	.02 (.02)
Covariates - Individual level risk attitude					
Risk score	Male respondent	579.36 (13.83)	598.84 (19.37)	559.89 (19.69)	38.94 (27.62)
	Female respondent	518.55 (13.26)	513 (18.64)	524.10 (18.92)	-11.10 (26.56)

*[a]: P-values from regression estimates with village-level clustered standard errors and village fixed effects. Values in () are standard errors. * p < .10; ** p < .05; *** p < .01.*

Source: Own estimates

The results of the balance tests suggest that both treatment groups are well balanced on the outcome of interest and most of the covariates. Some differences could be observed here and there but they are rather small in magnitudes.

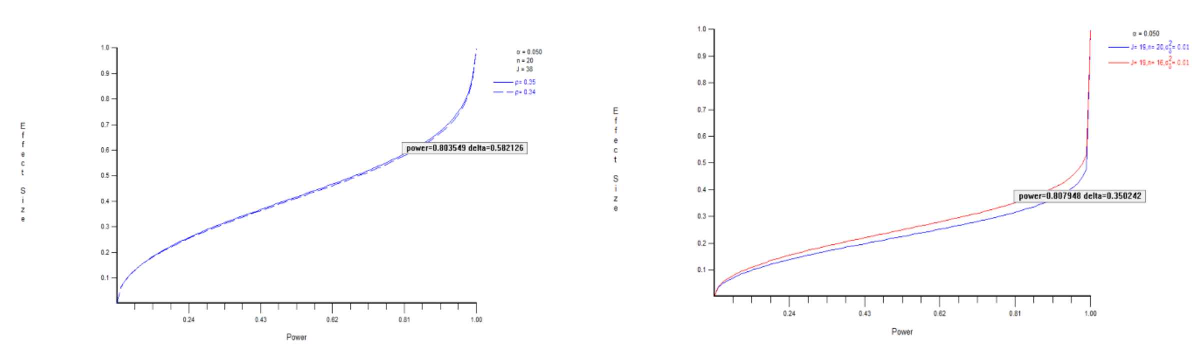
Appendix 5: Power calculations with baseline data

The descriptive statistics suggest that the baseline yield levels (827,16 ± 284.55 kg/ha and 796.23 ± 287.62 kg/ha for male and female farmers, respectively, for the whole sample are lower than our assumptions for power calculations (1063 ± 550 kg/ha). We perform power calculations for each random assignment level. Here, we determine MDEs, using our based on the baseline data summarised as follow:

Table 5.1: Baseline data for power calculations

Item	Assumption
Step 1: Comparing group 1/2 to 3 (Clustered RCT)	
Number of HH in each village	16 to 20
Number of villages (clusters)	38
ICC	0.34 (for women) and 0.35 (for men)
Alpha	0.05
Beta (power)	80%
Step 2: Comparing group 1 to group 2 (individual level RCT)	
Number HHs in each village	16 to 20
Effect-size variability	0.01 (> 0 to assume random site effects)
Explained variance by blocking	0
Alpha	0.05
Beta (power)	80%

The following figures illustrate the results of the power calculations:



Step 1: Comparing group 1/2 to 3 (Clustered RCT) | **Step 2: Comparing group 1 to group 2 (individual level RCT)**

Figure 5.1: Graphs of power calculations, using baseline data

For the first level of random assignment to compare groups 1/2 and 3, the baseline yield levels are 827,16 ± 284.55 kg/ha and 796.23 ± 287.62 kg/ha for male and female farmers, respectively. We should be able to detect an effect size as small as 0.58 (changes in yield around 165.01 kg/ha and 166.81 kg/ha for male and female farmers, respectively) against 0.63 to 0.72 (changes in yield between 350 kg/ha to 400 kg/ha) as assumed in our initial power calculations. For the second level of randomisation to compare Groups 1 and 2, the baseline yield levels are 827,16 ± 277.96 kg/ha and 813.06 ± 274.80 kg/ha for male and female farmers, respectively. We should be able to detect an effect size as small as 0.35 (changes in yield around 97.28 kg/ha and 96.18 kg/ha for male and female farmers, respectively) against 0.36 to 0.45 (changes in yield between 200 kg/ha to 250 kg/ha) as assumed in our initial power calculations. These results evidence that our sample is optimal to detect the MDE we hypothesized in our initial power calculations.