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

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April 28, 2017

Abstract

Vitamin A deficiency is a widespread public health problem in Sub-Saharan Africa. This paper analyzes the impact of an intervention fighting vitamin A deficiency through the promotion of the production and consumption of orange-fleshed sweet potato (OFSP). We conducted a randomized evaluation of OFSP-related training to female farmers in Mozambique, who were also the primary caretakers of pre-school children. The treatment consisted of group and individual-level training where basic knowledge about nutrition was taught, and planting and cooking skills related specifically to OFSP were developed. We found clear evidence of adoption of OFSP for production in the short and medium-run, but results in our measures of OFSP consumption were not significant. However, there was evidence of increased consumption of other vitamin A rich foods. With respect to anthropometric measures, the treatment led to marginally significant gains in child nutrition status one year and half after the treatment was administered, identified by improvements in height-for-age z-score. We also found considerable increases in nutrition-related knowledge, as well as knowledge about cooking and planting OFSP.

JEL Classification: O12, O13, Q16, I15.
Keywords: Vitamin A, Orange-fleshed Sweet Potato, Mozambique, Randomized Evaluation.

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* We would like to thank Filipa Zacarias, Patrícia Maridalho and the VIDA team for their cooperation and support. We are also grateful to André Moreira, Inês Vilela, Matilde Grácio and Taibo Abdulah, who contributed to make this project possible. We thank participants at CSAE-Oxford 2016 Annual Conference and INOVA/NOVAFRICA seminars for useful comments. We wish to acknowledge the financial support provided by Fundação Calouste Gulbenkian, through the project "Conhecer, produzir e nutrir: capacitação das Associações para o reforço da Segurança Alimentar no distrito de Matutuíne". Caeiro would also like to acknowledge FCT for the PhD Scholarship PD/BD/105725/2014.
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1 Introduction

Malnutrition and food insecurity continue to be widespread in all of Sub-Saharan Africa. In that region, vitamin A deficiency has stood out as an underlying cause of severe illness, blindness and premature death for children and women. In Mozambique, where this study was conducted, vitamin A deficiency affects 69 percent of children under five and 14 percent of pregnant women.[1] Vitamin A plays a key role in human growth and development, namely through contributing to a healthy immune system. The leading approach to fighting vitamin A deficiency has been capsule supplementation, but the need for capsules to be administered regularly, poor road access, isolated rural communities, and underdeveloped health-provision systems make this solution unlikely to be sustainable in the long-term. In this context, food fortification[2] and promoting consumption of available nutritive foods have emerged as promising new trends.[3]

In this paper we analyze the impact of the dissemination of orange-fleshed sweet potato (OFSP) as a food-based approach to fighting malnutrition and in particular vitamin A deficiency. OFSP is not only highly rich in pro-vitamin A,[4] it is also a resilient and affordable crop, suitable for cultivation in all rural areas of Mozambique. We conducted a randomized evaluation of OFSP-related training to female farmers. This training was administered by VIDA,[5] an international 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 caretakers of pre-school children. 49 of these women were subject to treatment. The treatment consisted of two stages. In the first stage, group-level training was provided, which focused on the nutritional needs of young children and the nutritional benefits of OFSP, along with the theory and practical aspects (including demonstrations) of planting and cooking OFSP. Some OFSP vines were also distributed at the end of this training. This was then followed by a second stage, in which the main points of the previous training were revised at the individual level.

By exploiting our experimental design, we are able to measure the effects of the treatment on different outcomes of interest. These were collected through survey questions regarding planting and consumption patterns, children anthropometric indicators, and information measures. Our results show an increase in OFSP production right after the treatment, which remained significant more than one year after the treatment, but no statistically significant results in our specific survey

[1] See WHO (2009).
[2] Food fortification refers to the process of adding micronutrients to food.
[3] See Allen and Gillespie (2001).
[4] Pro-vitamin A is a precursor, which the human body converts into vitamin A.
[5] For more detailed information see http://www.vida.org.pt/.

measures of OFSP consumption. However, we found evidence of an increase in consumption of other vitamin A rich foods, specifically of fruits rich in vitamin A. We observe that the treatment led to marginally significant gains in key a nutritional indicator for children, namely height-for-age z-score. Consistent with the increased consumption of other vitamin A rich foods and the gains in height-for-age, the treatment translated into clear improvements in knowledge about nutrition, as well as about farming and cooking OFSP.

A large body of literature has documented the detrimental long-term effects of early-childhood malnutrition on human capital accumulation and general economic outcomes (Jamison, 1986; Stifel and Alderman, 2006; Maccini and Yang, 2008). In developed countries, strategies aimed at reducing child malnutrition and improving children's diets include nutritional education (Variyam et al., 1999) and in-kind transfers, such as school lunch programs (Gleason and Suitor, 2003; Smith, 2017), and supplemental nutrition programs (Carlson and Senauer, 2003). In developing countries, most of the focus has been on a mix of in-cash and in-kind transfers, such as conditional cash transfers (Gertler, 2004), food aid (Yamano et al., 2005), and food transfers (Stifel and Alderman, 2006).

However, given the majority of people in developing countries still depend primarily on agriculture, there is large potential for agricultural interventions to improve nutrition and health outcomes (Ruel and Alderman, 2013). Agriculture is thought to affect nutrition through several possible direct and indirect channels, such as food production for the household's own consumption, income generation, and empowerment of women through increased control over resources (World Bank, 2007). Particularly in the presence of market imperfections, agricultural production may play a relevant role in food security and nutrition through food production for own consumption.

Masset et al. (2012) provide a systematic review of the effectiveness of agricultural interventions aiming to improve the nutritional status of children. The paper reviews 23 studies conducted in developing countries, focusing on food fortification, home gardens, animal sources, food promotion, among other interventions. The review found that agricultural interventions typically have a positive impact on production and consumption of the specific foods promoted, but little evidence of improvements in dietary diversity and child anthropometrics. However, the authors suggest it might be the lack of statistical power in the reviewed studies which explains the lack of results linking agricultural production and children's nutritional status, rather than the ineffectiveness of the interventions themselves. More recently, Larsen and Lilleør (2016) analyzed the impact of an agricultural intervention providing farmers with a "basket" of agricultural technologies on child anthropometrics in Tanzania. Comparing cohorts of children conceived before and after the intervention using a difference-in-difference approach, they find a positive and sizable impact on height-for-age z-score among children from participant households.

Focusing specifically on the promotion of OFSP fortified variety in Mozambique, previous studies in the public health literature have found positive effects on OFSP consumption, as well as improvements in vitamin A status in women and children (Low et al., 2007; Hotz et al., 2012) and a reduction in diarrhea prevalence among children (Jones and Brauw, 2015). However, Jones and Brauw (2015) found no improvements in children's anthropometric outcomes, although they noted this might be due to limited statistical power. Hence, the extent to which OFSP promotion can affect children anthropometrics remains an open question.

The remainder of the paper is organized as follows. In section 2 we provide details about our Mozambican context. Section 3 presents the experimental design, where we describe the treatment, sampling and assignment to treatment, measures employed, mechanisms and the estimation strategy. The econometric results are displayed in section 4, where we analyze balance, consumption and planting patterns, anthropometric outcomes, and possible mediators including informational outcomes. In Section 5 we conclude.

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 (68 percent) lives in rural areas and depends primarily on subsistence agriculture (World Bank, 2013). Life expectancy at birth is 52 years old for men and 54 for women, the mortality rate under the age of 5 is of 90 per 1000 live births,[6] and 44 percent of children under 5 suffer from malnutrition.[7]

The fieldwork for the current study was carried out in the Matutuíne district, which is mainly rural and located in the southern extreme of the country. With a population of around 37 thousand according to the INE (2007) Population Census, it is characterized by low literacy rates, poor road infrastructures and underdeveloped health services.

[6] See the report 'World Health Statistics 2014', 2014 by WHO.
[7] See the report 'Child poverty and disparities in Mozambique 2010', 2011, by UNICEF.

3 Experimental design

3.1 Treatment

The main goal of the treatment was the diffusion and adoption of the OFSP variety as a means to reduce malnutrition and food insecurity. The treatment was administered to 49 female farmers distributed across nine villages in the Matutuíne district in joint collaboration with VIDA. It involved the provision of information about nutrition, farming and cooking training, all related to the OFSP variety.

The first stage of the intervention consisted of a two-day group training in VIDA's facilities in Matutuíne district. All individuals assigned to the treatment group received an invitation to attend the training and transportation to the facilities was provided. A nutrition worker from a local health center administered the first session, which covered 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 fighting vitamin A deficiency. This session had a particular focus in young children nutritional needs: it stressed the importance of increasing the intakes of vitamin A-rich foods through the inclusion of OFSP in their diet. An expert in agronomy delivered the second session. This session offered a theoretical exposition about OFSP-cultivation techniques. It then included 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 eight kilograms 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 first post-training survey.

3.2 Sampling and assignment to treatment

The sample of individuals in our study was taken from nine villages in the Matutuíne district, selected on the basis of the NGO having done prior work there. In each village 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 caretakers of children at pre-school age. In total, 100 people were selected. We then randomly selected 49 of these individuals to receive the treatment. The remaining individuals compose the control group. Note that our randomization procedure formed blocks at the level of each village, allowing for the allocation of approximately the same number of individuals to treatment and control within each village. The 100 female farmers were informed that two rounds of training would take place in the VIDA facilities, and that only 49 random individuals could participate in the first (the treatment group in our study). The remaining 51 (the control group) would be allowed to attend a future training-round, which was set to take place in the following year. In addition to the female farmers, we also followed a sample of children, composed of all the children up to five years old in 2013 whose primary caretakers were the farmers in our sample. At the time of the baseline data collection this amounted to 134 children, 68 belonging to the control and 66 to the treatment group. After the first data collection effort, 12 new children joined the considered households (6 in the control and 6 in the treatment group), and were thus included in the sample.

3.3 Measurement

We collected data in three rounds of household surveys. The baseline survey was conducted two weeks prior to the beginning of the treatment. A post-treatment survey was conducted one week and a half after the training in order to assess the short-run effects of the treatment. The final survey round was administered approximately one year and four months after the training. Our measurement is divided in three main categories: planting and consumption patterns, anthropometric measures and information.

The first group of measures concerns production and consumption patterns. The data concerning production were collected through survey questions at the baseline, post-treatment, and endline surveys. We recorded all crops planted in the previous agricultural season for the baseline and endline surveys, while at the post-treatment survey we recorded all crops planted since the date of the training session. This survey question allowed us to measure the reported differences in production between the survey dates. In addition to the above, we included a subsection of production-related questions, only present in the endline survey, in which we recorded the number of harvested crops in the previous agricultural season. The data on consumption patterns concern questions on consumption of OFSP and other vitamin A rich foods incorporated in the endline survey only. With respect to OFSP, 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. As for the consumption of other vitamin A rich foods, the questions focused only on the consumption of the different food items in the past week, namely consumption of vitamin A rich foods from animal source (milk and eggs), from vegetable source (orange vegetables and dark green leaves), and vitamin A rich fruits. These are specific questions, focusing on short periods of time, giving an indication of whether experimental subjects consumed OFSP and other vitamin A rich foods after the intervention took place.

The anthropometric measures were collected during the baseline and endline surveys. Specifically, we measured and weighted all the pre-school children of mothers in our sample that we were able to locate at the time of the surveys. These measurements were then processed using the height-for-age z-score and weight-for-age classification system,[8] where z-scores reflect the standard deviation from the mean of the WHO reference population[10] of the same age and gender. Z-scores below -2, meaning 2 standard deviations below the mean in the reference population, constitute the most common criterion for malnutrition. In particular, children with height-for-age falling below the -2 cut-off are considered to be stunted. As for the weight-for-age z-score, when the z-score falls below the cut-off, children are considered to be underweight and undernourished. A more detailed malnutrition classification distinguishes between mild (z-score ≤-1), moderate (z-score ≤-2), and severe malnutrition (z-score ≤-3). These measures allow us to assess children's development patterns, which proxy for the nutritional and health situation of the children in our sample.

Finally, our information measures were designed to assess subjects' knowledge about the topics addressed in the training. These measures are divided between nutrition knowledge, knowledge about cooking OFSP, and knowledge about planting OFSP. The specific questions employed are shown in Table 1. The nutrition questions were related to awareness of vitamin A and its importance, as well as to the prevention and consequences 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 questions about planting OFSP focused on knowledge concerning how to choose, prepare, irrigate, and harvest a field of OFSP. Each question presented a story about someone facing problems during the cultivation process of OFSP. These questions asked the respondent to pick one out of two potential solutions for the problem, one right and one wrong. All information measures were collected in the post-treatment and endline surveys.

< Table 1 around here >

3.4 Mechanisms

[8] Biologically implausible values were excluded from the analyses, as recommended by the WHO. For some children, age in months was not available (only in years): in these cases, the z-scores were computed using the average age in months that the child would have had at the timing of data collection.
[10] The anthropometric measures were calculated using 2006 WHO Child Growth Standards (WHO 2006).

There are two main channels by which the intervention could affect nutrition outcomes. First, the most direct potential channel is food production for household consumption. If the intervention resulted in increased OFSP production it could directly increase the availability of OFSP for household consumption, thus providing greater access to nutritionally rich food. Second, since the intervention conveyed information on children's nutritional needs, and promotedn healthy diets for the targeted households, it could have contributed to improve nutrition outcomes indirectly by raising farmers' awareness of such issues, potentially leading to an increase in consumption of nutritionally rich foods other than OFSP.[11]

3.5 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:

$$Y_{i,l} = \alpha + \beta T_i + \varepsilon_{i,l}, \quad (1)$$

where *Y* represents the outcome variables of interest based on information collected in the surveys, and *T* is a binary variable which takes the value of 1 if the individual was assigned to the treatment group and 0 otherwise. i and l are individual and location subscripts, respectively. The above specification was also expanded to include location dummies and individual control variables:

$$Y_{i,l} = \alpha + \beta T_i + \gamma Z_{i,l} + \theta X_i + \varepsilon_{i,l}, \quad (2)$$

where *Z* is a vector of location dummies and *X* is a vector of individual-specific characteristics.

The second approach followed was a difference-in-difference specification, which was only used to estimate the treatment effects on the planting patterns and anthropometric outcomes (in parallel with the first specifications), due to the structure of our available data. Note that difference-in-differences, like controls, can help us in face of limited statistical power in our experiment. The equation is as follows:

[11] A third channel could also be theoretically possible, as the intervention could also increase household income, via the use of produced OFSP for sale rather than own consumption. The resulting higher income could translate into an improvement in nutrition outcomes as farmers might use the additional income to increase the quantity and/or improve the nutritional quality of their food purchases. However, this is unlikely to have been a significant channel in our case since only five individuals in the sample reported selling OFSP.

$$Y_{i,l,t} = \alpha + \beta T_i + \mu t + \delta(t * T_i) + \varepsilon_{i,l,t}, \quad (3)$$

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

$$Y_{i,l,t} = \alpha + \beta T_i + \mu t + \delta(t * T_i) + \gamma Z_{i,l} + \theta X_i + \varepsilon_{i,l,t}, \quad (4)$$

All the estimations in our paper employ OLS. We clustered standard errors, allowing for correlation in the error term, at the village level except for the estimations of the anthropometric measures (at the level of the child), which were clustered at the household level.

4 Econometric results

4.1 Balance

We begin the analysis by assessing the comparability of the treatment and control groups. We run village and individual-level balance tests on a wide range of 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 endline samples. Note that we faced some attrition, as we resurveyed 93 of the 100 individuals in the original baseline sample.[12] Both tables report differences between the control and treatment groups, along with the control-group means.

< Tables 2 around here >

In Table 2a we focus on the existence of infrastructures, market vendors, electricity, and piped-water supply at the village level. As expected given our assignment rule, we do not find any statistically significant difference between the two groups in either sample. Table 2b displays the individual-level results for basic demographics, religion and ethnicity, occupation, assets and expenditures, and basic demographics and anthropometrics for children. Concerning basic demographics, none of the differences between groups is found to be statistically significant. Regarding religion and ethnicity, only one variable turns out to be significantly different across comparison groups: belonging to the Bitonga ethnic group is more likely in the treatment group.

[12] Two individuals from the control group and five from the treatment group were not surveyed at the endline data collection.

In the occupation category, none of the differences between control and treatments groups are statistically significant at conventional levels. With respect to assets and expenditures, we only find significant differences in ownership of ducks, which are less likely to exist in the treatment group. Finally, at the bottom of Table 2b, we report the results of the balance tests for basic demographics and anthropometrics for the children in our sample. From the baseline to the endline surveys, 93 baseline children remained in the sample and 12 new children joined the sample.[14] Looking at the table, we do not see any statistically significant difference between treatment and control groups for both survey samples. 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 two.

To conclude, even though a few differences between the treatment and control groups have been detected, we are confident that such differences are due to chance, and that the randomization procedure that we employed was effective at identifying comparable groups in our study.

4.2 Planting patterns

This section focuses on the outcomes relating to planting patterns. Tables 3a, 3b, and 3c display the corresponding econometric results. For each outcome of interest we present estimates of the treatment effects employing three different specifications: including no controls, including location dummies only, and including both location dummies and individual demographic controls. Estimates of the mean for the dependent variable in the control group are displayed as well. The first three regressions of Tables 3a and 3b and all the regressions of Table 3c employ versions of specifications (1) and (2). The remaining regressions use a difference-in-difference estimation strategy, based on specifications (3) and (4).

< Tables 3 around here >

Table 3a displays the short-run results of OFSP planting patterns (based on data collected just after the intervention), while Tables 3b and 3c focus on the longer-run results (based on data collected in the final survey). As we can see from the difference-in-difference estimates in Table 3a, the treatment effect on the probability of cultivating OFSP translated to an increase in 72 percentage points right after the treatment was administered, statistically significant at the 1

[14] The attrition rate relative to the baseline was not significantly different between the treatment and control groups of children. This attrition was due to the timing of the final data collection effort, which was contemporaneous to school holidays: for that reason, some children were away from their home village visiting relatives.

percent level. However, at the endline survey, the effect of the treatment is smaller: it yields an increase in approximately 26 percentage points. Moreover, these results are supported by the estimates not employing baseline data, in which the relevant coefficients decrease slightly but remain statistically significant. It is also worth noting that reported OFSP cultivation in the control group increased substantially between the baseline and the endline survey dates: specifically, by 36 percentage points, significant at 5 percent level, which points towards significant contamination of the treatment to control individuals.

In Table 3c we display the estimates computed for the number of OFSP harvested crops reported in the endline survey. We observe that individuals in the control group have on average 0.5 harvested crops, while treated individuals report having on average 0.39-0.41 more harvested crops, significant at 10 and 5 percent level depending on whether demographic controls are included. These results appears to provide evidence that not only the treatment group went on to cultivate OFSP even when significant time after the training had passed, but also that they had on average more OFSP production than the control group.

4.3 Consumption patterns

In Tables 4 we estimate the treatment effects on consumption of OFSP and other vitamin A rich foods, using endline reports of consumption while employing specifications (1) and (2). Once again results shown correspond to specifications without controls, with location dummies, and with location dummies and individual demographic controls at the same time.

Tables 4a and 4b, show treatment effects on the consumption patterns of OFSP for the previous week and the previous month, respectively. In each table, we show results for whether OFSP was consumed and the corresponding quantities consumed.

< Tables 4 around here >

We do not find statistically significant results on the probability of OFSP consumption in the previous week or on the quantities consumed during the same period, even though point estimates are positive. When the time period is expanded to include the full previous month, similar results arise: all the coefficients from the different estimation strategies are positive, but these are not statistically significant at conventional levels.

In Table 4c we analyze the consumption patterns of other vitamin A rich foods in the previous week, namely the consumption of milk and eggs, orange vegetables and dark green leaves, and vitamin A rich fruits. As we can observe, there is no statistically significant effects of the treatment on the consumption of milk and eggs, or on orange vegetables and dark green leaves. However, when we turn our attention to vitamin A rich fruits, consumption in the previous week is found to increase by 0.19-0.21 percentage points in the treatment group. This effect is statistically significant at the 5 percent level.

Although we fail to uncover statistically significant effects in our measures of OFSP consumption and consumption of some other products, it is possible that, at least to some extent, that reflects the inherent difficulties in accurately measuring consumption through surveys. Further challenges in capturing results in our consumption survey measures arise from the fact that baseline data on consumption are not available, in addition to limited statistical power.

4.4 Anthropometric outcomes

We now turn our attention to the anthropometric measures: height-for-age and weight-for-age z-scores. These were calculated from data collected on the height and weight of the children in our sample during the baseline and endline surveys. Tables 5a and 5b report the results for these anthropometric outcomes, employing both one-difference and difference-in-difference estimation strategies, i.e., versions of specifications (1), (2), (3) and (4).

< Tables 5 around here >

As we can see from the one-difference estimates in Table 5a, the treatment led to gains in height-for-age z-score of 0.54-0.6, statistically significant at the 5 percent level. In the difference-in-difference regressions, all the coefficients from the different estimation strategies are in line with the one-difference estimation although slightly smaller in magnitude, but the results are only significant when controlling for location dummies and individual characteristics. This corresponds to an improvement of 0.48 in the height-for-age z-score, significant at the 10 percent level.[15] Finally, we find no statistically significant improvements in child weight-for-age z-scores, as reported in Table 5b, even though all point estimates are positive.

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[15] We also estimate the treatment effects excluding the 12 children that were not present at the baseline data collection and find similar results.

Overall, we find some significant impacts of the treatment in child nutritional status, namely in height-for-age z-score, although these were not robust to the different estimation strategies. These effects are approximately equivalent to an average height gain of 1.1 cm in the treated group. Our results are broadly in line with those of Larsen and Lilleør (2016), which found a significant impact of approximately 0.9 standard deviations in height-for-age z-score as a result of an agricultural intervention.

4.5 Information

The information measures are divided in three groups: nutrition information, information about cooking OFSP, and information about planting OFSP. All information measures were collected in the post-treatment and endline surveys. The corresponding survey-questions are presented in Table 1. The survey measures were normalized using z-scores by subtracting the mean and dividing by the standard deviation of the control group. Therefore, each variable has mean 0 and standard deviation 1 for the control group. The estimations in this section were conducted using specifications (1) and (2). These results are shown in Tables 6.

< Tables 6 around here >

Table 6a presents the results regarding nutrition information outcomes, which refer to knowledge and awareness about the importance of vitamin A. These are expressed in terms of standard deviation units. As we can see there are clear significant effects on the nutrition-knowledge outcomes in both time periods. As expected the increases in nutrition knowledge are stronger right after the treatment and decreased as time passed. More specifically, looking at the endline outcomes of Table 6a, 'knowledge of who suffers most from vitamin A deficiency' and 'knowledge about importance of vitamin A' increased by 0.57 and 0.23 respectively, 'knowledge on preventing vitamin A deficiency' rose by 0.54, 'knowledge about food containing vitamin A' improved by 0.47, and, finally, 'awareness of OFSP' and 'knowledge about importance of OFSP', increased by 0.59 and 0.38, respectively. All of the previous effects are significant at standard significance levels. As for the remaining nutrition-knowledge outcomes we found no statistically significant differences between the treatment and control group more than one year after the training. The reported improvements in nutritional information outcomes are consistent with the hypothesis that the measured improvements in child nutritional status occurred via increased consumption of nutritive foods beyond OFSP, as suggested by the statistically significant increase in consumption of vitamin A rich fruits.

The estimation results regarding knowledge about cooking using OFSP as an ingredient in the post-treatment and endline surveys are reported in Table 6b. That table shows that the treatment increased knowledge of OFSP-based dishes by 1.9 standard deviation units right after the treatment was administered and by 0.96 at the endline. These results are all statistically significant at 1 the percent level.

Finally, Table 6c displays the outcomes relating to knowledge about farming OFSP. Looking at the table, with the exception of 'knowledge of how to plant OFSP' and 'knowledge of how to prepare the field after harvesting', all results that were statistically significant at the post-treatment survey remained significant at the endline survey, although smaller in magnitude. We begin with the variables for which the treatment effect was found to remain significant in the short and longer-run at the standard significance levels. In terms of standard deviation units, 'knowledge of how to prepare the field to plant OFSP' increased by 0.40, 'knowledge of when to harvest OFSP' improved by 0.35, 'knowledge of how to harvest OFSP' was found to be higher in the treatment group by 0.56. In turn, we found no significant results in 'knowledge of how to irrigate OFSP' right after the treatment, but it increased by 0.69 standard deviation units at the endline survey. The treatment effect on 'knowledge of how to plant OFSP' and 'knowledge of how to prepare the field after harvesting' was found to be significant in the post-treatment survey, yielding between 0.57 and 0.62 respectively, but found to be insignificant in the endline survey.

5 Concluding remarks

In this paper we have analyzed the short and medium-run impacts of a randomized evaluation of OFSP-related training as a food-based approach to fight vitamin A deficiency. Towards that end, group and individual-level training was provided by an NGO to female farmers in Mozambique. In that context, farmers were taught basic concepts of nutrition, how to plant OFSP, and how to introduce OFSP in household meals. We found evidence of adoption of OFSP planting right after treatment and a year and four months after the treatment. Although there was no measurable impact on our measures of OFSP consumption at the endline survey, we found statistically significant improvements in consumption of vitamin A rich fruits. The treatment also led to marginally significant gains in anthropometric indicators of the pre-school children. Finally, we found considerable improvement in knowledge associated with vitamin A, as well as with cooking and planting OFSP. The clear positive impact on nutrition knowledge, together with the increase in consumption of vitamin A rich fruits, suggest that the main channel through which the treatment might have affected children's nutritional status is likely to have been increased awareness of child nutritional needs, translating into increased consumption of nutritionally rich foods other than OFSP.

We believe that the results from this project provide relevant insights into the process of agricultural-technology adoption and, more importantly, to the efficacy of nutrition-sensitive agriculture interventions. More can be done to find sustainable approaches to overcome nutrition deficiencies in Africa. We believe our work may show that providing information and skills to targeted individuals can be part of such an approach.

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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
	knowledge about food containing vitamin A	Please name three food items that contain vitamin A.	0 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
	awareness of OFSP	What is an OFSP? (Answers ranged from not knowing to mentioning that it is na food item important for health)	1 to 3
	knowledege about importance of OFSP	Why do you think that eating 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 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. Vítorino 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 endline samples

	baseline sample		endline sample	
	control	treatment	control	treatment
complete primary school	0.784	-0.009 (0.026)	0.796	0.000 (0.016)
police	0.216	-0.012 (0.016)	0.204	0.000 (0.016)
health center	0.647	-0.014 (0.024)	0.653	-0.017 (0.020)
market vendors	0.333	-0.027 (0.019)	0.327	-0.008 (0.019)
electricity	0.412	-0.004 (0.025)	0.408	0.001 (0.021)
piped water	0.216	-0.012 (0.016)	0.204	0.000 (0.016)
paved road	0.098	0.004 (0.006)	0.102	0.012 (0.011)
land road	0.431	0.018 (0.024)	0.449	0.028 (0.020)
river	0.765	0.011 (0.016)	0.755	0.018 (0.026)

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

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

		baseline sample		endline sample	
		control	treatment	control	treatment
basic demographics	age	35.784	-0.478 (3.259)	36.449	-0.540 (3.550)
	years of education	3.196	0.212 (0.408)	2.980	0.407 (0.402)
	married	0.588	-0.017 (0.084)	0.571	-0.026 (0.096)
	separated	0.039	0.042 (0.050)	0.041	0.027 (0.052)
	single	0.333	-0.048 (0.128)	0.347	-0.029 (0.137)
	widowed	0.039	0.022 (0.056)	0.041	0.027 (0.062)
	father's education	1.627	-0.464 (0.399)	1.510	-0.556 (0.399)
	mother's education	1.039	-0.468 (0.259)	1.041	-0.473 (0.271)
religion and ethnicity	no religion	0.040	-0.018 (0.018)	0.042	-0.017 (0.017)
	zion	0.280	0.024 (0.067)	0.292	0.025 (0.069)
	other christian	0.065	-0.022 (0.096)	0.500	-0.037 (0.091)
	changana	0.137	-0.035 (0.032)	0.143	-0.052 (0.049)
	bitonga	0.000	0.061* (0.030)	0.000	0.068* (0.033)
	chironga	0.765	-0.112 (0.074)	0.796	-0.137 (0.081)
	chonga	0.020	-0.020 (0.020)	0.020	-0.020 (0.021)
	chopi	0.059	-0.018 (0.054)	0.041	-0.018 (0.049)
	zulu	0.020	0.021 (0.020)	0.045	0.045 (0.031)
occupation	farmer	0.784	0.012 (0.070)	0.796	0.000 (0.075)
	stays at home	0.000	0.020 (0.020)	0.000	0.023 (0.023)
	vendor	0.000	0.020 (0.020)	0.000	0.023 (0.023)
	has no job	0.020	-0.020 (0.020)	0.020	-0.020 (0.021)

Note: Standard errors reported in parenthesis, these are corrected by clustering at the village 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		endline sample	
		control	treatment	control	treatment
assets and expenditures	machamba	0.941	-0.043 (0.039)	0.959	-0.050 (0.041)
	expenditures	2,407.347	2130.457 (1737.045)	2445.957	2339.757 (1981.540)
	income	3,357.250	-1384.015 (839.067)	3420.000	-1337.667 (917.863)
	pigs	0.471	-0.042 (0.068)	0.490	-0.013 (0.052)
	cows	1.647	-0.994 (0.712)	1.694	-1.080 (0.765)
	donkey	0.333	-0.333 (0.235)	0.347	-0.347 (0.249)
	chicken	7.255	0.888 (1.918)	6.918	1.332 (1.759)
	ducks	1.549	-0.855* (0.441)	1.612	-1.021* (0.525)
	phone	1.451	-0.002 (0.131)	1.388	-0.001 (0.118)
	tables	0.980	0.122 (0.165)	1.000	0.114 (0.188)
	chairs	3.549	-0.120 (0.456)	3.490	-0.240 (0.417)
	bed	1.294	-0.253 (0.155)	1.327	-0.349 (0.139)
	radio	0.510	-0.061 (0.145)	0.531	-0.076 (0.149)
	tv	0.333	-0.007 (0.120)	0.347	-0.029 (0.114)
	bike	0.235	0.010 (0.082)	0.245	0.028 (0.085)
	clock	0.235	0.193 (0.212)	0.245	0.187 (0.223)
	solar panel	0.314	-0.110 (0.088)	0.286	-0.104 (0.102)
children basic demographics and anthropometric	age months	29.456	2.953 (2.582)	45.938	4.045 (2.552)
	gender	1.603	-0.141 (0.114)	1.600	-0.092 (0.102)
	weight-for-age Z-score	-0.607	0.041 (0.329)	-0.612	0.050 (0.357)
	height-for-age Z-score	-1.429	0.149 (0.389)	-1.408	0.081 (0.390)
	weight	11.635	0.565 (0.467)	11.519	0.751 (0.572)
	height	83.822	2.484 (1.789)	83.044	3.511 (2.581)

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

Table 3a: Planting patterns post-treatment

dependent variable ------>		planted OFSP					
		one-difference			difference-in-difference		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.628***	0.625***	0.616***	-0.089	-0.088	-0.102
	standard error	(0.068)	(0.070)	(0.082)	(0.109)	(0.108)	(0.122)
time	coefficient				-0.254**	-0.256**	-0.256**
	standard error				(0.095)	(0.096)	(0.101)
time*treatment	coefficient				0.717***	0.722***	0.724***
	standard error				(0.110)	(0.113)	(0.118)
mean dep. variable (control)		0.060	0.060	0.060	0.314	0.314	0.314
r-squared adjusted		0.417	0.401	0.404	0.228	0.245	0.257
number of observations		98	98	98	198	198	198
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variable is binary. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3b: Planting patterns endline

dependent variable ------>		planted OFSP					
		one-difference			difference-in-difference		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.167**	0.170**	0.168**	-0.089	-0.085	-0.100
	standard error	(0.063)	(0.068)	(0.071)	(0.109)	(0.109)	(0.102)
time	coefficient				0.360***	0.360***	0.360***
	standard error				(0.115)	(0.117)	(0.120)
time*treatment	coefficient				0.257**	0.255**	0.258*
	standard error				(0.127)	(0.129)	(0.132)
mean dep. variable (control)		0.673	0.673	0.673	0.314	0.314	0.314
r-squared adjusted		0.027	0.054	0.045	0.238	0.262	0.260
number of observations		93	93	93	193	193	193
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variable is binary. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3c: Planting patterns

dependent variable ------>		OFSP harvested crop		
		(1)	(2)	(3)
treatment	coefficient	0.409*	0.392*	0.355**
	standard error	(0.221)	(0.225)	(0.149)
mean dep. variable (control)		0.500	0.500	0.500
r-squared adjusted		0.025	0.042	0.156
number of observations		92	92	92
location dummies		no	yes	yes
demographic controls		no	no	yes

Note: All regressions are OLS. The dependent variable ranges from 0 (no harvested crop) to 4 (4 or more harvested crop). Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4b: 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	0.062	0.059	0.075	1.097	1.069	1.137
	standard error	(0.061)	(0.061)	(0.063)	(1.104)	(1.102)	(1.048)
mean dep. variable (control)		0.143	0.143	0.143	0.551	0.551	0.551
r-squared adjusted		-0.004	0.004	0.004	0.004	0.003	-0.031
number of observations		93	93	93	93	93	93
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variable has consumed OFSP is binary. The dependent variables quantity of OFSP consumed are expressed in Kg. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4a: 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	0.079	0.076	0.078	0.061	0.056	0.077
	standard error	(0.072)	(0.074)	(0.069)	(0.276)	(0.278)	(0.264)
mean dep. variable (control)		0.083	0.083	0.083	0.323	0.323	0.323
r-squared adjusted		0.004	0.002	0.006	-0.011	-0.022	-0.044
number of observations		91	91	91	91	91	91
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. The dependent variable has consumed OFSP is binary. The dependent variables quantity of OFSP consumed are expressed in Kg. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4c: Consumption patterns

dependent variable ------>		has consumed milk and eggs in the past week (0-1)			has consumed orange vegetables and dark green leaves in the past week (0-1)			has consumed vitamin A rich fruits in the past week (0-1)		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
treatment	coefficient	-0.063	-0.059	-0.094	-0.064	-0.067	-0.060	0.187**	0.193**	0.209**
	standard error	(0.093)	(0.094)	(0.099)	(0.046)	(0.045)	(0.046)	(0.090)	(0.088)	(0.092)
mean dep. variable (control)		0.449	0.449	0.449	0.837	0.837	0.837	0.245	0.245	0.245
r-squared adjusted		-0.011	0.168	0.213	-0.004	0.043	0.033	0.029	0.058	0.118
number of observations		93	93	93	93	93	93	93	93	93
location dummies		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. The dependent variables are binary. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5a: Anthropometric outcomes

dependent variable ------>		height-for-age z-score					
		one-difference			difference-in-difference		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.604**	0.542**	0.538**	0.149	0.124	0.104
	standard error	(0.279)	(0.262)	(0.271)	(0.301)	(0.302)	(0.315)
time	coefficient				-0.064	-0.045	-0.070
	standard error				(0.210)	(0.211)	(0.204)
time*treatment	coefficient				0.456	0.436	0.476*
	standard error				(0.278)	(0.289)	(0.282)
mean dep. variable (control)		-1.494	-1.494	-1.494	-1.429	-1.429	-1.429
r-squared adjusted		0.036	0.078	0.063	0.007	0.032	0.025
number of observations		99	99	99	222	222	222
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. All dependent variable are z-scores. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the household level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5b: Anthropometric outcomes

dependent variable ------>		weight-for-age z-score					
		one-difference			difference-in-difference		
		(1)	(2)	(3)	(4)	(5)	(6)
treatment	coefficient	0.414	0.340	0.396	0.041	0.007	-0.006
	standard error	(0.317)	(0.311)	(0.289)	(0.301)	(0.299)	(0.299)
time	coefficient				0.864***	0.877***	0.831***
	standard error				(0.228)	(0.235)	(0.239)
time*treatment	coefficient				0.373	0.361	0.427
	standard error				(0.310)	(0.321)	(0.324)
mean dep. variable (control)		0.257	0.257	0.257	-0.607	-0.607	-0.607
r-squared adjusted		0.008	0.031	0.047	0.101	0.115	0.118
number of observations		102	102	102	233	233	233
location dummies		no	yes	yes	no	yes	yes
demographic controls		no	no	yes	no	no	yes

Note: All regressions are OLS. All dependent variable are z-scores. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the household level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6a: Nutrition knowledge outcomes

dependent variable		post-treatment		endline	
		(1)	(2)	(3)	(4)
heard about vitamin A	coefficient	0.392**	0.341**	0.213	0.167
	standard error	(0.174)	(0.170)	(0.156)	(0.113)
knowledge of who suffers most from vitamin A deficiency	coefficient	0.671***	0.724***	0.585**	0.571**
	standard error	(0.166)	(0.168)	(0.267)	(0.263)
knowledge about importance of vitamin A	coefficient	0.857***	0.799***	0.214*	0.232*
	standard error	(0.141)	(0.114)	(0.118)	(0.139)
knowledge about preventing vitamin A deficiency	coefficient	0.608***	0.557***	0.557**	0.539**
	standard error	(0.137)	(0.167)	(0.169)	(0.198)
knowledge about food items containing vitamin A	coefficient	1.778***	1.797***	0.454***	0.468***
	standard error	(0.242)	(0.249)	(0.145)	(0.161)
considers vitamin A deficiency a problem	coefficient	0.733***	0.713***	0.084	0.113
	standard error	(0.171)	(0.179)	(0.206)	(0.197)
awareness of OFSP	coefficient	1.001***	1.024***	0.609***	0.594**
	standard error	(0.198)	(0.172)	(0.176)	(0.235)
knowledge about importance of OFSP	coefficient	1.182***	1.163***	0.428**	0.380*
	standard error	(0.150)	(0.158)	(0.186)	(0.218)
knowledge about who should consume OFSP	coefficient	1.655***	1.658***	0.387	0.333
	standard error	(0.185)	(0.202)	(0.242)	(0.277)
location dummies and demographic controls		no	yes	no	yes

Note: All regressions are OLS. All dependent variables are z-scores. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6b: Cooking knowledge outcomes

dependent variable		post-treatment		endline	
		(1)	(2)	(3)	(4)
number of dishes with OFSP	coefficient	1.927***	1.856***	1.076***	0.963***
	standard error	(0.297)	(0.248)	(0.246)	(0.166)
location dummies and demographic controls		no	yes	no	yes

Note: All regressions are OLS. All dependent variables are z-scores. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6c: Farming knowledge outcomes

dependent variable		post-treatment		endline	
		(1)	(2)	(3)	(4)
knowledge of how to prepare the field to plant OFSP	coefficient	0.675***	0.718***	0.407**	0.400**
	standard error	(0.191)	(0.120)	(0.176)	(0.161)
knowledge of how to plant OFSP	coefficient	0.556***	0.573***	-0.244	-0.126
	standard error	(0.110)	(0.114)	(0.321)	(0.295)
knowledge of how to irrigate OFSP	coefficient	0.184	0.216	0.521***	0.693***
	standard error	(0.169)	(0.207)	(0.154)	(0.196)
knowledge of when to harvest OFSP	coefficient	0.368**	0.406**	0.345*	0.348**
	standard error	(0.179)	(0.158)	(0.158)	(0.149)
knowledge of how to harvest OFSP	coefficient	0.600***	0.555***	0.627**	0.595*
	standard error	(0.199)	(0.178)	(0.257)	(0.283)
knowledge of how to prepare the field after harvesting	coefficient	0.591***	0.621***	0.093	0.129
	standard error	(0.182)	(0.171)	(0.209)	(0.215)
location dummies and demographic controls		no	yes	no	yes

Note: All regressions are OLS. All dependent variables are z-scores. Controls are location dummies and demographic characteristics, which include age, years of education, marital status dummies, occupation dummies and farmers' association membership. Standard errors reported in parenthesis, these are corrected by clustering at the village level. * significant at 10%; ** significant at 5%; *** significant at 1%.

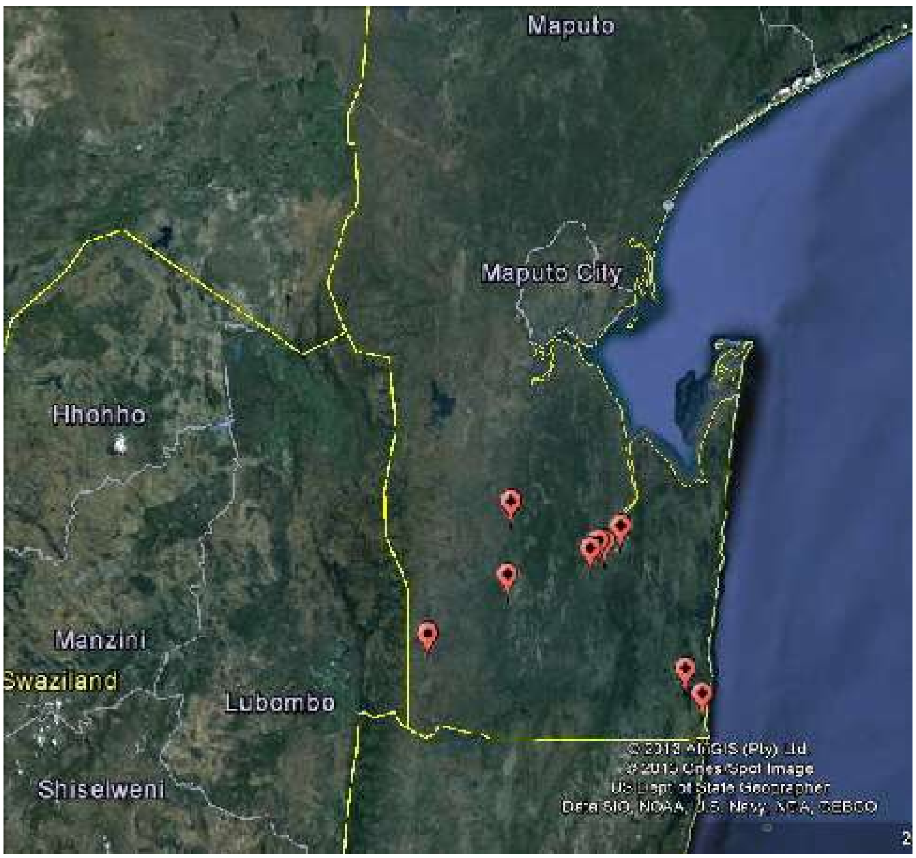

Figure 1: Map of experiment villages.