Synergizing fertilizer micro-dosing and indigenous vegetable production to enhance food and economic security of West African farmers (CIFSRF Phase 2)

Project Number 107983

Location of Study: Nigeria and Benin Republic

Impact Assessment of Production of indigenous vegetables in West Africa

Socio economic Team, Nigeria and Benin.

MICROVEG PROJECT

March 19th, 2018

Team Members

Adeolu Babatunde Ayanwale PhD[1]
Joseph Durodoluwa Oyedele PhD[1]
Titus Oluwagbenga Alao PhD[2]
Clement Odunayo Adebooye PhD[2]
Baco Mohamed N PhD[3]
Akponikpe P.B. Irénikatché PhD[3]
Sossa-Vihotogbe Carole N.A PhD[3]
Djenontin André J PhD [3]

[1] Obafemi Awolowo University, Ile – Ife , Nigeria
[2] Osun State University, Osogbo, Nigeria
[3]University of Parakou, Parakou, Republic of Benin

Table of Contents

List of Tables

Key Messages

- The project succeeded in engaging young educated female vegetable farmers in the project, this is evident by the fact that the average age of participants dropped from an average of 44 years at the baseline to 37 years at the end of the project.

- Due to the project intervention, people who were farther away from water source who would ordinarily not be interested in IV cultivation were made to increase their farmsize by over 350% (0.02ha to 0.71ha).over the life of the project.

- Income obtained from the IV enterprises increased by over three times from about $700 to $2100 weekly at the peak (dry) season.

- Due to increased income obtained from the enterprises, the household dependency ratio reduced significantly (from 3.52 (about 4 people at baseline) to 2.58 (about three people at endline)) as more people were able to take care of themselves that at the endline.

- Amount of inorganic fertilizer used before project has decreased and there is also an increase of cultivated areas and productivity.

- Microdose application improved the benefit of IV production by 1.8 and 2.0 times, respectively when the fertilizer is used directly or diluted in water.

- Farmers increased the scope of their IV enterprises by cultivating more UIV species with a commensurate increase in their income at the end of the project

Executive Summary

This project is a synergy of the Nigeria-Canada Indigenous Vegetables Project (NiCanVeg Project 106511) and the Integrated Nutrient and Water Management in the Sahel (INuWaM Project 106516). The promising results of the innovations that were developed by the two projects are being explored for complementarities to accelerate large-scale adoption and impacts of underutilized indigenous vegetable and fertilizer micro-dosing innovations to increase food and nutritional security and economic empowerment of resource-poor farming communities in Nigeria and Benin. This study was conducted with the objective of establishing the endline condition of the project outcomes and to identify drivers and aspects that will help sustain the participants in the project. The report answered three major questions viz; what are the endline conditions of the IVs producers, marketers and consumers in the selected MICROVEG (Project 107983) communities compared with the established baseline figures?; What are the gender dimensions of these baseline characteristics? and What aspects should MICROVEG project address in order to ensure that the achievements are sustained? The study involved 785 households made up of 533 households in four states spanning three agro-ecological zones in Nigeria and 252 households from Benin Republic. In Nigeria, 533 households comprising 171 IV farming households, 128 consumers and 254 IV marketers were considered, while we have 252 households in all from Benin Republic (130 farming households, 58 consumers, 35 marketers, 29 transporters/processors). Using both quantitative and qualitative methods of analyses the results showed that the mean age of the farming household head is 37year at the end-line, a figure lower than 44 years at the baseline, confirming that the project succeeded in involving younger households in the IV business. The average household size obtained at the endline was six which was also lower than the baseline figure of seven in Nigeria. The typical farming household are married with the couples living together and having an average of four dependants who would most likely be an old woman, however, at the baseline the dependency rate was lowered to three in both Nigeria and Benin.

The average number of years of formal education of the household head at baseline was 8 but at the endline the years of formal education increased significantly to about 10 years which is an indicator that more educated persons are entering the IV value chain. The typical vegetable farm size at the baseline was about 0.02ha but the farm size increased to 0.71ha at the endline representing an increase of over 350%. In terms of land acquisition, female who were generally not allowed to acquire farm land mainly due to tradition are now able to lease land for IV cultivation due to MICROVEG intervention. The econometric estimation of the impact shows that participants were able to increase their IV farm size by about 0.15 ha more than the non-participants. This is a significant increase in farm size and ultimately income obtainable from the enterprises. Due to the project intervention, people who were farther away from water source who would ordinarily not be interested in IV cultivation were able to increase their farm size by over 350% (0.02ha to 0.71ha) over the life of the project. Income obtained from the IV enterprises increased by over three times from about $700 to $2100 weekly at the peak (dry) season. Due to increased income obtained from the enterprises, the household dependency ratio reduced significantly (from 3.52 (about 4 people at baseline) to 2.58 (about three people at endline)) as more people were able to take care of themselves at the endline. Amount of inorganic fertilizer used has decreased comparatively to earlier and there is an increase of cultivated areas and productivity.

Microdose fertilizer application improved the benefit of IV production by 1.8 and 2.0 times, respectively when the fertilizer is used directly or diluted in water.

For marketers, the average age which was 42 years at baseline dropped to 38 at the endline with more than 97% female involved. An interesting observation is that younger women are entering the marketing component of the IV value chain. The project also succeeded in engaging better educated people in marketing as the average years of formal education increased from seven years at baseline to 11.36 at endline. More than 97% of marketers are female and the marketing households have an average of two dependants down from four at baseline. In terms of consumption, all the IV varieties are better consumed at the endline compared with only Ugu and Efotete at baseline, suggesting that households in the study area are better informed of the existence and benefits of IVs compared to other vegetables in the study area.

We note with interest our result that participants in the MicroVeg project were mostly educated married female farmers with small family size, who are close to water source and not given to religious taboos. However, for conventional vegetable producers the key features are that they are monogamously married and do hold some religious taboos. This result suggests that the MICROVEG intervention achieved the objective of gender-sensitivity in the study area. Hence it can be concluded that the project was gender and youth friendly.

Introduction

Although, economic growth in Sub-Saharan Africa is recovering at a modest pace, and is projected to pick up to 2.4% in 2017 from 1.3% in 2016, the outlook for the region remains challenging as economic growth remains well below the pre-crisis average.

In 2017, almost 124 million people across 51countries and territories faced *Crisis* levels of acute food insecurity or worse (Global report on Food Crisis 2017). The report defined acute food insecurity as hunger so severe that it poses an immediate threat to lives or livelihoods and that the food crisis are increasingly determined by complex causes such as conflict, extreme climatic shocks and high prices of staple food often acting at the same time. Indeed, studies have shown that rural communities face food insecurity and are chronically malnourished (Tiisekwa et al., 2004) because of drought stress (Boyer, 1982; Ludlow and Muchow, 1990; Harris and Mohammed, 2003; Babu, 2000), low adoption level of improved crop production technologies (Babu, 2000), poor soils and lack of resources. These have negative effects on arable crop production and result in considerable crop yield reductions (Boyer, 1982; Ludlow and Muchow, 1990).

Because food insecurity is primarily a problem of low household incomes and poverty, and not just inadequate food production, projects and programs for food insecure African farmers which aim at increasing production of subsistence crops were floated by various organisations in an effort to address the menace. One of such major intervention is the MICROVEG project funded by the International Development Research Corporation and the Global Affairs Canada through the Canadian International Food Security Research Fund (CIFSRF).

The project is a three-year (2015-2018) project that conducted action research on “Synergizing fertilizer micro-dose and indigenous vegetables innovations to enhance food and economic security of farmers in the West African sub-region”. This project (MICROVEG) is a synergy of the two earlier CIFSRF funded projects (NiCanVeg in Nigeria and INuWaM in Benin republic). The promising results of the innovations developed by the two projects were combined to accelerate large-scale adoption and impacts of underutilized indigenous vegetable and fertilizer micro-dosing innovations in order to increase food and nutritional security and economic empowerment of resource-poor farming communities in Nigeria and Benin. The research focused on scaling up advancements in indigenous vegetables production to increase traditional vegetable yields while also preserving soil and water ecosystems, and conserving fertilizer costs. The project also placed special emphasis on resource-poor women farmers in the development and implementation of the research project. The project aimed at promoting policy advocacy by integrating the successful indigenous vegetables production and value addition innovations into local, national and regional food security programmes in West Africa.

It was funded by the International Development Research Centre (IDRC) and the Canadian Department of Foreign Affair, Trade and Development (DFATD) through Canadian International Food Security Research Fund (CIFSRF) Project No 107983. The broad objective of the project is to increase food and nutrition security and economic empowerment of the poor farmers with resources focused on women in West Africa through integration microdosing on underutilized vegetable production.

Objectives of the MICROVEG

The general objective of this West Africa-Canadian-MicroVeg (Micro-Veg Project) collaborative project is to:

'Increase food and nutritional security and economic empowerment of resource-poor farming communities with emphasis on women in the West Africa sub-region through the integrations of fertilizer micro-dosing and under-utilized vegetables innovations'

The key objectives are:

- Developing technology capsule on fertilizer micro-dosing and water management technologies, value addition technology and seed production for indigenous vegetables.
- Extensive demonstrations on the technologies through District Knowledge Centers (DKC) by using two models (Innovations Platform and Satellite Dissemination Approach).
- Scaling up the technology capsule to advance indigenous vegetables production, enhance vegetable yields; promote consumption and value addition, propel marketing, preserve soil and water ecosystems and enable fertilizer cost-saving.
- Integrating the successful model into local, national and regional food security programmes in the West African sub-region through policy advocacy.

Objectives of the MICROVEG

This study sought to answer three major questions: what are the endline conditions of the IVs producers, marketers and consumers in the selected MICROVEG (Project 107983) communities compared with the established baseline figures?; What are the gender dimensions of these baseline characteristics? and what aspects should MICROVEG project address in order to ensure that the achievements are sustained? Initially, a study was conducted in order to establish the baseline conditions of the project outcomes and to identify drivers and aspects that will help the participants to achieve project's objectives.

Research locations:

The scaling up studies was conducted in the three main agro-ecological zones (forest, savannah and sahel) in the two countries (Nigeria and Benin Republic) of the West African sub-region. In Nigeria, the scaling up was carried out in seven southwestern States (Osun, Oyo, Ondo, Ekiti, Lagos, Kwara and Ogun) with 41 selected local government areas (LGAs) while in Benin Republic, the scaling up was carried out in nine Departments (Borgou, Colline, Donga, Zou, Atacora and Alibori, Littoral, Atlantic and Mono) with 10 major districts, making a total of 51 major districts.

The project targeted four indigenous vegetables that are Telfairia occidentalis (Ugu, Nigeria only), *Amaranthus cruentus* (aléfo), *Ocimum gratissimum* (tchiayo, Benin only) and *Solanum macrocarpon* (gboma).

MICROVEG Impact Pathway

Based on the research plan and programme for impact assessment (IDRC, 2015), the MICROVEG establishes an institutional innovation– the Innovation Platform—which, in turn, *endogenously* generates the innovations (technological, market, institutional and policy) contrary to the traditional template where innovations are exogenously determined. For a summary of the research-to-impact pathway used to hypothesize the causal relationships between research inputs and the research outputs (i.e., the Innovation Platform), institutional innovation and its results (knowledge increase, behavioural change, and innovations at the interfaces of processes driving productivity, environment, policies and markets), knowledge and behavioural outcomes at the household/community/market levels, and impact outcomes see Figure 1. This is the hypothesised generic impact pathway for MICROVEG. Impact pathways for individual country/communities exhibit minor variations to Figure 1, depending upon the specificities of the problem/opportunity that they address.

The main outcomes at the Innovation Platform (IP) level are increased awareness, increased knowledge drawn from several IP sources, increased access to information, inputs and output markets, and behavioural changes at the individual and system level. These combine to generate innovations directly and at the interfaces of productivity, care for the environment, policies, markets, product development, nutrition and gender with a potential to demonstrably increase the delivery of benefits to end users. This will, in turn, lead to outcomes at farm household, village community, and market levels. The main outcomes at the household and community levels are as follows:

- increased awareness and knowledge;
- behavioural outcomes (such as adoption of relevant innovations, more effective supply of inputs to satisfy demand, increased and better expressed demand for inputs, and increased volume of input sales);
- Market outcomes (increased and more effective supply of outputs, increased demand by consumers), and
- Efficiency outcomes (increased yields, technical and allocative efficiency and profit).

These outcomes lead to impacts in the form of welfare and equity outcomes (such as increased incomes, poverty reduction, improved health and nutrition, and equity) and environmental outcomes (for example, imputed soil fertility and erosion). It is hypothesized that evidence provided by the MICROVEG's research comparing the benefits of IP against conventional SDA approaches will determine whether communities and other organizations more directly involved in development will seek to adopt and use the IP approach and further scale it out to meet their needs. The outcomes and range of IP's impact are influenced by several conditioning factors (see Figure 1). These factors complicate the attribution of changes in impact indicators to IP alone. Factors exogenous at the household level but endogenous at the community level include infrastructure (public and privately supplied), institutions (governance and market structures), policies (macroeconomic, sectoral, pricing, social), technologies and information. These factors are well anticipated in the formation of Innovation Platforms as fora bringing together players that can potentially make necessary changes that may lead to the removal of obstacles against use of research results. Factors exogenous at the community level include agroclimatic conditions and external market conditions (world prices and access to foreign markets).

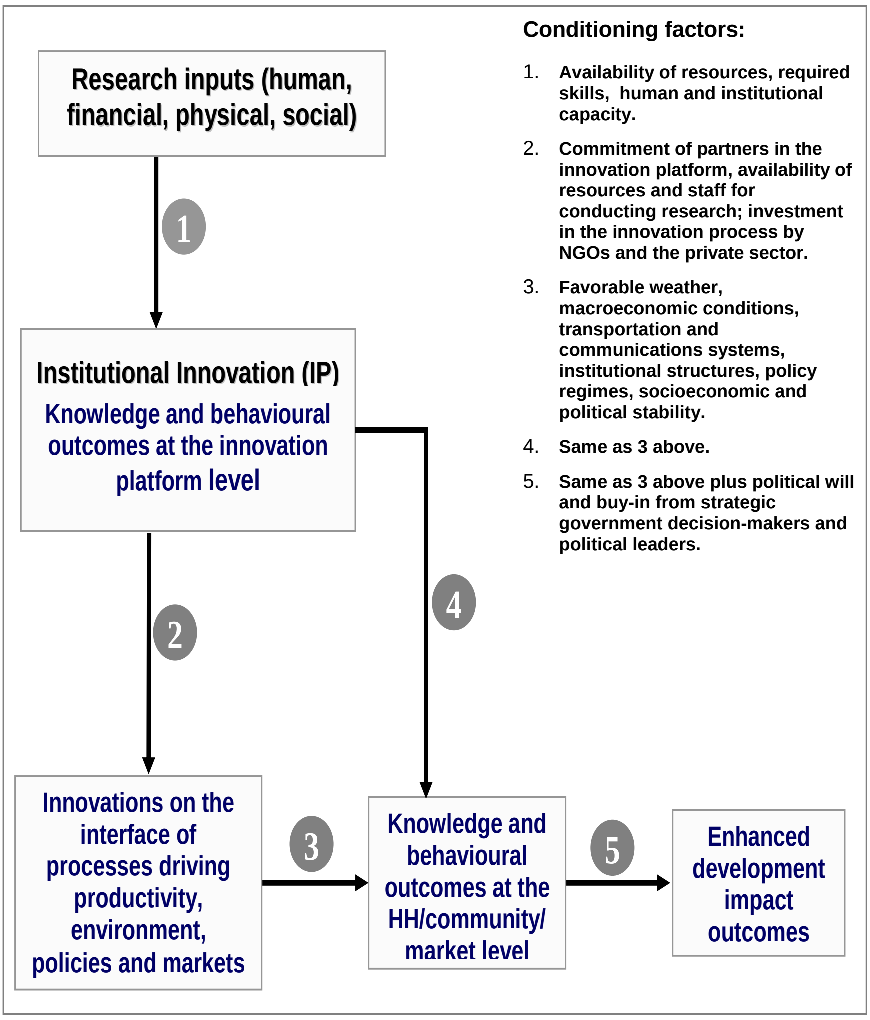

Figure 1. MICROVEG impact pathway (Source: IDRC, 2015)

Analytical Approach

The main aim of this report was to evaluate the impact of MICROVEG intervention on the key outcomes of the project. These outcomes include, among others, UIVs cultivated area expansion, youth and women particiaption and food security. The MICROVEG is being implemented through the Innovation Platform (IP) systems in 51 Local Government Areas/Districts of two countries of West Africa, namely, Nigeria and Benin Republic. In all, the project sites are characterized on the basis of agro-ecological parameters, market opportunities and other features. Each of the LGAs is has one IP and several Innovation clusters at the village level. The project is, therefore, made up 51 IPs. For each of the IPs where the MICROVEG is intervening (the treated site), there are two control sites, namely the conventional vegetable sites and the cash crop sites. In other words, the IPs are the treated sites and the conventional vegetable and the cash crop sites are the non-treated sites. The IPs are treated with the MICROVEG IPs, where existing and/or new UIV technologies are being promoted. If the technologies were randomly assigned to farmers, we could assess the impact of their adoption on households' food security and poverty levels by comparing the average outcomes of the treated and the non-treated households. In such a case, the average treatment effect (ATE) can be computed as follows:

$$ATE = E(Y_i \mid D=1) - E(Y_0 \mid D=1) \tag{1}$$

This is based on the assumption that the outcome levels of the treated before the intervention of the MICROVEG IP $E(Y_0 \mid D=0)$ can reasonably be approximated by the outcome level of the non-treated during data collection $E(Y_0 \mid D=0)$. Otherwise, estimation of ATE using the above equation is not possible, since we do not observe $E(Y_0 \mid D=1)$ though we do observe $E(Y_0 \mid D=1)$ and $E(Y_0 \mid D=0)$. However, technologies are rarely randomly assigned. Instead, technology adoption usually occurs through the self-selection of farmers or, sometimes, through programme placement. In the presence of self selection or programme placement, the above procedure may result in a biased estimation of the impacts of improved technologies, since the treated group (i.e., the MICROVEG site –IP farmers) are less likely to be statistically equivalent to the comparison group in a non-randomized setting. The propensity score matching (PSM) method, which was developed by Rosenbaum and Rubin (1983), has been extensively used in economics since the 1990s to solve the above problem. Rosenbaum and Rubin (1983) defined ‘propensity score’ as the conditional probability of receiving a treatment given pre-treatment characteristics:

$$P(X) \equiv \Pr\{D = 1 \mid X\} = E\{D \mid X\} \qquad (2)$$

where D = {0, 1} is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics.

The PSM method is a systematic procedure of estimating counterfactuals for the unobserved values E (Y1|D=0) and E (Y0|D=1) to compute the impact estimates with no (or negligible) bias. The validity of the outputs of the PSM method depends on the satisfaction of two basic assumptions, namely: the Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) (Becker and Ichino 2002). CIA (also known as Unconfoundedness Assumption) states that the potential outcomes are independent of the treatment status, *given X*. Or, in other words, after controlling for *X*, the treatment assignment is “as good as random”. The CIA is crucial for correctly identifying the impact of the programme, since it ensures that, although treated and untreated groups differ, these differences may be accounted for in order to reduce the selection bias. This allows the untreated units to be used to construct a counterfactual for the treatment group. The CSC entails the existence of sufficient overlap in the characteristics of the treated and untreated units to find adequate matches (or a *common support*). When these two assumptions are satisfied, the treatment assignment is said to be strongly ignorable.

Estimating Propensity Scores and Assessing Match Quality.

We used the probit model to estimate propensity scores. Selected socio-economic and demographic selected variables were included in the model. Because the matching procedure conditions on the propensity score but does not condition on individual covariates, one must check that the distribution of variables are ‘balanced’ across the treated and non-treated groups. Rosenbaum and Rubin (1985) recommend that standardized bias (SB) and *t*-test for differences be used to check matching quality. If the covariates *X* are randomly distributed across the treated and non-treated groups, the value of the associated pseudo-R^2 should be fairly low and the likelihood ratio should also be insignificant. A bootstrapping method was used to compute the standard error for the estimate of the MICROVEG impact.

Choosing a Matching Algorithm.

Three commonly used matching algorithms, namely nearest neighbor matching, radius matching and kernel-based matching, were employed to assess the impact of MICROVEG on households' income. The nearest neighbor matching (NNM) method matches each farmer from the treated group with the farmer from the non-treated group having the closest propensity score. The matching can be done with or without replacement of observations. NNM faces the risk of bad matches if the closest neighbor is far away. This risk can be reduced by using a radius matching (RM) method, which imposes a maximum tolerance on the difference in propensity scores. However, some treated units may not be matched if the dimension of the neighborhood (i.e., the radius) is too small to contain control units. The kernel-based matching(KM) method uses a weighted average of all farmers in the adopter group to construct a counterfactual. The major advantage of the KM method is that it produces ATT estimates with lower variance since it utilizes greater information; its limitation is that some of the observations used may be poor matches.

Evaluation Design

In order to assess the impact in a statistically robust fashion and empirically determine whether MICROVEG delivers more benefits than conventional approaches, a multiple treatments experimental design was used. This design compared household and community level outcomes under (i) MICROVEG, (ii) the conventional vegetables, and (iii) the cashcrop producers. In other words, the MICROVEG experiment comprised three treatments carried out in four blocks (the IPs in LGAs) and three repetitions.

Following White and Chalak (2006), the set of *counterfactuals* was taken to be the set of all possible states of the world, with outcomes taking different values under different possible states of the world. An *intervention* was also seen as the move from one possible state to another. So there are as many counterfactuals as there are possible states of the world. However, under the MICROVEG we limited ourselves to comparing outcomes under IPs and under only two other possible states, namely, the conventional vegetables and under cash-crop (non-intervention). So, our set of counterfactuals is limited to the set $\{\omega_0, \omega_1, \omega_2\}$ where ω_0 is the cash-crop (non-intervention state) consisting of having neither IP nor the conventional approach in operation, ω_1 the state consisting of having the conventional vegetables in operation, and ω_2 is the state consisting of having IP in operation.

The effectiveness and impact of MICROVEG IP were assessed throughout the impact pathway all the way to the farmer level. The hypothesis about whether IP works was tested by comparing the values of relevant knowledge, behavioural, efficiency, welfare, equity and environmental outcomes under ω_2 and under ω_0. Similarly, the hypothesis about whether IP delivers more benefits than the conventional vegetable was tested by comparing the values of relevant knowledge, behavioural, efficiency, welfare, equity and environmental outcomes under ω_2 and under ω_1. The "with" and "without" IP comparison was made by comparing the values of the same outcomes as above under ω_2 and under the composite possible state "ω_0 or ω_1".

Sampling Method

Multi-stage stratified random sampling was carried out within the selected districts (MICROVEG and counterfactual) to select the villages where the treatments were applied, that is villages where MICROVEG-IP was introduced, village communities where conventional vegetables were cultivated, and villages where only cash-crops are being promoted.

The Miguel and Kremer (2004) method of randomizing treatments across schools (districts and village communities) and not individual farm households was used, because it captures benefits from spillovers and externalities that would be underestimated if the treatment is randomized only at the individual level. All districts/local government areas/communes within the IP were first listed and grouped according to their representation of the development domains. Depending on the context and its specific requirements, each stratum was defined, the strata within which it randomly selected the four districts served as its MICROVEG-IP treatment sites; that is, where MICROVEG-IP was introduced. Within the MICROVEG-IP sites, a census of the village communities was conducted to develop a village sampling frame and stratify the villages into clean and non-clean villages. At least 5 focal villages per MICROVEG-IP site were randomly selected from only cash-crop villages. These villages became the theatres for action research, aimed at developing innovations on the interface between productivity, care of the environment, policies and markets. Within the focal MICROVEG-IP village communities, at least 10 households per village were randomly selected for monitoring and evaluation.

Four counterfactual districts/local government areas/communes that were similar to the MICROVEG-IP sites (for example, sharing the same development domain) were assigned to conventional and non-MICROVEG-non-conventional ("cash-crop" village) treatments. As for MICROVEG-IP sites, a village census was carried out and villages stratified into clean and non-clean. For each counterfactual site matching a MICROVEG-IP site, 5 focal villages were randomly selected from clean villages only and assigned to the non-MICROVEG-IP-non-conventional treatments. Similarly, 5 focal villages were randomly sampled from non-clean villages and assigned to the conventional approach treatment. At least 10 households per focal village were randomly selected for monitoring and evaluation.

Sample Selection

The data used in this report were taken from baseline and midline surveys of over 1,500 households across the MICROVEG project sites. The survey was conducted by socioeconomic task forces within the project in both Nigeria and Benin Republic.

The sample frame was derived from different districts, selected to represent the basic areas of MICROVEG intervention.

Baseline surveys for IP and community level characteristics

Baseline surveys, field observations and focus group discussions were conducted to benchmark pre-treatment characteristics of IPs, site characteristics and baseline levels of outcomes predicted under the MICROVEG: number, variety and time to develop innovations; knowledge and behavioural outcomes (adoption, input supply, input demand, volume of sales); market outcomes (output supply and consumption demand); productivity outcomes (yields, technical and allocative efficiency, and profit) and impacts (incomes, livelihood assets and equity). Several indicators were used to measure outcomes, which were different with context. The questionnaires were designed for comparison within an IP over time and across IPs. To generate counterfactuals, surveys and field observations were conducted in the comparison sites and villages assigned to conventional and non-MICROVEG-non-conventional treatments. Key players in the innovation systems—such as public and private agricultural researchers, extension workers, farmer leaders, traders, dealers, lenders and key informants—were interviewed to characterise innovation systems and establish the baseline levels in the IP sites.

Baseline survey for household and village community characteristics

Baseline surveys, observations and focus group discussions were conducted to collect data on household-level and village-community-level characteristics, and behavioural, efficiency, environmental and welfare outcomes. Surveys were used to track feedback, information diffusion, awareness and knowledge changes, adoption, and market effects of innovations and spillovers, using the Miguel and Kremer (2004) approach and other methods.

Evaluation surveys

Follow-up evaluation surveys and qualitative assessment studies were conducted to assess the implementation process; document all the intermediate steps of the research-to-impact pathway and conditioning factors; assess participants' subjective reactions to the MICROVEG; identify subgroups experiencing greater or lesser impact than the sample as a whole; and measure changes in outcomes at the levels of the IP, household, community and market. Follow-up surveys used the same indicators as were used in the baseline surveys to measure outcomes.

Data Analysis

Assessing the impact of any intervention requires making an inference about the outcome that would have been observed had the programme participants not participated. Following Heckman et al. (1997) and Smith and Todd (2001), let Y_1 be the mean of the outcome conditional on participation, that is, treatment group, and let Y_0 be the outcome conditional on non-participation, that is control group. The impact of participation in the program is the change in the mean outcome caused by participating in the program, which is given by

$$\square Y \ \square\square Y_1 \ \square Y_0, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where □ is the notation for the impact for a given household (1)

The fundamental problem of evaluating this individual treatment effect arises because for each household, only one of the potential outcomes, either Y_1 or Y_0, can be observed, but Y_1 and Y_0 can never be observed for the same household simultaneously. This leads to a missing-data problem, which is the heart of the evaluation problem (Smith and Todd 2001). The unobservable component in equation (1), be it Y_1 or Y_0, is called the counterfactual outcome. Measuring impact as the difference in mean outcome between all households involved in the project and those not involved, even when controlling for programme characteristics, may thus give a biased estimate of programme impact. Since there will never be an opportunity to estimate individual treatment effects in (1) directly, one has to concentrate on population averages for the impacts of a treatment.

Two treatment effects are dominantly used in empirical studies. However, the most commonly used evaluation parameter is the so-called average impact of the treatment on the treated (ATT), which focuses explicitly on the effect on those for whom the programme is actually introduced. In a random programme assignment, the expected value of ATT is defined as the difference between expected outcome values with and without treatment for those who actually participated in the treatment (Heckman et al. 1998b), which is given by

$$\square Y_{ATT} \ \square\square ATT\ (\square Y|\ X{:}\ Z\ \square\square\square\square\square\square E(Y_1 \square Y_0|,\ Z\ \square\square\square\square\square\square E\ (Y_1|\ Z\ \square\square\square\square\square\square E(Y_0|\ Z = 1) \ \ ..(2)$$

Commented [akp1]: Seems that there are typo errors like here in this section

where Z is an indicator variable, indicating whether a household i actually received treatment or not: Zi being equal to 1 if the household is a beneficiary, and 0 otherwise. X denotes a vector of control variables.

Data on programme beneficiaries identify the mean outcome in the treated state E (Y1|X, Z=1). The mean outcome in the untreated E (Y0|X, Z=1) is not observed, and a proper substitute for it has to be chosen in order to estimate ATT.

Various quasi-experimental and non-experimental methods have been used to address the bias problem Heckman et al. (1998 a). One of the most commonly used quasi-experimental methods is propensity score matching (PSM), which selects project beneficiaries and non-beneficiaries who are as similar as possible in terms of observable characteristics expected to affect project participation as well as outcomes. The difference in outcomes between the two matched groups can be interpreted as the impact of the project on the beneficiaries (Smith and Todd 2001). We used this method to estimate the ATT for impacts of the MICROVEG on the key outcomes of the project (that is, poverty/food security, factor productivity, market participation, awareness and adoption, as well as natural resource management).

The PSM method matches project beneficiaries with comparable non-beneficiaries using a propensity score, which is the estimated probability of being included in the project. Only beneficiaries and non-beneficiaries with comparable propensity scores are used to estimate the ATT. Those who do not have comparable propensity scores are dropped from the comparison groups.

Among the advantages of PSM over econometric regression methods is that it compares only comparable observation and does not rely on parametric assumption to identify the impacts of projects. However, PSM is subject to the problem of "selection on unobservables", meaning that the beneficiary and comparison groups may differ in unobservable characteristics, even though they are matched in terms of observable characteristics (Heckman et al. 1998a). Econometric regression methods devised to address this problem suffer from the problems previously noted. The bias resulting from comparing non-comparable observations can be much larger than the bias resulting from selection on unobservables, although they could not say whether that conclusion holds in general (Heckman et al. 1998a).

In this study, we address the problem of selection on unobservables by combining PSM with the use of the double-difference (DD) estimator. The double-difference estimator compares changes in outcome measures (i.e., change from before to after the project) between project participants and non-participants, rather than simply comparing outcome levels at one point in time.

$$DD = (Y_{p1} - Y_{p0}) - (Y_{np1} - Y_{np0}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where Y_{p1} = outcome (e.g., income) of beneficiaries after the project started; Y_{p0} = outcome of beneficiaries before the project started; Y_{np1} = outcome of non-beneficiaries after the project started; and Y_{np0} = outcome of non-beneficiaries before the project started.

The advantage of the double-difference estimator is that it nets out the effects of any additive factors (whether observable or unobservable) that have fixed (time-invariant) impacts on the outcome indicator (such as the abilities of the farmers or the inherent quality of natural resources), or that reflect common trends affecting project participants and non-participants equally (such as changes in prices or weather; see Ravallion 2005).

Thus, for example, if project participants and nonparticipants are different in their asset endowments (mostly observable) or in their abilities (mostly unobservable), and if those differences have an additive and fixed effect on outcomes during the period studied, such differences will have no confounding effect on the estimated ATT.

In principle, the double-difference approach can be used to assess project impacts without using PSM, and it will produce unbiased estimates of impacts as long as these assumptions hold. However, if the project has differential impacts on people with different levels of wealth or observable characteristics, the simple double-difference estimator will produce biased estimates if participant and non-participant households differ in those characteristics (Ravallion 2005). By combining PSM with the double difference estimator, controls for differences in pre-project observable characteristics can be established. A bias could still result from the heterogeneous or time-variant impacts of the unobservable differences between participants and non-participants. For example, communities and households that had participated in projects may have different responses to MICROVEG than those in the clean environment, because of the cumulative effects of social capital developed under the previous projects, favorable or adverse experiences under the projects, or other factors. Such shortcomings are unfortunately inherent in all non-experimental methods of impact assessment (Duflo et.al. 2006). Although no solution to these potential problems is perfect, we believe the method we have used addressed these issues as well as possible in this case.

The standard errors estimated by the double-difference method may be inconsistent because of serial correlation or other causes of a lack of independence among the errors. In ordinary regression models, serial correlation can result from unobserved fixed effects, but by taking first differences, the double-difference method eliminates that source of serial correlation.

However, serial correlation still may be a problem if more than two years of panel data are used (Duflo et al. 2004). In this study, because we used only two periods, before and after the project, we do not have the concern about serial correlation among multiple periods. Another reason for the possible non-independence of the errors is clustering of the sample.

The propensity scores were computed using binary logit regression models. We estimated three probit models for three comparisons: (1) MICROVEG beneficiaries compared with all non-beneficiaries; (2) MICROVEG beneficiaries compared with conventional vegetable producers, and (3) MKICROVEG beneficiaries compared with non-beneficiaries in cash-crop communities. The dependent variable in each model is a binary variable, indicating whether the household was a beneficiary of the MICROVEG project.

The explanatory variables used in computing the propensity scores are those expected to jointly determine the probability to participate in the project and the outcome. We focused on the determinants of income and productive assets when selecting the independent variables for computing the propensity score matching.

The independent variables used in the regression are summarized in Table 3.

Table 1: Variables Used to compute Propensity Scores and their Expected Signs.

Variable	Expected Impact on Participation in MICROVEG	Why?	Expected sign on Income and Wealth	Why?
Gender of Respondent (Male=1; Female=0)	-	MICROVEG is gender friendly	-	Women are usually poorer than men
Household Size	+	Larger families could be associated with poverty or other vulnerabilities that makes participation in MICROVEG worthwhile	-	The larger the family, the poorer it is
Age of respondent	+/-	MICROVEG supports both the young and old but skewed to youths	+	Older respondents likely to be better off because of accumulation of wealth and experience over the life cycle
Level of Education of respondent(years of formal education)	+	Some project requirements need a certain level of education	+	Education increases income opportunities, such as on-farm activities
Area of farmland cultivated (ha)	+/-	MICROVEG concept encourages more area of land to be cultivated	+	More area of land enables households to earn more income and more productive assets
Agro-ecological Zone	+/-	The technologies promoted by MICROVEG in each agro-ecology motivate participation	-	Some zones closer to urban centers have more potential of membership than the remote ones

Distance to nearest water source	+	Closeness to water encourages participation since products needs water	+	Access to water increases income opportunities and reduces transaction costs
Household Depedency ratio	-	Dependants do lower the tendency to adopt new innovations	-	High level of dependants indicate high level of expenditure and lower level of wealth
Type of marriage	+	Marriage stabilises and encourages adoption	+	Married couples are likely to have more wealth
Religion	+	Religion is a social mobiliser for positive development	+-	Depends on the way religion is used in the community

Source: Data Analysis 2018

Results and Discussion

The results of the analysis are presented in this section. Descriptive statistics from the results are presented with the students t-tests for quantitative variables of the difference between the baseline and the endline.

The total sample size was 553 this was because the endline survey made use of a sample of the baseline respondents for the matching exercise. Results in table 4 shows the comparison of continuous variables between the MICROVEG and non MICROVEG farmers.

Table 2: Comparison of continuous variables between Pooled baseline and Endline in Nigeria

Variables	Number	Baseline		Endline		t-test	Status
Age (yrs)	553	44.34	0.53	37.45	0.70	-7.66***	S
Household size	553	6.79	0.16	5.89	0.17	3.79***	S
Household Working Class	553	3.26	0.11	3.31	0.14	-0.22	NS
Household dependants	553	3.52	0.10	2.58	0.09	6.95***	S
Education Level	553	8.50	0.23	10.46	0.22	6.14***	S
Dist to Water (km)	553	0.09	0.02	0.16	0.03	1.84**	S
UIV Farm size (ha)	142	0.02	0.16	0.71	0.06	11.24***	S
Rev from UIV	105	252,117.6 ($700.33)	60523.46	761884.8 ($2116.35)	75329.45	5.39***	S

Source: Endline survey data analysis 2018

The results presented in table 4 shows that there were significant improvement in the indicators of development among the participants. The project was able to reach out to educated young people who have committed greater size of land to UIV cultivation during the period in Nigeria. The table shows that the age or respondents at the endline was younger than at the baseline suggesting conscious targeting of youths in the project. Further, The size of land committed to UIV cultivation increased from an average of 0.02 ha to 0.71ha which is more than 350% increase over the lifetime of the project. Similarly, the weekly revenue obtained from UIV sales improved from about $700 to more than $2000 over the period and increase of over three times.

The key socio-demographic characteristics of UIV farmers in Benin Republic presented below (Table 3).

Table 3: Sex, age and marital status of UIV farmers

Characteristics		**2015**	**2018**
Gender (%)	Male	60.0	68.5
	Female	40.0	31.5
Age (year)	Average	42.40 (12.20)*	36.60 (11.03)
Marital status (%)	Never married	4.60	14.6
	Married living together	80.90	76.9
	Married not living together	0.00	5.4
	Widowed	0.00	2.3
	Divorced	14.50	0.8

Source: Microveg Impact data analysis, 2018. * Figures in parenthesis are standard deviation

The analysis revealed that majority of UIV farmers in Benin Republic are male with slight increase in their number (68.5 % in 2018 instead of 60 % in 2015). Farmers were younger in 2018 with an average 36.60 years old. However, majority of UIVs farmers are middle-aged in both years; highlighting the fact that the farmers are in their active and productive years. Most of the farmers are married and lived with their spouses.

The distribution of age by gender of the UIV farmers is presented in Table 5.

Table 4: Category of age of UIV farmers by gender in Benin Republic

Farmers' category of age	**2015**			**2018**		
	Male	**Female**	**All**	**Male**	**Female**	**All**
≤ 30 years (%)	26.6	15.4	22.3	38.2	19.5	32,3
31-55 years (%)	65.8	61.5	63.8	56.2	68.3	60,0
>55 years (%)	7.6	23.1	13.8	5.6	12.2	7,7
Average (year)	40.3 (10.75)*	45.6 (13.53)	42.40 (12.20)	34.9 (10.56)	40.29 (11.25)	36.60 (11.03)

Source: Microveg Impact data analysis, 2018. * Figures in parenthesis are standard deviation

Globally, female farmers are older than male with an average age of 40.29 years; implying that UIVs production is often made by older women. Majority of male and female UIVs farmers are aged from thirty one to fifty five years old.

The level of education of UIVs farmers by gender is showed on Table 7.

Table 5: Level of formal education of ILVs' farmers by gender

Education level	2015			2018		
	Male	**Female**	**All**	**Male**	**Female**	**All**
No formal Education (%)	51.00	87.00	64.6	24.7	68.3	38.5
Primary (%)	14.00	6.00	10.80	23.6	14.6	20.8
Junior Secondary (%)	19.00	8.00	14.60	23.6	12.2	20.0
Senior Secondary (%)	13.00	0.00	7.70	14.6	2.4	10.8
Tertiary (%)	4.00	0.00	2.30	13.5	2.4	10.0

Source: Microveg Impact data analysis, 2018

The result of 2018 revealed that most female ILVs' farmers had no formal education (68.3 %) while male farmers had more formal education. Majority male ILVs' farmers (23.6 %) had primary level and junior secondary level. In all, there are more literate ILVs' farmers.

The land acquisition by gender is summarized in Table 8.

Table 6: Land acquisition by gender

Land acquisition	2015		2018	
	Male	**Female**	**Male**	**Female**
Inheritance	40 (24.84)*	18 (11.18)	34 (24.64)	6 (4.35)
Gift	28 (17.39)	32 (19.87)	12 (8.70)	11 (7.97)
Purchase	3 (1.86)	5 (3.10)	19 (13.77)	6 (4.35)
Lease	5 (3.10)	1 (0.62)	31 (22.46)	19 (13.77)
Share cropper	1 (0.62)	0	0	0
Other	19 (11.80)	9 (5.59)	0	0

Source: Microveg Impact data analysis, 2018. * Figures in parenthesis are expressed in percentages

Most male obtained their farm land from inheritance (24.64 %) and leasing (22.46 %) while female got their own by leasing (13.77 %). Some male (13.77 %) purchased their farm land while very few female (4.35 %) inherited or purchased their farm land. Some female (7.97 %) obtained their farm land from donation. Either male or female practiced share cropping. Table 8 shows the location of ILVs' farm land by gender.

Table 7: Location of UIV Land by gender

Land location	2015		2018	
	Male	**Female**	**Male**	**Female**
Homestead land	0	0	38 (17.51)	9 (4.15)
Upland	79(23.58)*	51(15.22)	69 (31.80)	25 (11.52)
Wetland	79(23.58)	51(15.22)	47 (21.66)	24 (11.06)
Others	33(9.85)	42(12.53)	3 (1.38)	2 (0.92)

Source: Microveg Impact data analysis, 2018. * Figures in parenthesis are expressed in percentages

The analysis of this table indicated that farm land located in the upland and wetland belonged more to the male (31.80 % and 21.66 %, respectively) than the female (11.52 % and 11.06 %, respectively). Some male (17.51%) and very few female (4.15%) had the homestead their farm land.

Land area under vegetable cultivation

Results presented in Table 8 shows the total land area used for ILVs by gender.

Table 8: Land area used for ILV by gender in Benin Republic

Year	Land size (ha)	Total land (%)		Homestead land (%)		Up-land (%)		Wetland (%)	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
2015)	Small (< 1ha)	43.07	28.46	0	0	58.46	39.23	38.09	9.52
	Medium (1-3 ha)	10.77	9.23	0	0	1.53	0.0	21.42	9.52
	Large (>3 ha)	6.92	1.53	0	0	0.76	0.0	19.04	2.38
	Total	85.7	73.0	0	0	77.9	48.6	7.8	24.4
2018	Small (< 1ha)	50.54	22.58	67.59	30.56	53.39	27.97	66.04	32.08
	Medium (1-3 ha)	6.45	6.45	0.93	0.00	6.78	1.69	0.94	0.94
	Large (>3 ha)	12.90	1.08	0.93	0.00	9.32	0.85	0.00	0.00
	Total	69.89	30.11	69.44	30.56	69.49	30.51	66.98	33.02

Source: Microveg Impact data analysis, 2018

Table 8 revealed that there is more male ILVs' farmers (50.54 %) having total land area of less than one hectare (ha) than female (22.58 %). Only, few male (12.90 %) and very few female

(1.08 %) had more than three hectares of total farm land area. Majority male had less than one hectare in upland (53.39 %) and wetland (66.04 %). Inversely, less female had less than one hectare in upland (27.97 %) and wetland (32.08 %). Only, few male (9.32 %) and very few female (0.85%) had more than three hectares in upland area. None male and female had more than three hectares in wetland area.

Majority of male (67.59 %) and some female (30.56 %) had less than one hectare the homestead their farm land. Very few male (0.93 %) and none female had more than three hectares in homestead land.

The economic analysis of ILVs' production based on 0.5 ha is presented in Table 16 which compares labors costs, net benefit and benefit-cost ratio between various practices of ILVs' production.

Table 9: Economic analysis of UIV production (Based on 0.5 ha

Parameters	**2015**			**2018**								
	Traditional practice of inorganic fertilization			Direct beneficiaries; microdosing users without dilution			Direct beneficiaries; microdosing users with dilution			indirect beneficiaries		
	Quantity	*Unit Price*	*Amount CFA ($)*	*Quantity*	*Unit Price*	*Amount CFA ($)*	*Quantity*	*Unit Price*	*Amount CFA ($)*	*Quantity*	*Unit Price*	*Amount CFA ($)*
Seed (Kg)	7	4000	28000 **(56)**	10	4000	40000 (80)	10	4000	40000 (80)	10	4000	40000 (80)
Inorganic fertlizer (Kg)	425	300	127500 **(255)**	10	300	3000 (6)	10	300	3000 (6)	358	300	107400
Organic fertilizer (100 Kg)	150	1000	150000 **(300)**	150	1000	150000 (300)	150	1000	150000 (300)	150	1000	150000 (300)
Others cost (herbicide, insecticide, fuel, water…)	-	-	425000 **(850)**	-	-	350000 (700)	-	-	350000 (700)	-	-	350000 (700)
Labor (*Fertilizer application, land preparation, planting, weeding, irrigation,…*)	***217***	***1500***	***325000 (650)***	***300***	***1500***	***450000 (900)***	***250***	***1500***	***375000 (750)***	***217***	***1500***	***325500 (650)***
Amortization			5000 **(10)**	-	-	5000 (10)	-	-	5000 (10)	-	-	5000 (10)
Total variables costs (A)			***1060500 (2121)***			***998000 (1996)***			***923000 (1846)***			***977900 (1955.8)***
Average Yield adjusted (Kg)	2000			2855			2855			**2171**		
Price (g/F)			1500 **(3)**			1500 (3)			1500 (3)			1500 (3)
Gross product (B)			3000000 **(6000)**			4282935 (8565.87			4282935 (8565.87)			3256034 (6512.07)
Net benefit (B – A)			***1939500 (3879)***			***3284935 (6569.87)***			***3359935 (6719.87)***			***2278134 (4556.27)***
Benefit-Cost Ratio			***1.80***			***3.29***			***3.64***			***2.33***

Source: Microveg Impact data analysis, 2018 *Figures in parentheses are at $1=CFA500

The table revealed that the application of fertilizer microdosing reduced production cost and increased labor costs. The increasing in labor costs was mainly due to the application of fertilizers. Thus, the application of microdose is more demanding in labor than the traditional practice. Indeed, the cost of labor from direct application de fertilizer by microdosing ($ 900) is higher than the cost when when the fertilizer is diluted in water ($ 750). In both cases, the costs are higher than the application cost in the traditional method ($ 650).

Nevertheless, the application of the microdose results in an improvement of producers' income. Indeed, in 2015, the net profit of the production of ILVs on 0.5 ha was $ 3879.00 while the application of fertilizer microdosing enhanced when directly applied ($ 6569.87) or diluted in water ($ 6719.87). Similarly, for a producer who is not a direct recipient of MicroVeg project but living in the intervention zone, the net benefit in 2018 ($ 4556.27) was better than that of 2015.

Econometric Results

The discussion of results here is divided into two parts: (1) the factor predicting household participation in MICROVEG and (2) the impact of participation on members' outcome

Estimation Results of Propensity Scores

The importance of estimation of propensity scores is twofold: first, to estimate the ATT and, second, to obtain matched treated and non-treated observations. The results of the probit models are reported in Table 10.

Table 10: Probit Regression of MICROVEG Participation (Matched Observations).

Explanatory variables	Treated (MICROVEG)		Control (Conventional)		Control (Cash-crop)	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Educational Status	0.335***	0.166	-0.037	0.331	0.028	0.175
Household size	-0.296**	0.166**	-0.398	0.301	-0.034	0.176
Age of respondent (yrs)	0.169	0.285	-0.087	0.540	-0.225	0.315
Gender (0=male; 1=female)	0.250**	0.133	0.293	0.280	-0.014	0.142
Dist to water (km)	-0.282**	0.165	-0.007	0.034	0.045	0.156
Location (state)	0.071	0.049	-0.017	0.098	0.049	0.054
Marital Status	-0.552***	0.186	-0.761***	0.311	0.258	0.192
Res type(wealth index)	-0.004	0.004	-0.013	0.024	-0.003	0.004
Religion	-0.281***	0.084	0.466***	0.208	-0.206***	0.091
Constant	0.631	1.231	-0.048	2.539	1.603	1.364
Sample size (n)	309		309		309	
Pseudo R^2	0.081		0.134		0.025	
Prob > χ^2	34.62***		14.16**		8.54***	
Log likelihood	-196.678		-45.849		-165.829	

Source: Data Analysis (2018)

The results of the probit regression (Table 4) show that the participants in the MICROVEG would most likely be educated married female farmers with small family size, who are close to water source, not given to religious taboos. However, for conventional vegetable producers the key features are that they are monogamously married and do hold some religious taboos, while the cash crop farmers are also not given to religious taboos.. This result suggests that the MICROVEG intervention focused on married young female who are the more vulnerable groups in the study area.

These probit model results were used to compute the propensity scores that were used in the PSM estimation of ATT. Several methods are possible for selecting matching observations (Smith and Todd 2001). We used both the kernel matching method (using the normal density kernel), which uses a weighted average of “neighbors” (within a given range in terms of the propensity score) of a particular observation to compute matching observations, as well as, the nearest-neighbor method; using a weighted average improves the efficiency of the estimator (Smith and Todd, 2001). Observations outside the common range of propensity for both groups (i.e., lacking "common support") were dropped from the analysis. This requirement of common support eliminated more than half of the total number of observations, indicating that many of the observations from various strata were not comparable.

Further testing of the comparability of the selected groups was done using a "balancing test" (Dehejia and Wahba 2002), which tested for statistically significant differences in the means of the explanatory variables used in the probit models between the matched groups of the IMICROVEG participants and non-participants. In all cases, that test (balancing test) showed statistically insignificant differences in observable characteristics between the matched groups (but not between the unmatched samples), supporting the contention that the PSM ensures the comparability of the comparison groups (at least in terms of observable characteristics).

We used bootstrapping to compute the standard errors of the estimated ATT, generating robust standard errors, because the matching procedure matched control households to treatment households "with replacement" (Abadie and Imbens 2006).

Table 11 Impact of Participation in MICROVEG on UIV holdings : PSM results

Matching Method	Number of Households		ATT	t-test
	Treatment	Control		
Nearest neighbor	171	262	0.147**(0.08)	1.72
Kernel matching	171	291	0.147**(0.091)	1.61

Source: Endline survey data analysis 2018

For robustness checks of the estimated MICROVEG impact parameter, the propensity score matching method (PSM) was used. Since there is no evidence of selection bias due to unobservables as indicated by the insignificant λ in the treatment effect model, the PSM method would result in unbiased and robust impact estimates. The balancing property was selected in estimating the propensity scores. The use of the balancing property ensures that a comparison group is constructed with observable characteristics distributed equivalently across quintiles in both treatment and comparison groups (Smith and Todd, 2005) In constricting the matching estimates, the common support was imposed. Heckman et al. (1977) encouraged dropping treatment observation with weak common support as inferences can be made about causality only in the area of common support. All standard errors were bootstrapped with 50 repetitions following Smith and Todd (2005) and Dillon (2011).

Two matching methods: the nearest neighbor and Kernel matching methods were used to estimate the impact. Comparing results across different matching methods can reveal whether the estimated project effect is robust (Khandker et al 2010). PSM results presented in Table 13 support the conclusion that participation in the MICROVEG project enables households to put more land (0.15ha) into UIV cultivation more than the non-participants and hence make more income. The results also show that participation has a significant effect on area of land put into UIV cultivation.

The nearest neighbor matching method identified 262 matching households as control and concluded that MICROVEG project results in an increase of about 0.15ha (about 2.5 plots) is put into UIV cultivation more than those of non-participants. This result is corroborated by the Kernel matching method which gave similar result indicating robustness, but that the number of matching households increased to 291.

The PSM although reporting slightly lower MICROVEG impact estimates support the conclusion made by the treatment effect model that the project has made significant positive influence on the participants.

References

Adebooye, O.C., S.A. Ajayi, J. J. Baidu-Forson and J.T. Opabode (2005) Seed constraint to cultivation and productivity of African indigenous leaf vegetables. *African Journal of Biotechnology* 4 (13): 1480-1484

Adebooye, O.C and J.T. Opabode (2004). Status of conservation of the indigenous fruits and vegetables of Africa. *African Journal of Biotechnology* 3(12): 700-705.

Adebooye O.C. (2004) *Solanecio biafrae* (Olive&Heirne) C. Jeffery. In Plant Resources of Tropical Africa *(PROTA)*: Vegetables: 2: 469-471.

Adebooye, O. C.(2001) Wild plants for medicinal and culinary uses. *Sharing Innovative Experiences (TWAS/UNDP)* 2: 69-78.

Adekunle, A. A.; Ayanwale, A.B.; A.O. Fatunbi; L.O.Olarinde; O. Oladunni, S. Nokoe; J.N. Binam; A. Y. Kamara; K.N. Mamman; C. Dangbenon and A. Emechebe 2013. Unlocking Potentials for Integrated Aagricultural Research for Development in Savannah of West Africa. Forum for Agrricultural Research in Africa. Accra. Ghana. 39p

Ayanwale, Adeolu 2009. Baseline Report of FADAMA III in Osun State, Nigeria. Report submitted to the NFCDO under collaboration with IFPRI 59p

Ayanwale, Adeolu; Abdoulaye, Tahirou; Aduni Sanni, Damisa Maiyaki; Alpha Y. Kamara; Adewale, Adekunle; Oluwole Fatunbi; Ayedun Bamikole and Akinola Adebayo 2011. Baseline Report of the Sudan Savanna Zone of the Kano-Katsina-Maradi(KKM) Pilot Learning

Site (PLS) of the sub-Saharan Africa – Challenge Programme. International Institute of Tropical Agriculture (IITA), Ibadan. 83p

Ayieko, M. W., D. L. Tschirley, and M. W. Mathenge (2009). Fresh Fruit and Vegetable Consumption Pattern and Supply Chain Systems IN Urban Kenya: Implication for Policy and Investment Priorities. Egerton University.

Economic Report of Africa (2013). United Nations Economic Commission for Africa. Addis Ababa.

Niu, L., and M. Wohlgenant (2012). "A Censored Demand System Analysis of Fruits and Vegetables by Different Income Groups Using Micro Data." *Beitrag auf der Jahrestagung der AAEA* 12: 14.

Dahlia L, Kurniawan I, Anggakusuma D., Roshetko J.M. (2011). Consumer's knowledge of and preference for indigenous vegetables: a market demand and consumption behavior analysis. In: Susila, Purwoko, Roshetko, Budidarsono, Dahlia, Kartika, Luther, Midmore, Pambuyan, Palada, Puspitawati. Rahmanulloh, Raimadoya, Rauf, Reyes, Trikoesoemaningtyas, Cajilig, Kunta, and Sombatpanit (eds). *Vegetable agroforestry systems in Indonesia*. Special Publication 6b. Tokyo: World Association of Soil and Water Conservation.

Matenge S. T., van der Merwe D., De Beer H., Bosman M. J. and Kruger A. (2012). Consumers' beliefs on indigenous and traditional foods and acceptance of products made with cow pea leaves. African Journal of Agricultural Research Vol. 7(14), pp. 2243-2254. Available online at http://www.academicjournals.org/AJAR DOI: 10.5897/AJAR10.858 ISSN 1991-637X ©2012 Academic Journals.

Pollard, C. M., Daly, A. M., and Binns, C. W. (2009). Consumer perceptions of fruit and vegetables serving sizes. *Public health nutrition*, *12*(05), 637-643.

Van der Lans C., Snoek H., de Boer F. and Elings A. (2012). Vegetable chains in Kenya Production and consumption of vegetables in the Nairobi metropolis. Wageningen UR E-depot.

Avohou, H.T., Vodouhe, R.S., Dansi, A., Kpeki, B., and Bellon, M. (2012). Ethnobotanical factors influencing the Use and management of wild edible plants in agricultural environments in benin. Ethnobot. Res. Appl. *10*, 571–592.

Dansi, A., Adjatin, A., Vodouhè, R., Adéoti, K., Adoukonou-Sagbadja, H., Faladé, V., Yédomonhan, H., Akoègninou, A., and Akpagana, K. (2008). Biodiversité des légumes feuilles traditionnels consommés au Bénin. Bibl. Natl. Bénin Trois. Trimest. ISBN 978 – 99919 – 68 – 63 – 6 158p.

FAO (2011). Guidelines for Measuring Household and Individual Dietary Diversity. Rome: Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/fileadmin/.../FAO-guidelines-dietary-diversity2011.pdf.

Soro, L.C., Atchibri, L.O., Kouadio, K.K., and Kouamé, C. (2012). Evaluation de la composition nutritionnelle des légumes feuilles. J Appl Biosci *51*, 3567–3573.