Vitamin A Deficiency and Training to Farmers: Evidence from a Field Experiment in Mozambique*

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Abstract

Vitamin A deficiency is a widespread public health problem in Sub-Saharan Africa. This paper analyzes the impact of a food-based intervention to fight vitamin A deficiency using orange-fleshed sweet potato (OFSP). We conducted a randomized evaluation of OFSP-related training to female farmers in Mozambique, in which the treatment group was taught basic concepts of nutrition, and OFSP-planting and cooking skills. We found encouraging evidence of changes in behavior and attitudes towards OFSP consumption and planting, and considerable increases in nutrition-related knowledge, as well as knowledge on cooking and planting OFSP.

JEL Classification: O12, O13, O33, I15.

Keywords: Vitamin A, Orange-fleshed Sweet Potato, Mozambique, Randomized Evaluation.

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1 Introduction

Malnutrition and food insecurity continue to be widespread in all of Sub-Saharan Africa. Within these problems, vitamin A deficiency has stood out as an underlying cause of severe illness, blindness and premature death for children and women in the region. In Mozambique, where this study was conducted, vitamin A deficiency affects 69 percent of children under five and 11 percent of pregnant women according to a 2009 World Health Organization report. The leading approach to fighting vitamin A deficiency has been capsule supplementation, which has proven effective. Still, the need for capsules to be administered every 6 months, poor road access, isolated rural communities and underdeveloped health systems make this solution unlikely to be sustainable in the long-term. In this context, food fortification[1] and promoting consumption of available nutrition-rich foods have emerged as promising new trends, as documented by Allen et al. (2001).

In the current paper we analyze the outcomes of orange-fleshed sweet potato (OFSP) dissemination as a food-based approach to fight vitamin A deficiency. OFSP has been shown by Van Jaarsveld et al. (2005) and Low et al. (2007) to be effective in increasing vitamin A status. Not only is it highly rich in pro-vitamin A,[2] it is also a resilient and affordable crop, suitable for cultivation in all rural areas of Mozambique. We conducted a randomized impact evaluation of OFSP-related training to female farmers. This training was administered by VIDA,[3] a Portuguese NGO which has operated in Mozambique for two decades providing support to local communities. Our sample comprised 100 female farmers who were also the primary care-takers of pre-school children, 50 of which were subject to treatment. The treatment consisted of two stages. In the first stage group-training was provided which focused on the nutritional benefits of OFSP, along with a theoretical exposition and practical demonstrations on planting and cooking OFSP, and some vines were distributed at the end. This was then followed by a second stage, in which the main points of the previous training were revised. By exploiting this experimental design, we were able to measure the effects of the treatment over different outcomes of interest. These were collected through behavioral measures of consumption and

[1] Food fortification refers to the process of adding micronutrients to food.
[2] Pro-vitamin A is a precursor which the human body converts into vitamin A.
[3] For more detailed information see http://www.vida.org.pt/.

planting, and survey questions regarding consumption patterns, planting patterns and information. We found encouraging evidence of changes in behavior and attitudes towards OFSP-consumption and planting. In simple behavioral games – inspired by Batista and Vicente (2012)[4] – designed to proxy real life decisions, the treatment was found to increase the probability of choosing OFSP by 19-20 percent for consumption, and 23 percent for planting. Our results also showed an increase in OFSP consumption right after the treatment, but no statistical evidence on a later instance. Nevertheless, we found promising results on early stages of OFSP planting patterns for the treatment individuals. Finally, the treatment also translated into clear improvements of knowledge regarding nutrition, farming and cooking OFSP.

The present paper – as well as the ongoing project to which it refers – relates to the existing literature on the effects of malnutrition on human capital, on malnutrition mitigation strategies, and on the adoption and diffusion of agricultural technologies. Regarding malnutrition and human capital, Dasgupta and Ray (1986) formally linked the incidence of undernourishment to productivity, and therefore to unemployment and the distribution of income. On the empirical side, Strauss (1986) found evidence of a nutrition-productivity link in self-employed farmers from Sierra Leone, concluding that, for low starting calorie levels, a 10 percent increase in calorie intake would lead to a 4 percent increase in worker productivity. More recent studies have involved experimental work focusing on child-nutrition interventions. Bobonis et al. (2006), for instance, showed that delivering iron supplementation, vitamin A capsules, and deworming drugs to pre-school children substantially increased child-weight and decreased school absenteeism for the treated students. Field et al. (2009), taking a different approach, provided iodine supplements to mothers while pregnant and found a positive effect on school attendance in children born from mothers who received the treatment. Luo et al. (2012), however, showed that delivering multivitamins to students in rural China had no significant impact on test scores, despite decreasing iron deficiency levels. In an approach analogous to ours, Shi et al. (2012) addressed the issue of iron deficiency and anemia through health training to parents. This led to significant decreases in anemia rates among female children of treated parents. More closely related to our study is Low et al. (2007), who also uses OFSP to address vitamin A deficiency. Low et al. (2007) used a large

[4] Batista and Vicente (2012) use behavioral games similar in nature in a mobile banking study in order to assess the marginal willingness to save and send remittances.

scale dissemination campaign involving groups of farmers in several sessions (9 to 12) on agricultural and nutrition topics. The intervention reveled that treated farmers were more likely to cultivate OFSP two years after, and that children of treated parents had higher intakes of vitamin A than the control group. The final results of our study should confirm whether these conclusions hold in a distinct setting, with a different smaller-scale and potentially more cost-effective intervention, as our preliminary findings seem to indicate.

Finally, a few contributions regarding the adoption and diffusion of agricultural technologies are worth mentioning. Foster and Rosenzweig (1995), for instance, took advantage of the Indian Green Revolution to investigate the adoption of new seed varieties, having found that farmers uneducated in the management of new seeds were less likely to adopt new varieties, and more likely to have negative profits in the first year of adoption. Duflo et al. (2007), in a different contribution related to fertilizer adoption in Kenya, found farmers who participated in demonstration plots to be more likely to adopt the new technology. Also in Africa, Bandiera and Rasul (2006) concluded that farmers were more likely to adopt a new technology when other farmers within their network did as well.

The remainder of the paper is organized as follows. In section 2 we provide a context of Mozambique. Section 3 presents the experimental design, where we describe the treatment, sampling and assignment to treatment, measures employed, and the estimation strategy. The econometric results are displayed in section 4, where we analyze the balance tests, behavioral outcomes, consumption and planting patterns, and information outcomes. Section 5 presents the concluding remarks.

2 Context

Mozambique is a Portuguese-speaking country, located in Sub-Saharan Africa. While it is richly endowed with natural resources and has experienced impressive GDP growth in recent years, it is still considered one of the poorest countries in the world. It has a population of around 23 million, of which the vast majority (69 percent) lives in rural areas and depends primarily on subsistence agriculture. Life expectancy at birth is 52 years old for men and 53 for women, and the probability of dying under the age of 5 is of 103 per 1000 live births, according to the World Health

Organization.[5] As of 2008, 44 percent of children under 5 have been reported by the United Nations Development Programme to suffer from malnutrition. The field work for the current study was carried out in the Matutuíne district, located in the south extreme of the country near the capital, Maputo. With a population of around 37 thousand, it is characterized by low literacy rates, poor road infrastructures and underdeveloped health systems.

3 Experimental design

3.1 Treatment

The goal of the treatment was to introduce OFSP in individuals' regular diet as a way to fight vitamin A deficiency. The treatment was administered to 50 female farmers spread across 9 villages in the Matutuíne district in joint collaboration with VIDA. It involved the provision of nutrition, farming and cooking training, all related to the OFSP variety.

The first stage of the treatment consisted of a two-day group training in VIDA's facilities. All individuals assigned to the treatment group received an invitation to attend the training and transportation to the facilities was provided. The first session was administered by a nutrition-worker from a local health center who went through basic concepts of nutrition. Topics covered included diversified diets, the consequences of malnutrition, and the role of vitamin A. At this point, OFSP was introduced as a food-based approach to fight vitamin A deficiency. The second session was delivered by an expert in agronomy, who first gave a theoretical exposition on OFSP-cultivation techniques and then led a practical exercise in which the participants planted a small field of OFSP themselves. The final stage of the training consisted of a cooking-demonstration of potential uses of OFSP in daily meals, also complemented with a practical exercise. Finally, each individual in the treatment group received 8 Kg of vines of five different OFSP-varieties, together with a manual summarizing the training session for future reference.

The second stage of the treatment revised the key topics covered in the first stage. This was conducted at the individual level before the post-training survey.

[5] Source: http://www.who.int/countries/moz/en/

3.2 Sampling and assignment to treatment

The sample was taken from 9 locations in the Matutuíne district, selected on the basis of the NGO having done prior work there. In each location we gathered a group of female farmers who showed interest in participating in the study and receiving the corresponding training, conditional on them being the primary care-takers of children at pre-school age. In total, 100 people were selected, of which 50 would be randomly assigned to treatment and 50 to the control group. The 100 female-farmers were informed that two rounds of training would take place in the VIDA facilities one year apart from each other, and that only 50 random persons could participate in the first, thus constituting the treatment group. The remaining 50, who would form the control group, would be allowed to attend the second training-round one year later. After selecting the sample, we conducted the randomization at the individual level, assigning the same number of individuals to treatment and control within each location.

3.3 Measurement

All measures were taken around one week and a half after the training. These are divided in three main categories: behavioral measures of consumption and planting, consumption and planting patterns collected through survey-questions, and information measures.

The first set of measures is the result of two experiments designed to infer the adoption of OFSP in consumption and production, respectively. The consumption experiment offered a coupon to individuals of both groups, which could then be exchanged by either 1 Kg of OFSP or 1 Kg of common (not sweet) potato. Note that the average prices of 1 Kg of OFSP and 1 Kg of common potato are very similar (the common potato is 2Mts, or 0.05€, cheaper). As for the planting experiment, a second coupon was offered and the individuals were asked to decide whether they preferred 0.5 Kg of white sweet potato vines – the white sweet potato is the sweet-potato variety commonly cultivated in Mozambique – or 0.5 Kg of OFSP-vines. Again, note that white sweet potato and OFSP-vines are very closely priced.

The second group of measures concerns consumption and production patterns. These were collected through questions asked in the baseline and post-treatment surveys. Regarding consumption patterns, in both surveys we asked the respondents to report every food-item consumed by the household in the past 24 hours. As for production patterns, we recorded in the baseline survey all crops planted in the last agricultural season, while in the post-treatment survey we recorded all crops planted during the past week. These two sets of questions allowed us to measure the reported differences in consumption and production between the two survey-dates. In addition to the above, there was a subsection of consumption-related questions only present in the post-training survey, in which respondents were asked to report whether or not they had consumed OFSP in the past month and in the past week, and, if so, the corresponding quantities.

Lastly, the information measures were designed to assess knowledge regarding the topics addressed by the training. These measures are divided among the following topics: nutrition knowledge, cooking knowledge, and knowledge on planting OFSP. The nutrition questions were related to awareness of vitamin A and its importance, as well as to the consequences and prevention of vitamin A deficiency. The cooking questions asked the respondents to report all the dishes they were aware of which included OFSP as an ingredient. Finally, the planting OFSP questions focused on knowledge regarding how to choose, prepare, irrigate and harvest a field of OFSP. Each question presented a story about someone having trouble at some stage of the OFSP-cultivation process and asked the respondent to pick one out of two potential solutions for the problem, one wrong and one right.

3.4 Estimation strategy

Two main strategies were used in order to obtain estimates of the treatment effects for the different outcomes. The first one involved the use of the specification:

$$outcomes_{i,l} = a + bT_i + \varepsilon_{i,l}, \tag{1}$$

where *outcomes* are the survey-variables of interest, T is a binary variable which takes the value of 1 if the individual was assigned to the treatment group and 0 otherwise, and where i and l are individual and location indexes, respectively. The above specification was also expanded to include location and individual control variables:

$$outcomes_{i,l} = a + bT_i + cY_{i,l} + dX_i + \varepsilon_{i,l}, \tag{2}$$

where Y is a vector of location dummies and X is a vector of individual-specific characteristics. These were employed in all our outcomes of interest using OLS.

The second approach followed was a difference-in-difference regression, which was only used to estimate the treatment effects on the consumption and planting patterns (in parallel with the first specifications). The equation is as follows:

$$outcomes_{i,l,t} = a + bT_i + et + f(t * T_i) + \varepsilon_{i,l,t}, \quad (3)$$

where t is a dummy for time taking the value of 0 before the treatment and 1 after, $t * T$ is an interaction between the time and treatment dummies, and the subscript t stands for time. Once again, the model was expanded to include location and individual-specific control variables:

$$outcomes_{i,l,t} = a + bT_i + et + f(t * T_i) + cY_{i,l} + dX_i + \varepsilon_{i,l,t}, \quad (4)$$

Equations (3) and (4) were estimated using OLS.

A version of equation (4), substituting time invariant independent variables for individual fixed-effects, was also estimated:

$$outcomes_{i,l,t} = \mu_i + bT_i + et + f(t * T_i) + \varepsilon_{i,l,t}, \quad (5)$$

where μ is a dummy for each individual. All the estimations were clustered at the location level, allowing for correlation in the error term.

4 Econometric results

4.1 Balance

We begin the analysis by assessing the comparability of the treatment and control groups. We run location-specific and individual-specific balance tests on selected variables from the baseline survey, the results of which are reported in tables 2a and 2b, respectively. The aforementioned tests are conducted for both the baseline and the post-treatment samples, where 93 percent of the individuals remained from one sample to the other. Both tables report differences between the control and treatment groups, along with the control-group means. In table 2a we focus on the existence of infrastructures, market vendors, and electricity and piped-water supply at the location level. As expected, we do not find any statistically significant difference between the two groups in either sample. Table 2b displays the individual-specific results for the "basic demographics", "religion and ethnicity", "occupation", "assets and expenditures", and "baseline outcomes" categories. Concerning "basic demographics," none of the differences between groups is found to be statistically significant except for mother's years of education. Regarding "religion and ethnicity," only two variables turn out to be significantly different: belonging to the Bitonga and the Changana ethnic groups. In the "occupation" category, none of the differences between control and treatments groups are significant at the conventional significance levels. With respect to "assets and expenditures," we only find significant differences in income and ownership of ducks. Income is found to be lower in the treatment group, with the difference being significant at the 10 and 5 percent levels in the baseline and post-treatment samples, respectively. Finally, at the bottom of table 2b, we report the results of the balance tests for "baseline outcomes." These are only carried out for the variables we have available at the baseline. Looking at the consumption and production patterns before the treatment we do not see any statistically significant difference between treatment and control groups. In addition to those already discussed, we performed tests for fifty-four other baseline variables, the results of which are omitted to avoid excessive length. All the corresponding differences between groups were found to be insignificant, except for one.

To conclude, even though a few differences between the treatment and control groups have been detected, these were not completely unexpected. Given the randomization procedure that we employed and that is documented above, we are confident that such differences are due to chance.

4.2 Behavioral outcomes

This section focuses on the outcomes of two behavioral experiments involving real decisions regarding which items to consume and to plant. These are henceforth referred to as "potato experiment" and "vine experiment," in that order. In the potato experiment individuals were asked to choose between two types of potato: common potato and OFSP. In the vine experiment they were given the choice between OFSP vines and white sweet potato vines instead. All choices were recorded in the post-treatment survey. The behavioral estimations, using specifications (1) and (2), are displayed in table 3. All the dependent variables are binary, taking the value of 1 if individuals opted for OFSP in the potato experiment or for the OFSP-vine in vine experiments, and 0 for the alternative. For each outcome of interest we present three estimates of the treatment effects: including no controls, including location controls only, and including both location and individual demographic controls. Estimates of the control-group averages are displayed as well.

We begin by looking at the potato experiment in greater detail, in which individuals were faced with the choice of taking home either 1 Kg of OFSP or 1 Kg of common potato. Before moving on to the results, it is worth noting that survey-answers point towards the common potato being a superior good, as 66 percent (against 14.9 percent for OFSP) of individuals in the control group reported usually consuming common potato on special occasions, such as ceremonies or when they have an important guest, or when they have some extra money, and only 34 percent (against 38 percent for OFSP) reported consuming the common potato on a daily basis. On average, the control group reported have eaten 1.1 kg of common potato, and that they would eat more of both common potato and OFSP if they had extra money.[6] Choosing OFSP in this experiment is interpreted as evidence that the individual will actually prefer consuming the nutritionally-superior OFSP over the attractive alternative. In table 3 we observe that the treatment increased the likelihood of choosing OFSP by 19-20 percentage points. These estimates are significant at the 5 percent level.

As for the vine experiment, the decision was between acquiring 0.5 Kg of OFSP vines and 0.5 Kg of white sweet potato vines. Individuals thus faced a choice between the relatively new OFSP variety and a vine that they were already familiar with. On average both groups reported having cultivated white sweet potato at least twice in the past 2 years, while the average for OFSP was less than once in the same period. The control group reported that they could expect to have at least 3 harvests a year for both varieties. Participants were also asked to rank, in a scale of 1 to 5 (with 1 as the lower bound and 5 as the upper bound), the perceived irrigation necessary to cultivation, difficulty to preserve vines, and effort involved in cultivating vines. The answers were similar for both types of potato. On average the control group answered

[6] None of the previous statistics were significantly different across groups at conventional significance levels.

that "more or less irrigation," was necessary to cultivate white sweet potato, and "little irrigation" for OFSP. The perceived difficulty to preserved vines and the effort involved to cultivate was ranked "more or less difficult" and "more or less effort", respectively. These results hold for both types of potato varieties.[7] Looking at table 3, we observe that the treatment increased the likelihood of choosing OFSP-vines over the alternative by about 23 percentage points. All the estimates are significant at the 1 percent level and no significant changes arise when control variables are included.

We are confident that the results of both the potato and the vine experiments, in which the treatment led to a significant increase in the choice of OFSP relative to the common potato and of the OFSP-vine relative to the white sweet potato-vine, may be good proxies for future real life decisions regarding which type of potato to consume and to plant. Furthermore, these results are in line with self-reported intentions of the treatment group: all individuals reported that they intended to include OFSP in their diet, 97.6 percent said they intended to cook meals using OFSP as an ingredient, and 93 stated intentions of growing it, planting an average area of $255m^2$.

4.3 Consumption and planting patterns

Tables 4a, 4b, 4c and 5 display the econometric results regarding consumption and planting patterns. Once again estimation results are shown without controls, with location controls, and with location and individual demographic controls. The averages for the control group are presented as well. On table 4a we estimate the consumption patterns, using specifications (1), (2), (3), (4) and (5). In this case, consumption patterns concern the intakes of OFSP in the past 24 hours, reported in the baseline and post-training surveys. All the coefficients from the different estimation strategies are negative, but none of the results is statistically significant. Therefore we see no treatment effects on the 24-hour consumption of OFSP. However, the 24-hours criterion is a very restrictive one. Using post-treatment reports of OFSP consumption we analyze the consumption patterns of OFSP for the past week and the past month.

[7] None of the previous statistics were significantly different across groups at conventional significance levels.

Tables 4b and 4c display the estimates computed using specifications (1) and (2). We see no significant results of the effect of training on the reported consumption of OFSP in the past week and on the quantities consumed during the same period. However, when the time period is expanded to the past month substantially different effects arise, with positive and significant differences between reported consumption of OFSP in treatment and control groups. The effect of the treatment on consumption is a 21-24 percentage point increase, which is significant at the 1 percent level. The quantities consumed in the same period also display positive and significant differences. The effect is 31-38 percentage points higher consumption for the treatment group. These are significant at the 1 percent level for the estimations with no controls and location controls only. When demographic controls are included the effect is only significant at 10 percent, however. Regarding the above OFSP consumption results, it is worth noting that the post-treatment survey for most of the sample was conducted approximately a week and a half after the training. As a consequence, the reported intakes of OFSP in the last month generally refer to the period lasting from approximately three weeks before the training to about a week and a half after. The report of OFSP consumption in the past week therefore excludes consumption on the day of the treatment as well as in the subsequent 3-4 days. The presented results, with a positive effect on consumption in the past month but with an insignificant impact on consumption over the past week, imply that the effect of the treatment was strongest right after the training, and then faded. The insignificance of the effect on consumption over the past week, however, should not necessarily lead to the conclusion that long-run effects are insignificant as well. A plausible justification for such a result which is still consistent with a positive long-run impact could rely on the fact that a large proportion of household-consumption comes from self-production. As such, some time is needed before participants can grow their own OFSP and include it in their regular diet. It is therefore crucial to wait for the follow-up surveys before stronger conclusions can be drawn.

We now turn our attention to the production patterns of OFSP. The planting patterns are reported in table 5. The first three regressions employ specifications (1) and (2). The remaining regressions use a difference-in-difference estimation strategy – specifications (3) and (4), as well as the individual fixed-effects estimation — specification (5). As we can see from the difference-in-difference estimates, the treatment effect on the cultivation of OFSP translated to an increase 73-74 percentage points, significant at the 1 percent level. Moreover, these results are supported by the "one-difference" and fixed effects estimates, in which the relevant coefficient remains high (although not as high) and statistically significant at the 1 percent level. This appears to be evidence that many of the participants went on to cultivate OFSP, and provides some support to the above hypothesis that consumption may be expected to increase significantly again in the near-future, once enough time has passed for households to grow their own supply of OFSP.

4.4 Information

The information measures are divided in three groups: nutrition information, information on cooking OFSP, and information on planting OFSP. All information measures were collected in the post-treatment survey. The corresponding survey-questions are presented in table 1. The estimations in this section were conducted using specifications (1) and (2).

Table 6a presents the results regarding nutrition information outcomes, which refer to knowledge and awareness of vitamin A. With the exception of "heard about vitamin A", which is binary, and "considers vitamin A deficiency a problem," scaled 1 to 5, all the remaining dependent variables are ranked from 1 to 3, with 1 corresponding to not knowing the answer, 2 to providing a correct but incomplete answer, and 3 to providing a correct and complete answer. As expected, there are clear significant effects on the nutrition-knowledge outcomes. More specifically, looking at table 6a, "knowledge of who suffers most from vitamin A deficiency" increased by 0.58 points (in the scale of 1 to 3), "knowledge about importance of vitamin A" improved by 0.79-0.80 points, "knowledge on preventing vitamin A deficiency" rose by 0.96-0.97 points, and, finally, "knowledge about importance of OFSP" and "knowledge about who should consume OFSP", increased by 0.82-0.85 points and 0.93-0.98 points, respectively. All of the previous effects are significant at the 1% level. The weakest effect was on "heard about vitamin A," in which the difference between treatment and control was found to be 13-15 percentage points, and only significant at the 10 percent level. Note, however, that 81 percent of the control group had already heard of vitamin A to begin with. As for "considers Vitamin A deficiency a problem," the average response in the control group was 3, meaning they considered it a “somewhat serious” problem, while the response of the treated was on average 1.5 points higher, meaning they considered it “very severe.”

The estimation results regarding knowledge of cooking using OFSP as an ingredient are reported in table 6b, which shows that the treatment increased knowledge of OFSP-based dishes by 2.5-2.6 dishes, statistically significant at 1 the percent level.

Lastly, table 6c displays the planting knowledge outcomes. All dependent variables are binary, taking the value of 1 for correct answers and 0 otherwise. Looking at the table, results are mixed. We begin with the variables for which the treatment effect was found to be significant at the 1 percent level. Among these, “knowledge of how to prepare the field to plant OFSP” increased by 32 percentage points, “knowledge of how to harvest” increased by 31-32 percentage points and “knowledge of how to prepare the field after harvesting” improved by 30-33 percentage points. In turn, “knowledge of when to harvest” was found to be higher in the treatment group by 19-22 percentage points, but only significant at 5 percent or 10 percent, depending on the specification considered, while the estimated effect on “knowledge of how to irrigate OFSP” was a 22 percentage-point improvement, significant only when excluding demographic controls and at the 10 percent level. Finally, the treatment effects on “knowledge of where to plant OFSP” and on “knowledge of how to plant OFSP” are both insignificant at the conventional significance levels.

5 Concluding remarks

In this paper we have analyzed the results of a randomized impact evaluation of OFSP-related training as a food-based approach to fight vitamin A deficiency. Towards that end we provided group training to female farmers in Mozambique, in which they were taught basic concepts of nutrition, how to plant OFSP, and how to introduce OFSP in household meals. We found evidence of changes in behavior and attitudes towards OFSP consumption and planting, and considerable increases in knowledge associated with vitamin A, as well as with cooking and planting OFSP. We are confident that the presented results may point towards long-term adoption of OFSP in household diet, and to possible improvements in the nutritional status as a consequence.

In 2014 we intend to produce a follow-up round of studies in which we will reassess the extent of OFSP-adoption, as well as its effects on key nutrition indicators (such as anthropometric measures) of the pre-school children of mothers in our sample. We believe that both the reported and the future findings resulting from this project may provide relevant insights into the process of agricultural-technology adoption and, more importantly, to the efficacy of nutrition-related interventions. More can be done to find sustainable approaches to overcome nutrition deficiencies in Africa. We believe our work may show that providing instruction to targeted individuals can be part of such an approach.

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A Appendix

Table 1: Information survey measures

	variables	phrasing of the question	original scale
Nutrition knowledge	**heard about vitamin A**	Have you heard about vitamin A? (no/yes)	**0 to 1**
	knowledge of who suffers most from vitamin A deficiency	Who suffers most from vitamin A deficiency? (Answers ranged from not knowing to mentioning pregnant women and children)	**1 to 3**
	knowledge about importance of vitamin A	How is vitamin A important for people? (Answers ranged from not knowing to mentioning it being important for growth and development of the body/protecting the eyes/protecting against infections)	**1 to 3**
	knowledge about preventing vitamin A deficiency	What can you do to prevent vitamin A deficiency? (Answers ranged from not knowing to mentioning eating vitamin A rich foods)	**1 to 3**
	considers vitamin A deficiency a problem	Do you consider vitamin A deficiency a problem? (Answers ranged from not serious problem to very serious problem)	**1 to 5**
	knowledege about importance of OFSP	Why do you think OFSP is important? (Answers ranged from not knowing to mentioning that it is important for growth and development/that it protects against diseases)	**1 to 3**
	knowledege about who should consume OFSP	In your view who would benefit the most from eating OSFP? (Answers ranged from not knowing to mentioning pregnant women and children)	**1 to 3**
Cooking knowledge	**number of dishes with OFSP**	Please name dishes you can cook using OFSP as an ingredient.	**0 to 10**
Farming knowledge	**knowledge of where to plant OFSP**	Mr. Manuel wants to plant OFSP and he has two farms. One in flooded soil and another in dry soil. Where do you think he should plant? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowledge of how to prepare the field to plant OFSP	Mrs. Alzira wants to plant OFSP and she has two farms. One where she has always planted OFSP and another where she has not planted OFSP in the past two years. Where do you think she should plant? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowlede of how to plant OFSP	Mr. José wants to plant OFSP, but he does not know if he should plant in mounds or just bury the vine. What do you think he should do? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowledge of how to irrigate OFSP	Mr. Vitorino has planted OFSP in the past week but he does not how many times he should irrigate the vine. What do you think he should do? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowledege of when to harvest OFSP	Mrs. Maria planted OFSP, but she does not know when to harvest. When do you think she should harvest? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowledge of how to harvest OFSP	Mrs. Idalina planted OFSP and it is ready to be harvested. However, she does not know if she should leave the potatoes in the field or store them in a hole. What do you think she should do? (wrong answer or not knowing/correct answer)	**0 to 1**
	knowledge of how to prepare the field after harvesting	Mr. António harvested the OFSP and he wants to plant another crop. However, he does not know if he should leave the stover in the field or if he should clean the field. What do you think he should do? (wrong answer or not knowing/correct answer)	**0 to 1**

Table 2a: Location characteristics - differences across treatments and control; for both baseline and post-treatment samples

	baseline sample		post-treatment sample	
	control	treatment	control	treatment
complete primary school	0.780	0.000 (0.026)	0.787	-0.026 (0.044)
police	0.220	0.000 (0.026)	0.234	-0.017 (0.026)
health center	0.640	0.000 (0.027)	0.660	-0.051 (0.042)
market vendors	0.220	0.000 (0.026)	0.234	-0.017 (0.026)
electricity	0.440	-0.020 (0.042)	0.426	-0.056 (0.048)
piped water	0.220	0.000 (0.026)	0.234	-0.017 (0.026)
paved road	0.100	0.020 (0.019)	0.106	0.002 (0.011)
land road	0.460	0.000 (0.042)	0.426	-0.012 (0.051)

Note: Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2b: Individual characteristics - differences across treatment and control groups; for both baseline and post-treatment samples

		baseline sample		post-treatment sample	
		control	treatment	control	treatment
basic demographics	age	35.900	18.080 (20.725)	35.681	20.276 (21.920)
	years of education	3.160	0.280 (0.381)	3.128	0.242 (0.400)
	married	0.580	-0.020 (0.075)	0.574	-0.031 (0.082)
	separated	0.040	0.040 (0.050)	0.043	0.044 (0.054)
	single	0.340	-0.040 (0.121)	0.340	-0.036 (0.144)
	widowed	0.040	0.020 (0.055)	0.043	0.023 (0.059)
	father's education	1.620	-0.380 (0.414)	1.681	-0.572 (0.422)
	mother's education	1.060	-0,440* (0.262)	1.085	-0,520** (0.244)
religion and ethnicity	no religion	0.040	-0.020 (0.020)	0.043	-0.021 (0.020)
	zion	0.280	0.000 (0.061)	0.255	0.006 (0.064)
	other christian	0.600	0.020 (0.077)	0.617	0.013 (0.086)
	changana	0.140	-0.040 (0.031)	0.149	-0,062* (0.035)
	bitonga	0.000	0,060** (0.029)	0.000	0,065** (0.031)
	chironga	0.760	-0.100 (0.069)	0.766	-0.070 (0.085)
	chonga	0.020	-0.020 (0.021)	0.021	-0.021 (0.022)
	chopi	0.060	-0.020 (0.054)	0.064	-0.042 (0.051)
	zulu	0.020	0.020 (0.020)	0.000	0.043 (0.028)
occupation	farmer	0.780	0.000 (0.068)	0.766	0.017 (0.077)
	stays at home	0.000	0.020 (0.020)	0.000	0.021 (0.021)
	vendor	0.000	0.020 (0.020)	0.000	0.022 (0.021)
	has no job	0.020	-0.020 (0.020)	0.021	-0.021 (0.021)

Note: Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2b: Individual characteristics - differences across treatment and control groups; for both baseline and post-treatment samples (continued)

		baseline sample		post-treatment sample	
		control	treatment	control	treatment
assets and expenditures	machamba	0.940	-0.040 (0.039)	0.936	-0.023 (0.035)
	expenditures	2409.375	2055.285 (1730.974)	2452.000	2306.116 (1807.556)
	income	3357.250	-1384.015* (839.067)	3393.684	-1637434** (783.857)
	pigs	0.480	-0.060 (0.083)	0.511	-0.076 (0.084)
	cows	1.660	-1.020 (0.733)	1.340	-0.645 (0.496)
	donkey	0.340	-0.340 (0.242)	0.234	-0.234 (0.237)
	chicken	7.200	0.780 (1.920)	6.532	1.425 (1.831)
	ducks	1.580	-0,900** (0.437)	1.681	-0,942** (0.432)
	phone	1.440	-0.020 (0.140)	1.404	0.074 (0.142)
	tables	0.940	0.160 (0.196)	0.979	0.152 (0.189)
	chairs	3.460	-0.100 (0.409)	3.511	0.011 (0.427)
	bed	1.280	-0.220 (0.167)	1.319	-0.254 (0.187)
	radio	0.500	-0.040 (0.140)	0.532	-0.054 (0.144)
	tv	0.320	0.000 (0.127)	0.340	0.007 (0.131)
	bike	0.240	0.000 (0.083)	0.255	-0.016 (0.083)
	clock	0.240	0.200 (0.208)	0.255	0.201 (0.228)
	solar panel	0.300	-0.100 (0.087)	0.298	-0.080 (0.088)
baseline outcomes	consumption OFSP	0.040	-0.020 (0.037)		
	consumption common potato	0.040	0.000 (0.031)		
	planted OFSP	0.320	-0.080 (0.112)		
	planted white sweet potato	0.020	-0.020 (0.021)		

Note: Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Behavioral outcomes

dependent variable ------>		potato experiment			vine experiment		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.185**	0.188**	0.197**	0.234***	0.226***	0.225***
	standard error	(0.089)	(0.095)	(0.094)	(0.078)	(0.075)	(0.074)
mean dep. variable (control)		0.532	0.532	0.532	0.745	0.745	0.745
r-squared adjusted		0.026	0.207	0.123	0.104	0.124	0.027
number of observations		93	93	93	93	93	93
location controls		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. All dependent variable are binary, which take the value of 1 for OFSP and 0 otherwise. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4a: Consumption patterns

dependent variable ------>		consumed OFSP						
		one-difference			difference-in-difference			fixed effects
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
treatment	coefficient	-0.021	-0.023	-0.026	-0.019	-0.018	-0.017	
	standard error	(0.021)	(0.023)	(0.029)	(0.021)	(0.022)	(0.023)	
time	coefficient				-0.020	-0.020	-0.022	-0.021
	standard error				(0.037)	(0.037)	(0.036)	(-0.037)
time*treatment	coefficient				-0.001	-0.003	-0.003	0.000
	standard error				(0.031)	(0.032)	(0.033)	(0.043)
mean dep. variable (control)		0.021	0.021	0.021	0.040	0.040	0.040	0.031
r-squared adjusted		-0.000	0.015	0.005	-0.006	-0.002	0.003	0.000
number of observations		93	93	93	193	193	193	193
location controls		no	yes	yes	no	yes	yes	no
demographic controls		no	no	yes	no	no	yes	no

Note: All dependent variables are binary. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4b: Consumption patterns

dependent variable ------>		has consumed OFSP in the past week (0-1)			quantity of OFSP consumed in the past week		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	-0.000	0.010	0.021	-0.057	-0.039	-0.034
	standard error	(0.045)	(0.045)	(0.076)	(0.075)	(0.079)	(0.110)
mean dep. variable (control)		0.114	0.114	0.114	0.193	0.193	0.193
r-squared adjusted		-0.012	0.041	0.108	-0.008	0.047	0.158
number of observations		88	88	88	88	88	88
location controls		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variables quantity of OFSP consumed are expressed in Kg. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4c: Consumption patterns

dependent variable ------>		has consumed OFSP in the past month (0-1)			quantity of OFSP consumed in the past month		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.210***	0.243***	0.235**	0.315***	0.383***	0.352*
	standard error	(0.067)	(0.062)	(0.099)	(0.119)	(0.126)	(0.188)
mean dep. variable (control)		0.222	0.222	0.222	0.356	0.356	0.356
r-squared adjusted		0.007	0.073	-0.008	0.002	0.069	0.066
number of observations		89	89	89	89	89	89
location controls		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variables quantity of OFSP consumed are expressed in Kg. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Planting patterns

dependent variable ------>		planted OFSP						
		one-difference			difference-in-difference			fixed effects
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
treatment	coefficient	0.654***	0.647***	0.638***	-0.080	-0.083	-0.080	
	standard error	(0.071)	(0.075)	(0.086)	(0.113)	(0.111)	(0.119)	
time	coefficient				-0.256***	-0.256***	-0.258***	-0.277***
	standard error				(0.095)	(0.097)	(0.101)	(-0.066)
time*treatment	coefficient				0.734***	0.735***	0.734***	0.755***
	standard error				(0.129)	(0.133)	(0.135)	(0.109)
mean dep. variable (control)		0.064	0.064	0.064	0.320	0.320	0.320	0.285
r-squared adjusted		0.444	0.434	0.404	0.237	0.259	0.265	0.266
number of observations		93	93	93	193	193	193	193
location controls		no	yes	yes	no	yes	yes	no
demographic controls		no	no	yes	no	no	yes	no

Note: The dependent variable is binary. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6a: Nutrition knowledge outcomes

dependent variable ------>		heard about vitamin A (0-1)			knowledge of who suffers most from vitamin A deficiency (1-3)			knowledge about importance of vitamin A (1-3)		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
treatment	coefficient	0.148*	0.149*	0.130*	0.578***	0.579***	0.578***	0.797***	0.789***	0.796***
	standard error	(0.088)	(0.089)	(0.077)	(0.142)	(0.150)	(0.186)	(0.143)	(0.145)	(0.154)
mean dep. variable (control)		0.809	0.809	0.809	1.422	1.422	1.422	1.681	1.681	1.681
r-squared adjusted		0.042	0.038	0.096	0.161	0.159	0.163	0.179	0.167	0.166
number of observations		93	93	93	91	91	91	93	93	93
location controls		no	yes	yes	no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes	no	no	yes

Note: All regressions are OLS. Heard about vitamin A is a binnary variable. Considers vitamin A deficiency a problem ranges from 1 to 5 (1: not serious at all; 2: not serious; 3: somewhat serious; 4: serious; 5: very serious). All remaining dependent variables range from 1 to 3 (1: does not know the answer; 2: correct but incomplete answer; 3: correct and complete answer). Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6a: Nutrition knowledge outcomes (continued)

dependent variable ------>		knowledge about preventing vitamin A deficiency (1-3)			considers vitamin A deficiency a problem (1-5)			knowledege about importance of OFSP (1-3)		
		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
treatment	coefficient	0.969***	0.952***	0.965***	1.500***	1.513***	1.520***	0.820***	0.824***	0.845***
	standard error	(0.197)	(0.183)	(0.174)	(0.350)	(0.345)	(0.370)	(0.098)	(0.100)	(0.129)
mean dep. variable (control)		1.574	1.574	1.574	3.021	3.021	3.021	1.636	1.636	1.636
r-squared adjusted		0.292	0.335	0.299	0.183	0.205	0.143	0.290	0.261	0.271
number of observations		93	93	93	93	93	93	90	90	90
location controls		no	yes	yes	no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes	no	no	yes

Note: All regressions are OLS. Heard about vitamin A is a binnary variable. Considers vitamin A deficiency a problem ranges from 1 to 5 (1: not serious at all; 2: not serious; 3: somewhat serious; 4: serious; 5: very serious). All remaining dependent variables range from 1 to 3 (1: does not know the answer; 2: correct but incomplete answer; 3: correct and complete answer). Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6a: Nutrition knowledge outcomes (continued)

dependent variable ------>		knowledege about who should consume OFSP (1-3)		
		(19)	(20)	(21)
treatment	coefficient	0.942***	0.930***	0.975***
	standard error	(0.102)	(0.100)	(0.117)
mean dep. variable (control)		1.340	1.340	1.340
r-squared adjusted		0.419	0.472	0.475
number of observations		93	93	93
location controls		no	yes	yes
demographic controls		no	no	yes

Note: All regressions are OLS. Heard about vitamin A is a binnary variable. Considers vitamin A deficiency a problem ranges from 1 to 5 (1: not serious at all; 2: not serious; 3: somewhat serious; 4: serious; 5: very serious). All remaining dependent variables range from 1 to 3 (1: does not know the answer; 2: correct but incomplete answer; 3: correct and complete answer). Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6b: Cooking knowledge outcomes

dependent variable ------>		number of dishes with OFSP		
		(1)	(2)	(3)
treatment	coefficient	2.630***	2.595***	2.524***
	standard error	(0.489)	(0.529)	(0.583)
mean dep. variable (control)		1.559	1.559	1.559
r-squared adjusted		0.466	0.486	0.472
number of observations		71	71	71
location controls		no	yes	yes
demographic controls		no	no	yes

Note: All regressions are OLS. The dependent variable is number of dishes. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6c: Farming knowledge outcomes

dependent variable ------>		knowledge of where to plant OFSP			knowledge of how to prepare the field to plant OFSP			knowlede of how to plant OFSP		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
treatment	coefficient	-0.019	-0.025	-0.014	0.317***	0.321***	0.322***	-0.062	-0.060	-0.055
	standard error	(0.075)	(0.076)	(0.072)	(0.096)	(0.100)	(0.073)	(0.076)	(0.074)	(0.077)
mean dep. variable (control)		0.106	0.106	0.106	0.596	0.596	0.596	0.149	0.149	0.149
r-squared adjusted		-0.010	0.026	-0.022	0.126	0.100	0.153	-0.002	-0.033	-0.070
number of observations		93	93	93	93	93	93	93	93	93
location controls		no	yes	yes	no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes	no	no	yes

Note: All regressions are OLS. All dependent variable are binary, which take the value of 1 for a correct answer and 0 otherwise. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6c: Farming knowledge outcomes (continued)

dependent variable ------>		knowledge of how to irrigate OFSP			knowledege of when to harvest OFSP			knowledge of how to harvest OFSP		
		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
treatment	coefficient	0.217*	0.222*	0.224	0.189**	0.193*	0.222**	0.318***	0.322***	0.310***
	standard error	(0.123)	(0.125)	(0.152)	(0.096)	(0.101)	(0.101)	(0.110)	(0.117)	(0.106)
mean dep. variable (control)		0.196	0.196	0.196	0.652	0.652	0.652	0.326	0.326	0.326
r-squared adjusted		0.045	0.036	0.032	0.036	0.058	0.183	0.091	0.058	0.026
number of observations		92	92	92	90	90	90	91	91	91
location controls		no	yes	yes	no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes	no	no	yes

Note: All regressions are OLS. All dependent variable are binary, which take the value of 1 for a correct answer and 0 otherwise. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6c: Farming knowledge outcomes (continued)

dependent variable ------>		knowledge of how to prepare the field after harvesting		
		(19)	(20)	(21)
treatment	coefficient	0.304***	0.315***	0.328***
	standard error	(0.091)	(0.086)	(0.089)
mean dep. variable (control)		0.630	0.630	0.630
r-squared adjusted		0.127	0.130	0.078
number of observations		92	92	92
location controls		no	yes	yes
demographic controls		no	no	yes

Note: All regressions are OLS. All dependent variable are binary, which take the value of 1 for a correct answer and 0 otherwise. Controls are demographic and location characteristics, which include age, years of education, marital status dummies, occupation dummies, property and whether the location has police station, a health center, electricity supply, land road access and paved road access. Standard errors reported in parenthesis, these are corrected by clustering at the location level.* significant at 10%; ** significant at 5%; *** significant at 1%.

B Extra Appendix

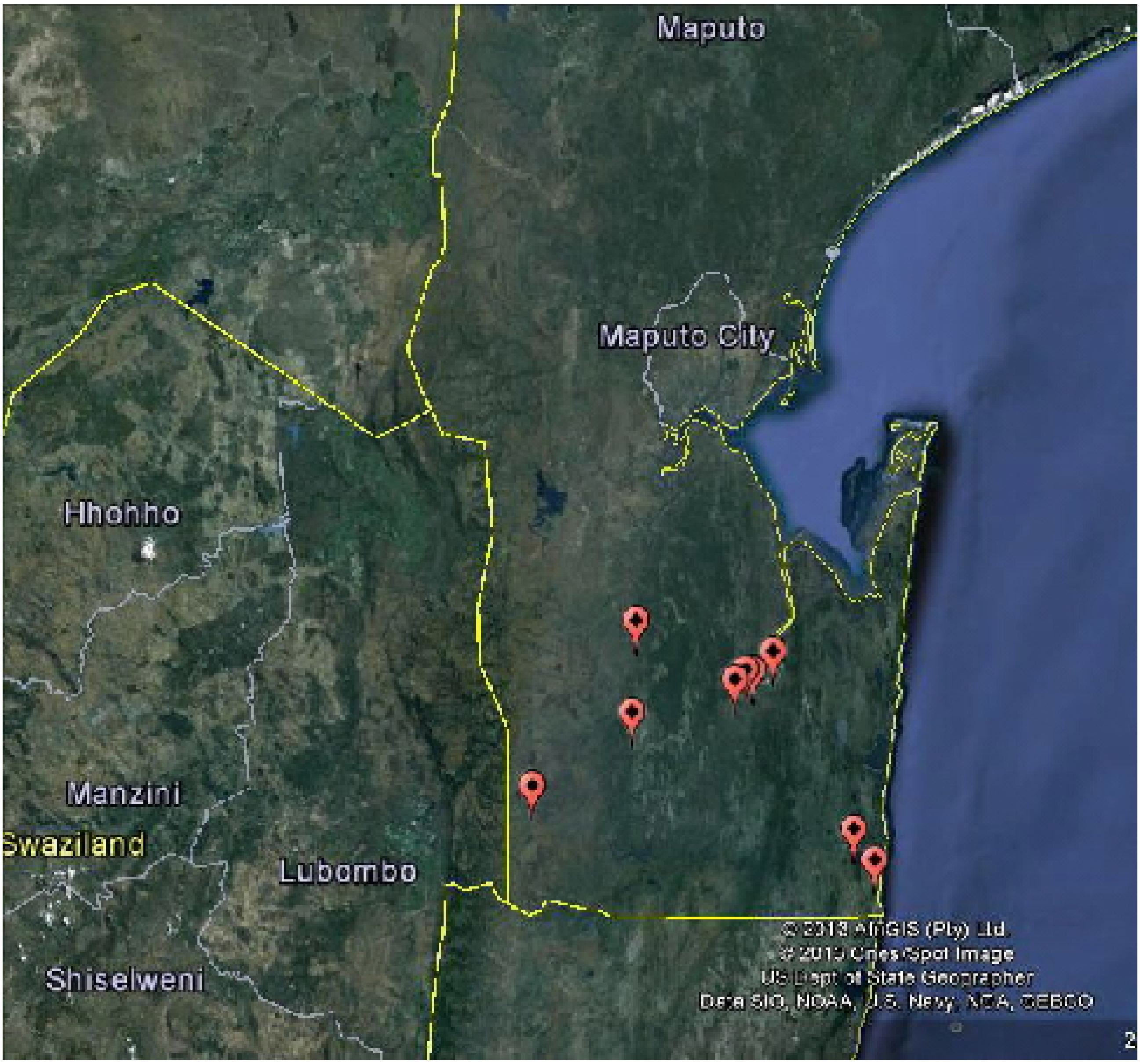

Figure 1: Map of experiment locations.