Renewable Agriculture and Food Systems: 33(2); 105–115 doi:10.1017/S1742170516000508

How promoting consumption of traditional African vegetables affects household nutrition security in Tanzania

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Accepted 21 November 2016; First published online 10 January 2017 **Research Paper**

Abstract

Traditional African vegetables have recently received considerable attention for their contribution to food and nutrition security and opportunities for enhancing smallholder livelihoods. Promoting the production and consumption of traditional vegetables is expected to enhance household nutrition among urban and rural households. The Good Seed Initiative (GSI) program promoted production and consumption of nutrient-dense traditional African vegetables in Arusha region in Tanzania to reduce malnutrition through diet diversification. We estimated the impact of promotion activities on households, women, and children's dietary diversity. The study used cross-sectional data from 258 and 242 households in intervention and control regions, respectively, and applied matching techniques and inverse probability weighting to control for unobserved heterogeneity and selection bias, which could otherwise bias the outcome estimates. We found that households benefiting from traditional vegetable promotion and demand creation activities had significantly higher dietary diversity of children under 5 yr and women in reproductive age. We found no significant impact of promotion activities on households' dietary diversity. The policy implication is that scaling up promotional and demand creation activities to encourage consumers to grow and eat traditional African vegetables would be an important element in initiatives to increase dietary diversity, particularly for children under 5 and women in Tanzania.

Key words: consumption, traditional African vegetables, nutrition, farming, children, women

Introduction

In sub-Saharan Africa, limited dietary diversity is a major challenge and cause of malnutrition in rural farming communities (Afari-Sefa et al., 2012; Thompson and Meerman, 2014). This situation persists because most households rely on carbohydrate-rich staples; only small quantities of animal products, fruit and vegetables are consumed, and thus diets lack the spectrum of nutrients needed for health. Although Tanzania has made good progress in many health indicators over the past decade, the nutritional status of the population remains low (UNICEF, 2016). Women and children under 5 yr old are particularly at risk of poor health, and are susceptible to infectious diseases such as diarrhea and respiratory infections that inhibit nutrient absorption and decrease appetite (Ivers and Cullen, 2011). Currently, in Tanzania, malnutrition affects about 34.7% of children under 5, and 5.5% of women 15–49 yr of age are considered to be underweight (TNNS, 2014).

Malnutrition is high among most rural and urban households in Tanzania, particularly in the low-income group, which consumes a diet of mainly carbohydrate-rich staples with low minerals and vitamins (Leach and Kilama, 2009). Agriculture is the primary source of livelihood for most households in Tanzania with the maize-based production system being pre-dominant in the Arusha region. Maize is a major staple food, providing over 40% of household calories (Cochrane and D'Souza, 2015) and usually intercropped with beans, cowpeas, pigeonpea and traditional vegetables, etc. Estimated maize consumption in grams per person is 240 g day^{-1}

person^{-1} (7.19 kg month^{-1}) in Tanzania (Cochrane and D'Souza, 2015). Dietary diversity is still low because most households depend on maize-based diet with limited consumption of meat and vegetables that provide the most required vitamins to meet daily food nutrient requirements. Moreover, starchy staples mainly cereals, provide more than 70% of the calorie intake of rural households in Tanzania with limited consumption of fruits and vegetables (Ecker et al., 2010). Dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, including traditional vegetables, and is also a proxy for nutrient adequacy of the diet of individuals (Kennedy et al., 2010). Diversifying diets with traditional African vegetables is a sustainable way to supply a range of nutrients to the human body while combating micronutrient malnutrition and associated health problems, particularly for poor urban and rural households. Traditional vegetables are a vitally important source of micronutrients, fiber, vitamins and minerals and are essential components of a balanced and healthy diet. In addition, traditional vegetables are better adapted to the environment than standard vegetables, and thus can provide low-cost quality nutrition to a large population segment (Chweya and Eyzaguirre, 1999).

Vegetables and particularly, traditional vegetables, are rich in micronutrients and other health-promoting phytochemicals. These nutrient-dense vegetables complement staple foods and improve the nutritional quality of diets (Ojiewo et al., 2013a). Integrating a diversity of micronutrient-rich foods such as vegetables, fruit and some animal products into diets has been found to be one of the easiest and most sustainable ways to stop micronutrient deficiency (Ali and Tsou, 1997). These vegetables have high levels of minerals, especially calcium, iron and phosphorus, vitamins A and C and proteins (Nesamvuni et al., 2001), which are important to vulnerable groups such as pregnant and nursing mothers. Traditional vegetables often require little space and can thus maximize scarce water supplies and soil nutrients better than crops such as maize, which need a lot of water and fertilizer (Tenkouano, 2011). Spider plant (*Chlorophytum comosum*), Roselle (*Hibiscus sabdariffa*) and Hair lettuce (*Lactuca sativa*) are excellent sources of iron (Weinberger and Msuya, 2004) while African nightshade (*Solanum nigrum*), jute mallow (*Corchorus olitorius*) and moringa (*Moringa oleifera*) are substantive sources of provitamin A (Muchiri, 2004). Farmers are more likely to produce traditional vegetables compared with other crops when they are aware of their nutritional and health benefits (Afari-Sefa et al., 2016).

The existing demand for vegetables, particularly traditional vegetables, is very low and that this is largely a problem of low consumer awareness. Demand creation activities such as promotion campaigns through road, cook shows, nutritional awareness and educational programs in hospitals, schools and markets are widely used in Africa to increase consumption of traditional vegetables by rural and urban consumers. For example, promotional activities by selected research institutes and non-governmental organizations in East Africa have increased demand for African nightshade in urban supermarkets, groceries, retail markets and hotels (Ojiewo et al., 2013b). However, there is a lack of evidence for the impact of such campaigns. This paper contributes to filling this gap by estimating the impact of these promotion campaigns on household dietary diversity in the northern Tanzania particularly Arusha region. This evaluation will be useful to program implementers when deciding to scale up promotion activities in different regions in Tanzania and beyond. The rest of the paper is organized as follows: the 'Methods' section describes the methods employed, including a brief description of the theory of change of promotion campaign, estimation strategy, data sources and sampling techniques. 'Estimation results and discussion' section discusses the results from the empirical analysis, while the last section concludes the paper.

Methods

Theory of change of traditional African vegetable promotion program

The trend in consumption of traditional vegetables has increased among 84% of consumers in Arusha, Tanzania, while 70% of respondents were influenced by increased awareness of the potential of vegetables to improve their health and nutrition (Amaza, 2010). The activities implemented by CABI's Good Seed Initiative funded by Irish Aid are expected to contribute to a further increase in consumption of vegetables. Traditional vegetables are generally considered to be of high nutritive value, and resistant to pests, diseases and climatic extremes compared with standard vegetables. The program strategy aims to (a) enhance nutrition security for poor urban and rural populations, including farmers, by increasing their consumption of nutrient dense traditional African vegetables to complement staple-based diets; and (b) improve food and income security for poor rural farmers producing seed through the increased use of high-quality seeds of improved vegetable varieties and adoption of good agricultural practices. The program is being led by CABI, with World Vegetable Center, INADES Formation International, and the Horticultural Research and Training Institute (HORTI)-Tengeru as implementing partners. The program aims to reach a large number of consumers and growers directly and indirectly through diverse, community-focused mass media approaches (i.e., road shows, seed rallies and agricultural shows and events) to delivering information and knowledge.

Promotional and demand creation activities were done through road shows, cook shows, nutritional sensitization and awareness program campaigns in hospitals, schools, markets and villages to increase consumption of traditional vegetables by rural and urban consumers, improve diet diversity, and create demand for traditional vegetables and market incentives for producers. These activities were undertaken between June 2014 and August, 2015 in the Arusha region of Tanzania. The program distributed health and nutrition fact sheets about different vegetables to consumer households with children under 5 and women in reproductive age (15–35 yr) in English and Swahili (local language) (Fig. A1 in Appendix). These activities are expected to lead to increased awareness of the nutritional importance of traditional African vegetables, and to changes in knowledge, attitudes and behaviors related to their production and consumption. These activities have been carried out because, in other locations (i.e., some parts of Kenya and Tanzania), traditional vegetables are competing with standard vegetables in supermarkets and different market outlets (Ojiewo et al., 2013b). Therefore, it is important to understand the impact of these activities on households' nutritional well-being in the Arusha region of Tanzania and by extension to other similar agro-ecologies.

Estimation strategy

In theory, evaluating the impacts of a program, an experimental design or randomization approach is normally appropriate to obtain a comparison group to prevent selection bias. This is done by randomly allocating the intervention among eligible beneficiaries, the assignment process which itself creates comparable treatment and control groups that are statistically equivalent to one another. However, in this study, it was not possible to randomly assign consumers into intervention and control groups to prevent the underlying selection bias. In this kind of situation, an impact evaluation is often carried out using a suitable quasi-experimental approach (Baker, 2000; Caliendo and Kopeinig, 2008). Matched comparison techniques are generally considered a second-best alternative to experimental design. The majority of the literature on evaluation methodology is centered on the use of this type of evaluation, reflecting both the frequency of use of matched comparisons and the many challenges posed by having less-than-ideal comparison groups (Baker, 2000). In this case, we employed propensity score matching (PSM) (Rosenbaum and Rubin, 1983) and inverse probability of treatment weighting (IPTW) (Wooldridge, 2007), which are both non-parametric methods to estimate the impact of traditional African vegetables promotion program on dietary diversity of the households in Tanzania. These two methods have often been used in the literature to evaluate impacts of a binary treatment variable (e.g., Fischer and Qaim, 2012; Ochieng et al., 2015; Schreinemachers et al., 2016). We estimate average treatment effect on treated (ATT) which explicitly evaluate the effects on those for whom the program was actually intended. More information on PSM and IPTW can be found in Hirano and Imbens (2001), Wooldridge (2007), Caliendo and Kopeinig (2008) and Pirracchio et al. (2012).

The first step is to summarize the pre-treatment characteristics of each subject into a single index variable called propensity score, and then uses the propensity score to match similar households. This involves regressing program placement (intervention versus control households) on a set of independent farm and household characteristics that simultaneously influence program placement and outcomes. The relevant factors are presented in Table 1. Propensity score is the predicted probability of a household participating in the promotion program, conditional on confounding covariates. The propensity score were estimated using a probit model following the work of Johnston and DiNardo (2007).

The next step in the implementation of PSM method is to choose a matching estimator. Caliendo and Kopeinig (2008) indicate that a good matching estimator does not eliminate too many of the original observations from the final analysis but yield statistically equal covariate means for individuals in the intervention and control groups. The difference in outcome variables is calculated for each matched pair and then averaged over the entire sample to obtain the average treatment effect. The outcome variables in this paper are the dietary diversity of children, women and household. In this paper, we employed nearest-neighbor matching (NNM) and kernel matching (KM), two commonly used algorithms for empirical analysis (Caliendo and Kopeinig, 2008). While IPTW uses the inverse of the propensity score variable as weights in calculating the average value of the outcome variable (Wooldridge, 2007) and reduces selection bias into the promotional activities. This means that households with a low predicted probability of participating in the promotion program receive a lower weight and those with a high predicted probability receive a higher weight. Unlike PSM, it does not match intervention with non-intervention households, thus average treatment effect is the difference between their weighted averages.

Propensity scores requires that there must be a common support or overlap in the estimated propensity scores of the intervention and control households. Common support ensures that intervention and control households have similar characteristics, which we visually checked by plotting the propensity score distributions of the two groups as presented in Figure 2 and Table A1 (Appendix) in subsection 'Factors influencing program participation'. Matching propensity scores as well as weighting in IPTW, requires that the distribution of covariates in both groups be similar or balanced. Moreover, another assumption of PSM that must be fulfilled is conditional independence assumption (Rosenbaum and Rubin, 1983) which states that assignment to the promotion program depends only on observed characteristics such as farm size, age, offfarm income, satisfaction with traditional African vegetables,

Table 1. Descriptive statistics of intervention and control households in Arusha region.

Variable	Variable description	Intervention households (1)		Control households (2)		Pooled sample		Test
		Mean	SD	Mean	SD	Mean	SD	1 = 2
Gender	1 if female household head	0.22	0.42	0.23	0.42	0.23	0.42	***
Age	Age of the household head in years	46.56	14.28	42.33	12.36	44.53	13.55	**
Education	Number of years of formal education	7.14	2.92	7.75	2.62	7.43	2.79	
No. of children	Number of children ≤5 yr	0.59	0.73	0.41	0.60	0.50	0.67	***
Active household members	Number of female and male members b/w 15 and 64 yr	2.64	1.18	2.55	1.22	2.60	1.20	
No. of children b/w 6 and 14 y	Number of children b/w 6 and 14 yr old	1.12	1.09	0.98	0.97	1.05	1.04	
Satisfaction with TAVs	1 if the satisfied with consumption of TAVs	0.91	0.29	0.94	0.23	0.93	0.26	
Off-farm income	1 if household has access to off-farm income	0.60	0.49	0.78	0.41	0.69	0.46	**
Health perception of TAV	1 if aware TAVs have health benefits	0.91	0.29	0.94	0.24	0.92	0.27	
Grow vegetables	1 if household grow vegetables	0.60	0.49	0.49	0.50	0.55	0.50	**
Location	1 if the location is rural	0.79	0.40	0.34	0.48	0.58	0.49	***
HDDS	Household dietary diversity score	6.89	1.42	6.89	1.54	6.89	1.48	
WDDS	Women dietary diversity (14–35 yr)	3.88	2.34	3.30	2.35	3.60	2.36	***
CDDS	Children <5 yr dietary diversity	2.08	2.49	1.47	2.20	1.78	2.37	***
Observations		258		242		500		

Note: Asterisks denote the level of significance for a t/χ^2-test of difference in means, ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. TAV, traditional African vegetables; SD, standard deviation.

etc. (Table 1). As a result, the estimates could still be biased if there is unobserved heterogeneity (unobserved characteristics which may include but not limited to understanding ability and risk aversion of the households, etc.). We therefore, test for influence of such hidden bias by calculating Rosenbaum bounds (Rosenbaum, 2010). Rosenbaum's bounds helps to assess how robust the results are to hidden biases due to unobserved characteristics that could influence participation in promotional program. High sensitivity to hidden bias often exists when conclusions change, for the critical value of gamma (Γ) is just slightly above one while low sensitivity exists if conclusions change at large values of Γ (Rosenbaum, 2005). We estimated PSM using Psmatch2 command in STATA as proposed by Leuven and Sianesi (2003).

Dietary diversity

Dietary diversity was determined by a qualitative 24-h recall of all the different categories of foods and drinks consumed by the respondent (individual level) or any other household member (household level). The household dietary diversity score (HDDS) is meant to reflect, in snapshot form, the economic ability of a household to access a variety of foods. Individual dietary diversity scores (IDDS) aim to reflect nutrient adequacy (Kennedy et al., 2010). Measuring IDDS in different age groups has shown that an increase in an IDDS is related to increased nutrient adequacy of the diet (Kennedy et al., 2010). For the purpose of this study, we calculated children's dietary diversity score (CDDS) and women's dietary diversity score (WDDS).

The WDDS and CDDS reflect the probability of micronutrient adequacy of the diet and therefore food groups included in the score are tailored toward this purpose. They basically show the quality of the diet consumed by women (aged 15–35 yr) and children (under 5 yr). Savy et al. (2005) found out that the dietary diversity score represents the overall dietary quality of women and children in a poor rural African setting very well and can be linked easily to their nutritional status. We focus on women only as they are usually responsible for household food preparation and they are also a vulnerable group in terms of nutritional health (Keding et al., 2007). To estimate the HDDS, the questions were answered by the person responsible for food preparation for the household on the previous day, while for IDDS responses were elicited from women aged 15–35 yr. The WDDS and CDDS captured all the foods a woman consumed the previous day, both inside and outside the home.

The questionnaire captured the respondents' dietary history based on a 24-h dietary recall to obtain information about the food intake of respondents or households. Data collection for this study was undertaken in November and December 2015. Respondents were asked to recall all the foods eaten and beverages taken in the previous 24 h prior to the interview. A set of 12 food groups was used in assessing the HDDS, while nine food groups were used to compute WDDS and CDDS (Kennedy et al., 2010). This was justified, as previous research has shown that some food groups—fats and oils, sugar/honey, and spices, condiments and beverages—do not contribute to the micronutrient density of the diet. These food groups were not part of the women's and CDDSs (Kennedy et al., 2010). As part of the field survey, we did more probing for snacks eaten between main meals and special foods given to children.

Data sources and sampling

The sample for this study was based on a primary survey of farm households that consume traditional African vegetables in Arumeru and Arusha districts of Arusha region in Tanzania. Arusha region falls under the Northern highlands agro-climatic zone and experiences bimodal rainfall of 760–1200 mm per annum; usually from October to December and March to May. Most farmers in the region are small-scale and dominantly intercrop maize with beans, pigeon peas and sometimes with vegetables, particularly traditional ones. A purposive sampling technique was adopted to identify the survey area based on interaction with project partners and prominence in vegetable production and marketing. The target population was identified from a previous feedback survey carried out in the study locations in 2014 and early 2015 which targeted household with children of under 5 and women between 15 and 35 yr to get reflections of those who participated in the promotional activities. The intervention areas were those regions where the program team and partners performed promotion activities while in control areas no promotion was carried. The sample includes consumers from rural and urban areas and includes farmers, traders and urban consumers. A random sample from intervention and control areas yielded a total sample size of 500 households with children under 5 yr and women in reproductive age (15–35 yr). Out of this sample, 258 and 242 were designated as households from intervention and control regions, respectively. Households from intervention areas consisted of direct and indirect beneficiaries. Direct beneficiaries were selected randomly from those who participated in the feedback survey during promotional activities such as road shows and cook shows; this category was randomly sampled from the list of beneficiaries generated during the promotional activities. The second category was indirect beneficiaries-people who lived in the same program intervention area and received promotion information from neighbors. The *control group* had never been exposed to any of the promotional and demand creation activities introduced by project team members. While the main sampling unit of the study was the household head or spouse of the head, questions related to dietary diversity or food consumption in the household was elicited from women from 15 to 35 yr of age or to the person who was responsible for food preparation within the household. Data collection was conducted in November and December in 2015, which is a period within short rainy season for Arusha region and supply of vegetables is highly influenced by availability of water for irrigation. Therefore, November and December months are considered to have medium supply of vegetables as compared with the period of long rains usually March to May.

Estimation Results and Discussion

Descriptive statistics

Farmers need to integrate traditional vegetables into dominant staple-based farming systems to complement other sources of household income in Tanzania in order to meet the increased demand. African nightshade (*S. nigrum*), African eggplant (*Solanum aethiopicum*), amaranth, okra (*Abelmoschus esculentus*), sweet potato (*Ipomoea batatas*) and pumpkin leaves (*Cucurbita maxima*) were the most widely consumed traditional vegetables, mainly purchased from markets in the Arusha region (Fig. 1). Afari-Sefa et al. (2016) also reported similar results that amaranth is the most preferred traditional African vegetable cultivated followed by African eggplant, Ethiopian mustard and African nightshade. Traditional vegetables such as baobab leaves (*Adansonia digitate*), false sesame (*Ceratotheca sesamoides*), black jack (*Bidens pilosa*; 'Vishonanguo' in Swahili) and *Crotalaria* ('Majerea' in Swahili) were not consumed by the sampled households.

We included a number of variables hypothesized to influence participation in the promotion program. The number of children under 5 yr of age and those above 5 has been included to indicate the number of dependents, a factor that may influence household participation in the program. This is because children are the most affected in terms of nutrient deficiency in Tanzania (TNNS, 2014). The variable for active members of the household between 15 and 64 yr of age indicates household labor self-sufficiency, which has a positive influence on both vegetable production and purchase decisions. The average household size was five and four persons in intervention and control households, respectively (Table 1). The average age of the household head was 46 yr in intervention groups and 42 yr in the control group. Overall, 23% of the sampled households were headed by women. The gender of the household head is important because it influences decisions and is linked to natural, financial and labor resource access, which consequently affects the accessibility to information and dietary diversity.

Education facilitates acquisition of skills that would enable a household to have better access to human nutritional education information and may enhance understanding of the importance of increasing consumption of traditional vegetables. However, based on previous research, household heads with a higher educational status have a lower probability of consuming traditional vegetables compared with the less educated (Taruvinga

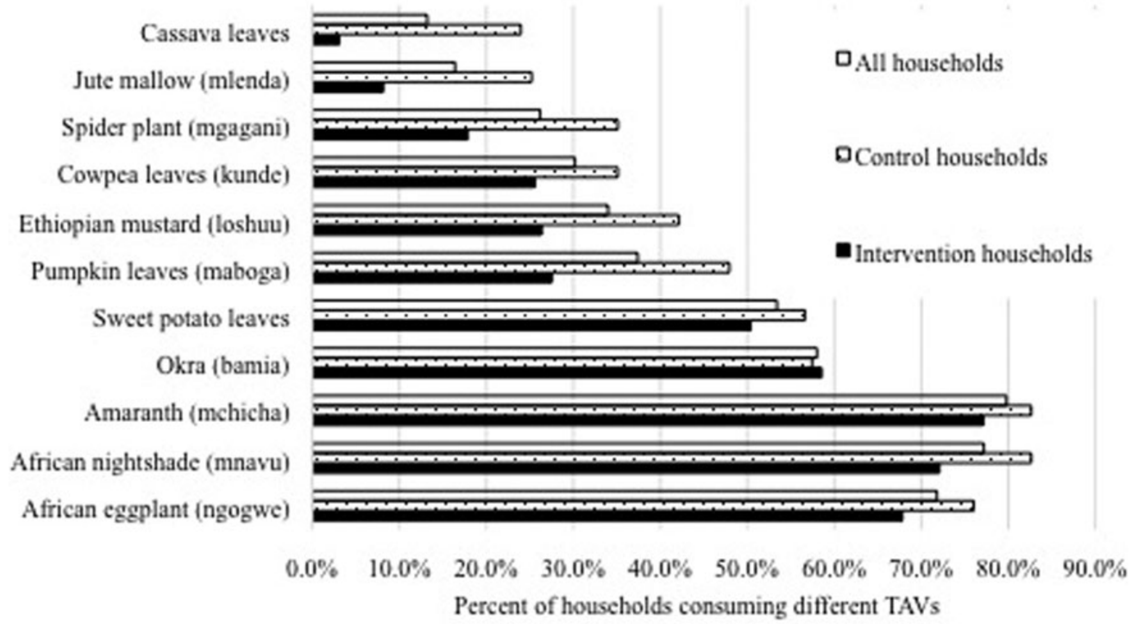

Figure 1. Percentage of households consuming traditional African vegetables (TAVs) in 7 days.

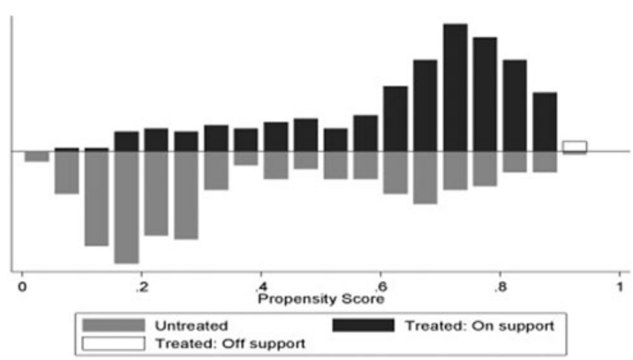

Figure 2. Distribution of estimated propensity scores and common support for the intervention and control groups.

and Nengovhela, 2015). Households growing vegetables and those living in rural areas would have a higher probability of participation in the program, as they would be expected to consume more traditional vegetables.

Factors influencing program participation

The estimation results indicated that participation in the Good Seed Initiative traditional African vegetable promotion program is strongly associated with the household's socio-economic as well as location characteristics (Table 2). The simple mean comparisons of the outcome variables between the two groups do not control for the effect of other covariates (see Table 1). In particular, the households with more numbers of children aged between 6 and 14 yr old were more likely to participate in the program, probably because this age category, children are in a much better position age-wise to consume all types of traditional vegetables. Also households with many children under 5 yr also were more likely to participate in traditional African vegetable promotion activities. Households in Tanzania have been advised to increase feeding of children on fruits and vegetables to protect children against stunting and vitamin and mineral deficiencies (UNICEF, 2010). Previously, cereals and tubers such as Irish potatoes have been the most common child-weaning foods across sub-Saharan Africa (Sawadogo et al., 2010). Households located in rural areas were more likely to participate in the program. This is consistent with the results that rural populations often have positive perceptions of traditional vegetables and have a higher propensity to consume them than urban consumers (Johns and Sthapit, 2004).

Impact of promotion program

The probit model to calculate individual propensity scores was used to match intervention households that benefited from promotional activities and control households (Table 2). The procedure revealed the underlying causal effects of participating in promotions on household food and nutrition security. As is typically the case, PSM controls for all confounding factors that correlate with both dietary diversity and program participation. Before assessing the impacts of participation, we tested the quality of matches to check for the fulfillment of common support conditions, and to ensure that the balancing requirement of PSM is satisfied. The density distribution of estimated propensity scores for the two groups of farmers is presented in Figure 2. The propensity score distributions of the intervention and control farmers indicate that there

Table 2. Factors influencing consumers' participation in the Good Seed Initiative traditional African vegetable promotion program.

Variables	Coefficient	SE	Marginal effect
Gender	0.196	0.165	0.078
Age	0.008	0.006	0.003
Education	−0.041	0.026	−0.016
No. of children ≤5 yr	0.187*	0.101	0.075
Active household members	0.028	0.056	0.011
No. of children b/w 6 and 14 yr	0.129**	0.064	0.052
Satisfaction with TAVs	−0.328	0.273	−0.128
Off-farm income	−0.252*	0.145	−0.100
Health perception of TAV	0.274	0.266	0.108
Grow vegetables	0.314**	0.134	0.125
Location	1.296***	0.134	0.482
Constant	−0.044	0.508	
LR $\chi^2(11)$	135.410		
Prob > χ^2	0.000		
Pseudo R^2	0.207		
Log-likelihood	−259.191		

Note: Asterisks denote the level of significance, ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. TAV, traditional African vegetables; SE, standard error.

might be a lack of overlap at the left- and right-hand side of the distributions. We therefore tested if the average treatment effects are sensitive to dropping observations outside the common support in subsection 'Dietary diversity'. We further plotted the density plots for the matched sample, which are nearly indistinguishable, implying that matching on the estimated propensity score balanced the covariates (Fig. A2 in Appendix).

We further carried out several tests including a balancing test based on KM for all the covariates (Table A1 in Appendix). Intervention and control households had statistically similar characteristics after matching in contrast to the unmatched sample. In particular, the test for equality of the two group means shows that there was no statistically significant difference between intervention and control households after matching. Moreover, the standardized differences (% bias) for the mean values of all covariates after matching are below 20% (Table A1 in Appendix). Based on Rosenbaum and Rubin (1985), matching is regarded as successful if it results into bias less than 20% for all covariates.

The outcome impacts are estimated using alternative matching estimators to ensure robustness (Table 3). All the matching estimators yielded similar results and show that participating in the program had a positive and significant effect on children's dietary diversity (CDDS) and women's dietary diversity (WDDS). However, the promotional program seemingly did not favor the whole household dietary diversity (HDDS), first because the household heads gave priority to young women (15–35 yr) and children under 5 yr old with regard to household nutrition. Secondly, another possible reason could be that during pregnancy women get an opportunity to interact with health specialists as they attend clinics for prenatal care where they receive advice about the importance of eating balanced diets in human nutrition. It is a standard responsibility of women to provide food for under-five children as well as the advice they receive from clinics as they take their children for regular checkup as well. According to Becker and Ichino (2002), a combination of matching approaches is adequate to reach a reliable conclusion on the relative effect of an intervention. The underlying results from our study thus offer useful insights and recommendations for the Good Seed Initiative project implementers, other development partners, and policy makers on how best to scale up promotional activities to improve diet diversity for rural and urban households while also creating demand for traditional vegetables and market incentives for producers. This is important, particularly for children below 5 yr, women who are usually vulnerable in terms of nutrition, and whose health would benefit from traditional African vegetable consumption. Our results are thus consistent with those of several authors on the need to increase fruit and vegetable consumption to increase a household's opportunities to achieve a properly balanced diet (Keatinge et al., 2011; Afari-Sefa et al., 2012).

Robustness checks

We carried out additional analyses to test the robustness of our estimated results with respect to possible hidden bias and sample size challenges in PSM estimation. PSM does control for selection bias in impact/outcome assessment that is caused by observed heterogeneity between intervention and control groups. Despite using a broad set of household socio-economic factors to calculate the propensity scores (Table 2), it is still possible that there were unobserved factors that could be jointly correlated with the decision to participate in the promotional program, and with household nutritional status. This kind of unobserved heterogeneity could bias the estimated effects. To test the robustness of the results, we calculated Rosenbaum bounds sensitivity analysis for hidden bias (Rosenbaum, 2005). Rosenbaum bounds show the critical values of gamma (Γ) at which the estimated impact can be questioned. It measures how large the difference in unobserved factors influencing the decision to participate would have to render the estimated impact insignificant.

The test for the significant impact on CDDS gave values ranging from 1.15 to 1.90. The critical values of gamma (Γ) are presented in the second last column of Table 3. The upper bound of 1.90 implies that matched households with the same observed covariates would have to differ in terms of unobserved covariates by a

https://doi.org/10.1017/S1742170516000508 Published online by Cambridge University Press

Table 3. Estimation of average treatment effect of program participation and sensitivity analysis.

Dietary diversity outcome	ATT	SE	*t*-statistic	Γ
Nearest-neighbor matching (NNM)				
HDDS	−0.044	0.142	−0.31	
WDDS	0.724	0.216	3.34***	1.15–1.90
CDDS	0.539	0.222	2.43**	1.25–1.65
Kernel matching (KM)				
HDDS	−0.221	0.177	−1.24	n.a
WDDS	0.093	0.275	0.45	n.a
CDDS	0.679	2.530	2.53**	1.15–1.63
Inverse probability of treatment weighting (IPTW)				
HDDS	−0.118	0.158	−0.75	n.a
WDDS	0.649	0.236	2.75***	n.a
CDDS	0.377	0.210	1.79*	n.a

Note: Asterisks denote the level of significance $*P < 0.1$, $P < 0.05$ and $***P < 0.01$. Γ, Critical level of hidden bias; SE is standard error and n.a is not applicable. CDDS, children dietary diversity; WDDS, women's dietary diversity and HDDS, household dietary diversity.

factor of 1.90 (90%) to invalidate the conclusion of a significant treatment effect. We acknowledge that the 1.15 critical value of Γ indicates that the result is highly vulnerable to unobserved bias. However, the results conform to those of other studies such as Becerril and Abdulai (2010), Clement (2011) and Ochieng et al. (2015) that have also reported low values of Γ. Based on the test results we can conclude that the impact of the program on dietary diversity, particularly on children below 5 yr, is robust to possible hidden bias. The IPTW results are presented in Table 3. The estimated treatment effects with PSM and IPTW approaches are very similar, which further increases the confidence in the estimated impact of promoting consumption of traditional African vegetables on nutritional outcomes.

Conclusion

Reducing malnutrition, particularly among women and children under 5 yr, is a priority of the Tanzania's government, since more than one-third of all under-5 deaths are associated with malnutrition (UNICEF, 2010). Therefore, the Good Seed Initiative sought to contribute to the government's goal of reducing malnutrition through diet diversification by promoting production and consumption of nutrient-dense traditional African vegetables in the Arusha region, Tanzania. Our study estimated the impact of the nutrition education promotional activities on the dietary diversity of households, women between 15–35 yr, and children under 5 yr using matching technique to control for problems associated with unobserved heterogeneity, which often bias the estimated outcomes. Promoting consumption of traditional vegetables is expected to play an important role in achieving better nutrition among urban and rural households in Tanzania. Our results suggest that promoting consumption of traditional African vegetables has a statistically significant and positive impact on dietary diversity of children and women. However, we do not find positive and significant impact of the promotion program on household dietary diversity because households often give priority to young women and children under 5 yr old, particularly during food shortage, women's responsibility to provide food to children and influence of advice women receive about the importance of eating balanced diet when they interact with health specialists.

Since we compared our findings with the IPTW and conducted robustness tests, our results can be considered reasonably robust. We acknowledge, however, that these results cannot be generalized at the national level because the sample is not representative of the whole country. Despite this limitation, the findings of this paper contribute to the limited body of knowledge on household nutrition and benefits of promoting and creating demand to produce and consume traditional African vegetables in Tanzania. Specifically, our findings suggest that scaling up promotional activities and encouraging consumers to grow and consume traditional African vegetables would be important in increasing nutrition, particularly for children under 5 yr and women of childbearing age. Participation in such promotion programs could be made easier by targeting children and women in hospitals and schools.

Acknowledgements. We would like to acknowledge the contributions of staff from our collaborating partners, INADES Formation International and HORTI-Tengeru, who participated in planning and rolling out the Good Seed Initiative traditional African vegetable nutrition education promotion program. Financial support provided by the Irish Aid for the Good Seed Initiative through CABI is gratefully acknowledged. We also wish to thank Karen Hampson and Japhet Emmanuel of Farm Radio International, Tanzania for their contribution in the implementation of the Good Seed Initiative in Tanzania.

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Appendix

Table A1. Testing for the matching quality.

	Before matching			After matching		
Variables	**Intervention**	**Control**	**% (bias)**	**Intervention**	**Control**	**% (bias)**
Gender	0.221	0.228	−1.6	0.216	0.207	2.1
Age	46.713	42.526	31.4	46.631	46.754	−0.9
Education	7.131	7.741	−21.9	7.183	7.662	−17.2
No. of children ≤5 yr	0.578	0.430	22.1	0.568	0.519	7.4
Active household members	2.680	2.575	8.7	2.676	2.830	−12.6
No. of children b/w 6 and 14 yr	1.115	0.961	15	1.108	1.004	10.1
Satisfaction with TAVs	0.930	0.947	−7.1	0.938	0.937	0.4
Off-farm income	0.623	0.776	−33.9	0.627	0.576	11.2
Health perception of TAV	0.934	0.943	−3.6	0.938	0.921	6.8
Grow vegetables	0.594	0.487	21.6	0.589	0.592	−0.5
Location	0.799	0.346	102.7	0.797	0.794	0.6

Note: The results are for KM procedure. TAV, traditional African vegetables.

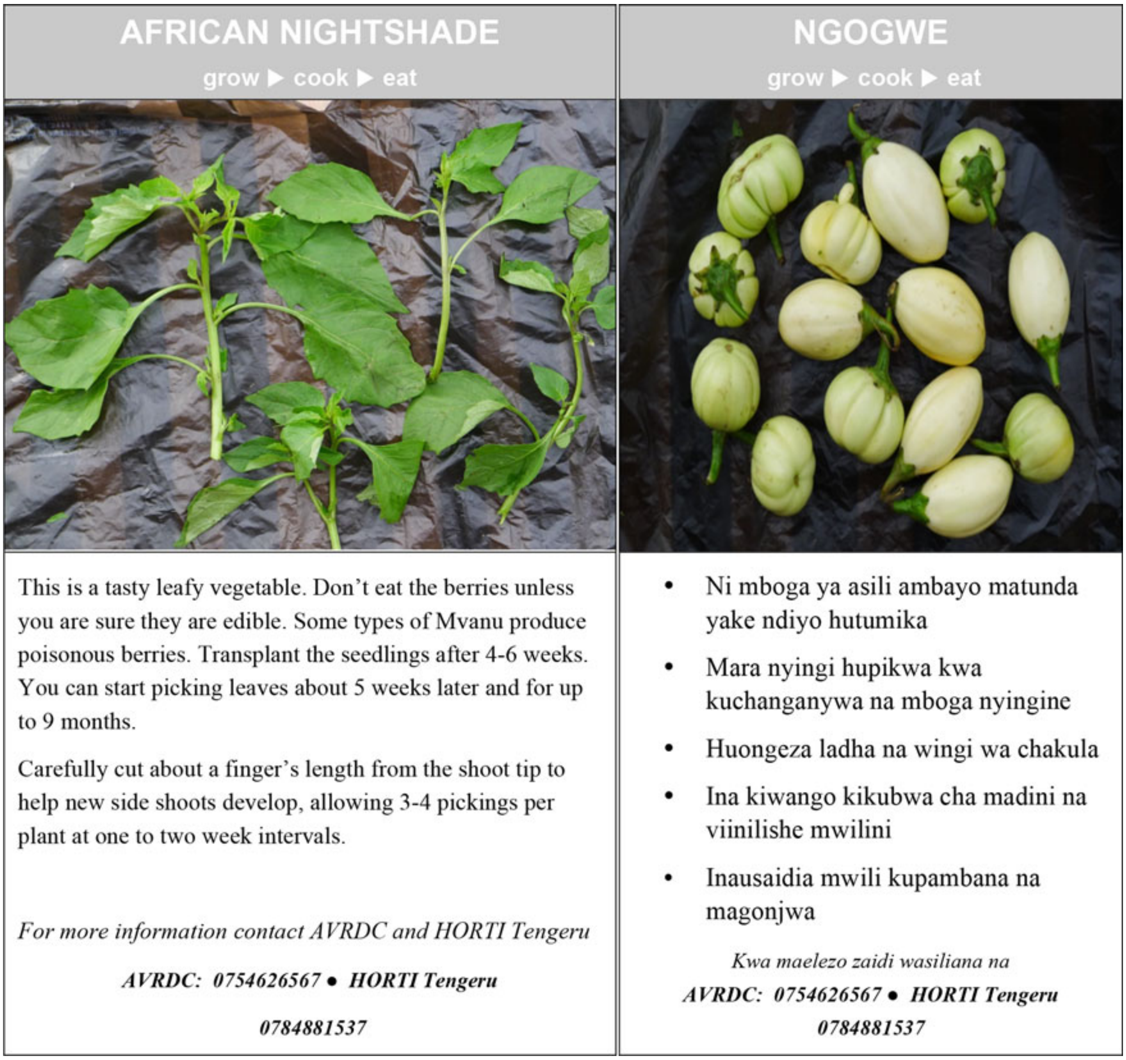

Figure A1. Fact sheet for traditional African vegetables.

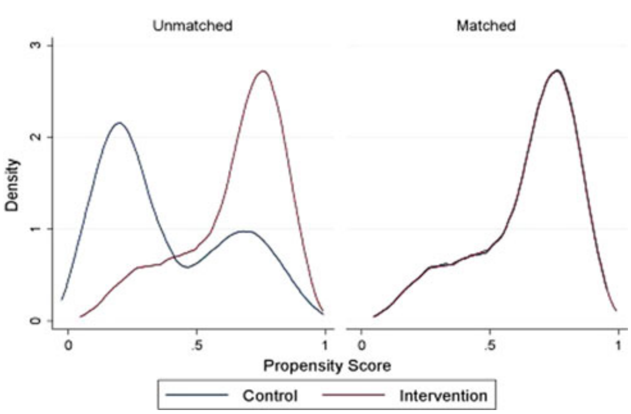

Figure A2. Kernel density distribution showing overlap between intervention and control households.

https://doi.org/10.1017/S1742170516000508 Published online by Cambridge University Press