Food Ethics (2019) 3:35–48
https://doi.org/10.1007/s41055-019-00045-5

RESEARCH ARTICLE

Vegetable Diversity, Productivity, and Weekly Nutrient Supply from Improved Home Gardens Managed by Ethnic Families - a Pilot Study in Northwest Vietnam

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Accepted: 22 July 2019 / Published online: 27 July 2019

Abstract

Assess to quality diets is a basic human right. Geographical challenges and cultural traditions have contributed to the widespread malnutrition present among ethnic minorities of mountainous areas in Northwest Vietnam. Home gardens can play a role in increased diet diversity and micronutrient intakes. However, low production yields and plant diversity in ethnic home gardens have limited their contributions to household food security and nutrition. The pilot study tested a home garden intervention in weekly vegetable harvests and increasing household production and consumption of diverse vegetables year-round. Food ethics issues encountered included limited access to quality food by resource-poor groups, conflicts arising from low preference and value given to some nutritious foods, limited access to information and technology for food production and consumption, each of which were addressed in the study design. The intervention includes: (1) nutrition-focused home garden training and (2) locally-adapted home garden packages consisting of garden planning, technical assistance, and high-yielding seed varieties. Twenty households from two ethnic villages in Son La province participated in the study and were randomly assigned into two groups (intervention and non-intervention). The total vegetable supply from weekly harvests of home garden produce was significantly higher in the intervention households (226 kg) compared to the non-intervention households (39 kg). The intervention group yielded 5.8 and 1.7 times more vegetables by weight and weight per area than those without the intervention. The vegetables were mainly consumed at home for both groups, but the intervention households gave more vegetables as gifts to neighbors. The intervention group cultivated a higher diversity of vegetables with a total of 42 different vegetables compared to 24 in the non-intervention group, which is reflected in an overall higher nutritional yield of vitamin A, iron, other micronutrients and phytochemicals. The home garden training significantly improved the amount, diversity and continuity of household food and nutrient supply. The home garden model is effective and could be scaled up to improve household vegetable supply and consumption, particularly in Northwest Vietnam.

Keywords Home garden · Vegetables · Nutritional yield · Diversity · Developing countries

Abbreviations

CGIAR	Consultative Group on International Agricultural Research
FAO	Food and Agriculture Organization
FAVRI	Fruit and Vegetable Research Institute
INFOODS	International Network of Food Data Systems

INI	National Institute of Nutrition in Vietnam
NUTTAB	Food Standards Australia New Zealand.
RAE	Retinol Activity Equivalent
RDA	Recommended Dietary Allowances
USDA	United States Department of Agriculture
WHO	World Health Organization

Introduction

Access to sufficient amounts of quality foods in daily diets is a basic human right and essential for food and nutrition security. In recent decades, reduction in malnutrition, especially for children under 5 years old have seen remarkable progress in Vietnam. However, undernutrition still exists among ethnic minorities in remote mountainous regions. Undernutrition in children is largely caused by a combination of low energy, protein, and multiple micronutrient intake, and poor maternal nutrition and health care (King et al. 2015; Prendergast and Humphrey 2014). In the latest General Nutrition Survey in Vietnam (NIN, UNICEF 2010), all ethnic groups with the exception of the Kinh have underweight and stunting rates between 16.4–33.9% and 25.8–55.1%, well above the country's average of 15.9% and 25.9% (NIN 2014). The H'mong, followed by Bana, E-de, Dao and Thai have the highest rates among ethnic groups. Main contributing factors are: maternal height, weight, body mass index and education level, and household dietary diversity (NIN, UNICEF 2010). Some ethnic customs and beliefs such as proscribing certain nutritious local foods for pregnant women and the notion that traditional green vegetables are for poor people are hinder proper nutritional care practices and healthy eating. (Huong et al. 2013). Therefore, minority groups would benefit from nutrition education and affordable and culturally acceptable nutrition interventions focused on household food diversification that should target mothers to reduce malnutrition for the entire household.

Home gardens are traditional food production systems with the potential to improve household nutrition at low-cost (Jones et al. 2005; Berti et al. 2004). Evidence from Asia, Africa and Latin America suggest that home gardens can play a role in increased diet diversity and micronutrient intakes with benefits in family income and employment, and ecosystem services (Jones et al. 2005; Wezel and Bender 2003; Sunwar et al. 2006; Vlkova et al. 2010; Galhena et al. 2013). Vegetables are easy to grow, and provide essential micronutrients and health-promoting phytonutrients to alleviate malnutrition in the household (Chadha and Oluoch 2003). For a healthy diet, World Health Organization (WHO) recommends daily consumption of at least 400 g of fruits and vegetables. The Vietnam food pyramid recommends eating at least 300 g of vegetables each day. However, home garden programs would require investment in human capital such as agricultural training, nutrition education and gender empowerment to achieve successful nutritional outcomes (Berti et al. 2004).

A scoping study was conducted one-year prior in remote upland communes of Son La province to identify opportunities, gaps and barriers in designing a suitable home garden intervention for ethnic groups. Situated in the Northwest mountains of Vietnam, Son La is populated with 12 distinct ethnic groups scattered across the hilly countryside. Due to geographical challenges, malnutrition and poverty remains a prevailing issue with high underweight and stunting among children under 5 years old (22.1% and 34.4%) and one of the lowest income in the country (NIN 2014; GSO 2014). In Thai and H'mong groups, women are the predominant decision-makers in home garden activities and feeding practices in the

household. However, there was an overall lack of understanding in basic nutrition concepts and the nutritional benefits of vegetables. While almost all Thai and H'mong households (99.1% and 97.5%) maintained home gardens, only 23.9% and 2.4% used their gardens for commercial purposes. Pests and diseases are the biggest constraints in home gardening followed by animal damages for Thai and access to irrigation water for H'mong. Main vegetables grown by the Thai are kangkong, pumpkin, H'mong mustard and cabbage, while the H'mong households mainly grew H'mong mustard. Both groups would like to grow tomato, cabbage, kohlrabi, cauliflower, carrot, and green bean in their garden. Comparatively, Thai households had larger home garden areas, grew more diverse crops, and had better access to water sources than most H'mong households.

Evidently, all households would benefit from systematic home garden training, nutrition education, nutrition-focused garden planning and access to quality seeds. The purpose of our pilot study is to test a multi-approach home garden intervention to in increase production and consumption of diverse vegetables in ethnic households. This study took into account several ethical positions in regard to food ethics and serves as a model for the design of culturally-adapted home garden programs to improve household nutrition.

Materials and Methods

Pilot Study Design

The pilot study was implemented in the Central Mekong Action Area of the Humidtropics, a Consultative Group on International Agricultural Research (CGIAR) Program. Two villages were identified in Mai Son district of Son La Province for the pilot study: Rung Thong in Muong Bon Commune, and Xum in Chieng Mung Commune. The villages were located in mountainous areas with limited road access and predominantly consisted of ethnic minorities: Thai, Kinh, H'mong, and Kho Mu.

Households that met the following selection criteria were recruited for the study: household members have limited nutritional knowledge and vegetable production training and own at least 30 m^2 of land for home garden activities. Verbal and written consent was obtained from the study households for their participation.

The study households in Rung Thong village consisted of 10 H'mong households. Prior to the intervention, they cultivated 1–3 vegetables in their gardens, primarily H'mong mustard, eggplant and spices for cooking. Rain was the main water source. Xum village enrolled 9 Thai and 1 Kinh households in the study. The Thai households regularly cultivated 2–3 different vegetables such as kangkong, onion, mustard and chili pepper while the Kinh household grew 7 types of vegetables. All the households in Xum village relied on spring water for gardening.

The study was conducted from July 2014 to June 2015. Ten households from each of the two villages participated in the study for a total of 20 households. In each village, five households randomly selected from the 10 participating households received the study intervention and the other five households did not receive any intervention. Non-intervention households received training on data collection and were offered home garden training at the end of the study as to not bias the comparison between intervention and non-intervention groups. An on-station home garden was grown in Hanoi as a reference point for the study. The study intervention consisted of nutrition-focused home garden training and locally-adapted home garden packages.

Nutrition-Focused Home Garden Training

The two-day home garden training was developed and taught by the World Vegetable Center, Fruit and Vegetable Research Institute (FAVRI) and National Institute of Nutrition (NIN) in August 2014 at Rung Thong and Xum villages. Household women were the main target recipients for the training. To overcome barriers for women to attend the training, the women's union in the communes assisted in determining a suitable schedule and the translation of the training from Vietnamese into ethnic dialects.

The home garden training focuses on both nutrition education and nutrition-focused garden techniques to maximize nutritional benefits. The lessons included both lectures and hands-on activities in cooking preparations and home garden techniques. Topics include:

(1) Basic Nutrition Principles: Importance of nutrition, malnutrition and nutritional deficiencies, balanced diet and Vietnamese Food Guide Pyramid, nutritional value of vegetables, feeding the family
(2) Home Garden Management: Soil preparation, plot design, intercropping, fertilizer application, irrigation and drainage pest and disease control, seed conservation
(3) Data Collection: Methods for collecting data for home garden harvest and consumption

Participants completed a training evaluation form to assess their learning experience, preparedness for establishing their home garden, and feedbacks on areas of improvement for the training.

Locally Adapted Home Garden Package

The study team partnered with agricultural extension workers to provide home garden packages customized to the local culture and environmental conditions. The package included a list of suitable vegetables, year-round cropping plan, seeds of high-yielding vegetable varieties, and technical assistance for improved crop management methods, food preservation, storage and preparation methods. The list of vegetables and seeds were developed from a survey of the dietary and cultural preferences of the study households. Each intervention household selected vegetables for their home gardens according to their household preferences and needs. The study team worked with the households to plan their garden area and year-round cropping calendar.

The preparation of the home garden space involved cleaning weeds and cutting down shade trees, fencing, and preparing beds for cultivation. The gardens were designed with 4–8 beds of 120–150 cm wide and 3–5 m long depending on the home garden area. A space of 25 cm wide was ensured between the fence and the beds, and between adjacent beds. A ditch of 25 cm was dug beside each bed for drainage. The fence was protected with a net to avoid damage to the garden by grazing animals.

Data Collection and Analysis

Both intervention and non-intervention households were trained in collecting weekly home garden data. The data collected include crop varieties grown in the home garden, crop schedule (planting and harvesting dates), weight (kg) of weekly harvest by crop, use of harvested produce (% consumed by the household, shared with other, or sold). The households were

surveyed on the role of women and men in home garden activities and possible constraints of home garden food production.

Due to no significant differences in annual garden production among the intervention groups, and among the non-intervention groups of Rung Thong and Xum 1 villages, the data from the two villages were combined for analysis, comparing between intervention and non-intervention.

Statistical analysis of the data was conducted using Excel's two sample t-test assuming unequal variances to compare means of intervention and non-intervention groups at a significance of $p < 0.01$.

Total vegetable yield adjusted by area (kg/m^2) was calculated by dividing the total grams of vegetable production over the plot area for each household. Daily vegetable supply (g/person/day) was calculated by dividing the total grams of vegetable production over the number of household members, and then divided by 365 days.

The vegetable nutrient content was retrieved from the food composition tables for Vietnam from International Network of Food Data Systems (INFOODS) and was calculated according to the weight of the vegetables produced from the home gardens. Carotenoid contents were converted to Retinol Activity Equivalent (RAE). Missing nutrient information was collected from other databases including World Vegetable Center Nutrient Database, United States Department of Agriculture (USDA) Food Composition Databases, and Food Standards Australia New Zealand (NUTTAB).

Household Recommended Dietary Allowances (RDA) was assumed to be the average of five RDA values found in the 2007 and 1998 Vietnam RDA reviews (Khan and Van Hoan 2008; Kim et al. 1998): one male and one female adult, one adolescent (10–18 years), one child under 10 years old, and one child under 2 years old. Percentage of RDA fulfillment for each household was calculated by dividing each household's total nutrient yield over the Household RDA value that is multiplied by the actual number of members in that household.

Results and Discussion

Ethical Positions in the Food Ethics Aspect

The study was designed involving decisions that took into account the principles of food ethics in human conduct in food production, distribution, preparation and consumption. These included (1) **Basic right to food and quality diets:** the study focused on one of the most vulnerable food insecure populations (mothers and children of minority ethnic groups) living in remote mountainous areas and prone to high malnutrition rates. (2) **Conflicts between low values accorded to some nutritious foods versus current food preference and practice:** the study involved nutrition education and behavior change communication to enhance nutritional knowledge, healthy eating behavior, and encouraging the production and consumption of nutritious local vegetables. (3) **Food distribution as affected by social-economic status**: The households included in the study were resource-poor people living in remote mountainous areas and often subject to food supply shortages. Many of them rely on subsistence food systems. The study applied a home garden program as a means to produce food for own consumption, by-passing the market which also reduced household food expenditures. (4) **Access to agricultural technology for food production:** Capacity development was the key project intervention. The study provided quality seeds of high-performance lines of vegetables, lectures and hands-on trainings on gardening. Options with different cropping

plan, types and numbers of vegetables were given and the gardeners could choose among them according to their preferences and knowledge gained from the lecture and training. Limited water access is one the major constraints in the target areas for food crop production and methods to preserve water for household consumption and gardening were incorporated in the training program. (5) **Environmental concerns:** the study emphasized traditional vegetables, plants locally grown and adapted and accepted in the food culture.

Home Garden Vegetable Yields and Productivity

The total harvest of the home gardens in both intervention and non-intervention households (Tables 1 and 2) showed significantly higher vegetable yields in intervention households in the comparison of means (Table 3) ($p < 0.001$). The mean yield of the intervention group produced 5.8 times more vegetables by weight than the non-intervention group. When adjusted for area (kg/m^2), the intervention group produced 1.7 times more vegetables per m^2 than the non-intervention households. This proves the intervention also improved productivity of home gardens in the same amount of given space. Under the similar water availability conditions, the intervention households still produced more vegetables in their gardens.

A high percentage of the vegetables grown in the home gardens were consumed by the household members: 49–100% and 83–100% in intervention and non-intervention households, respectively. When comparing the mean, the intervention group consumed 78% of home garden vegetables while the non-intervention group consumed 95%. Intervention households also gave more produce as gifts compared to the non-intervention households. On average, the intervention group gave out 22% of their produce as gifts while the non-intervention group only gave 5%.

Although the improved home garden can help meet the 200 g Food and Agriculture Organization (FAO) vegetables recommendation for two of the households in the intervention group, it still provided a substantial portion of vegetables for the diet of the intervention households. Households without intervention could not meet more than 25% of the daily recommendation and thus, the low amount of vegetables were mostly consumed at home. Increased gift-giving in the intervention group may be due to their abundant harvests. During

Table 1 Household information, annual vegetable yield, proportion of vegetables used for home consumption and gift, vegetable yield adjusted for area and daily vegetable supply per person in intervention households

Household[a]	Ethnic group	Household members	Plot area (m^2)	Annual production			Total yield by area (kg/m^2)	Daily supply (g/person/day)
				Total (kg)	Home (kg)	Gift (kg)		
1	H'mong	6	38	223	129	94	6	102
2	H'mong	4	53	188	111	77	4	129
3	H'mong	3	43	252	186	66	6	230
4	H'mong	7	38	114	56	59	3	45
5	H'mong	5	36	119	72	47	3	65
6	Thai	8	58	269	250	19	5	92
7	Kinh	4	69	387	292	95	6	265
8	Thai	8	79	397	367	30	5	136
9	Thai	6	30	140	132	8	5	64
10	Thai	5	41	175	175	0	4	96

[a] Households 1–5 from Rung Thong village, Muong Bon commune; households 6–10 from Xum village, Chieng Mung commune

Table 2 Household information, annual vegetable yield, proportion of vegetables used for home consumption and gift, total vegetable yield adjusted for area and daily vegetable supply per person in non-intervention households

Household[a]	Ethnic group	Household members	Plot area (m^2)	Annual production			Total yield by area (kg/m^2)	Daily supply (g/person/day)
				Total (kg)	Home (kg)	Gift (kg)		
1	H'mong	5	15	68	58	10	4	37
2	H'mong	4	3	18	18	0	6	12
3	H'mong	4	3	14	14	0	5	10
4	H'mong	4	7	18	15	3	3	12
5	H'mong	5	12	27	27	0	2	15
6	Thai	6	56	88	83	5	2	40
7	Thai	5	56	51	50	1	1	28
8	Thai	5	20	60	60	0	3	33
9	Thai	4	45	34	34	0	1	23
10	Thai	5	17	15	15	0	1	8

[a] Households 1–5 from Rung Thong village, Muong Bon commune; households 6–10 from Xum village, Chieng Mung commune

harvest periods, vegetable supply may be more than sufficient for the family's consumption and any additional vegetables are shared with neighbors. Moreover, gift-giving can increase social interactions with the neighbors and mental well-being for the households (Helliwell and Putnam 2004). It is important to note that better food storage and processing practices can help households prolong the usage of vegetables for home consumption.

Due to the low vegetable production and nutrient supply of the non-intervention group, further discussions will mainly focus on the intervention group.

Vegetable Diversity

The intervention households showed higher plant diversity and grew 42 different vegetables compared to the non-intervention group of 24 vegetables (Table 4 and Fig. 1). Diversity in production was directly reflected in the diversity of households diet (Chadha and Oluoch 2003; Gao et al. 2012).

Vegetable production and diversity fluctuates throughout the study period. This is mainly due to the low rainfall and water availability of the dry season which typically runs between February and May. From March to April, low production could be seen in all vegetable groups,

Table 3 Student t-test comparison between intervention[a] and control[a] group on household members, land area, total production and proportion of production used for home consumption and gift, total production adjusted by area and daily vegetable supply per person

Group	Household members	Plot area (m^2)	Annual production			Total yield by area (kg/m^2)	Daily supply (g/person/day)
			Total (kg)	Home (kg)	Gift (kg)		
Intervention	6 ± 2	48 ± 16	226 ± 102	177 ± 100	50 ± 34	5 ± 1	122.4 ± 72.3
Control	5 ± 1	23 ± 21	39 ± 26	37 ± 24	2 ± 3	3 ± 2	21.8 ± 11.9
p value	0.1481[ns]	0.0078**	0.0002***	0.0015**	0.0018**	0.0138*	0.0019**

[a] Values are means ± standard deviations; * significant at $p \leq 0.05$;** significant $p \leq 0.01$; *** significant $p \leq 0.001$

Table 4 Vegetable categories and percentage of yield in the year-round vegetable production of the intervention group during the study period

n	Category - Vegetables	Yield
18	Green leafy vegetables	
	H'mong mustard	17%
	Kang Kong	5%
	Others: Amaranth, Basil, Bulbostylis barbata, Chinese kale, Choy Sum, Chysamnthemum garland, Cokscomb mint, Coriander, Dill, Indian mustard, Lemon grass, Lettuce, Lolot, Malabar spinach, Pak Choi, Nightshade	21%
12	Roots, Stems, Heads, and Bulbs	
	Common cabbage	10%
	Chinese cabbage	8%
	Others: Bulk onion, Garlic,Ginger,Green onion,Indian taro, Kohlrabi, Spring onion, Sweet potato, Welsh onion, Yellow ginger	10%
8	Fruit and Fruit vegetables	
	Tomato	6%
	Egg plant	5%
	Others: Banana, Chilli, Cucumber, Luffa, Pepper, Star gooseberry	6%
3	Legumes	
	French bean	4%
	Yardlong bean	3%
	Kidney bean	1%
1	Orange fleshed vegetables	
	Pumpkin, fruit	4%
42	Total	100%

especially with the close to no production of root, stem and head vegetables. The dry season is a threat on home garden production, particularly to the H'mong households who rely on rain water for gardening as opposed to the Thai and Kinh households that uses spring water. Consistent and reliable water supply is necessary for home gardens to thrive, and overcome dry season constraints. Setting up simple irrigations systems and water-saving technologies can help sustain home gardens for year-round production.

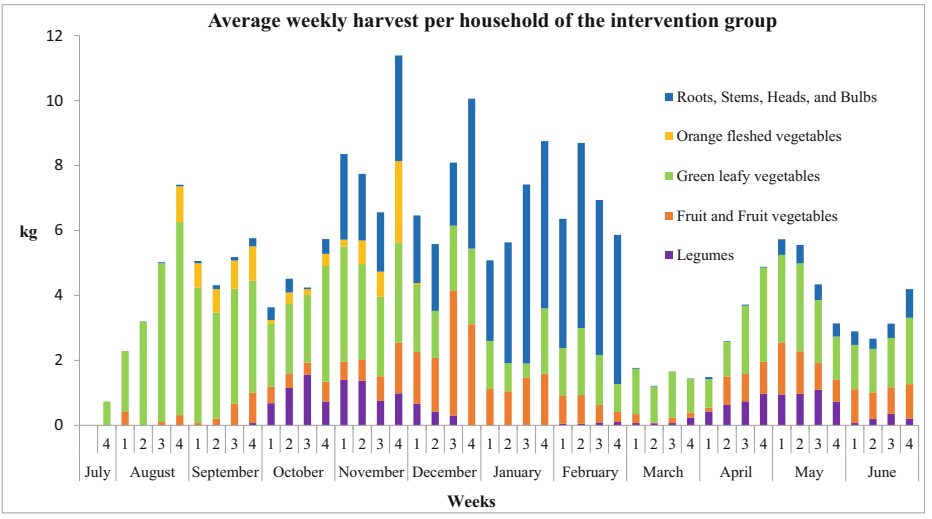

Fig. 1 Household garden produce (kg) by vegetable group of intervention group from weekly harvests during the study period

The five groups of vegetables and crops follow different growing seasons and was demonstrated in their harvest patterns. Roots, stems and heads were mostly harvested in the fall and winter, and had low productions during spring and summer. Pumpkin, the high β-carotene vegetable had a harvest season in the fall (late August to November). The largest supply of vegetables was from a year-round harvest of leafy green vegetables. Fruits and fruit vegetables were harvested depending on their different growing seasons, and beans were available between two periods, October to December, and April to June.

The dry season and food diversity gap could be reduced by teaching villagers on proper home-based food storage and preservation methods and technologies. Roots, stem and head vegetables, such as onions, cabbages and taro, and pumpkin could keep for a longer period of time and supplement both food supply and nutrient when production is low. When not eaten fresh, beans could be dried and used throughout the year. Leafy green vegetables and fruit vegetables, apart from chili are better eaten within the harvesting time for optimal nutrition and quality.

Nutritional Yield and Estimated Daily Supply

Vegetable yield and diversity is directly associated with the nutritional yield of the vegetables. For example, Vitamin A yields fluctuates with vegetable yield (Fig. 2). The intervention group obtained enough Vitamin A from their garden to meet 89% of their daily requirements, ranging from meeting 34% to 153% of different households needs. The main contributor to vitamin A in the diet is from pumpkin. Therefore, households who grew more pumpkins had a higher supply of vitamin A in their diets. Pumpkins were available from late August to November. Since they could be stored in dry conditions for up to 3 months, pumpkins could supply enough vitamin A for households to low vitamin A periods in January. Other vitamin A contributors included leafy green vegetables such as kang kong, H'mong mustard, amaranth, and nightshade, and also sweet potatoes.

On average, apart from vitamin A, the garden provided high levels of vitamin C and B6 for the households (Table 5). Vegetables generally could not provide sufficient supply of protein,

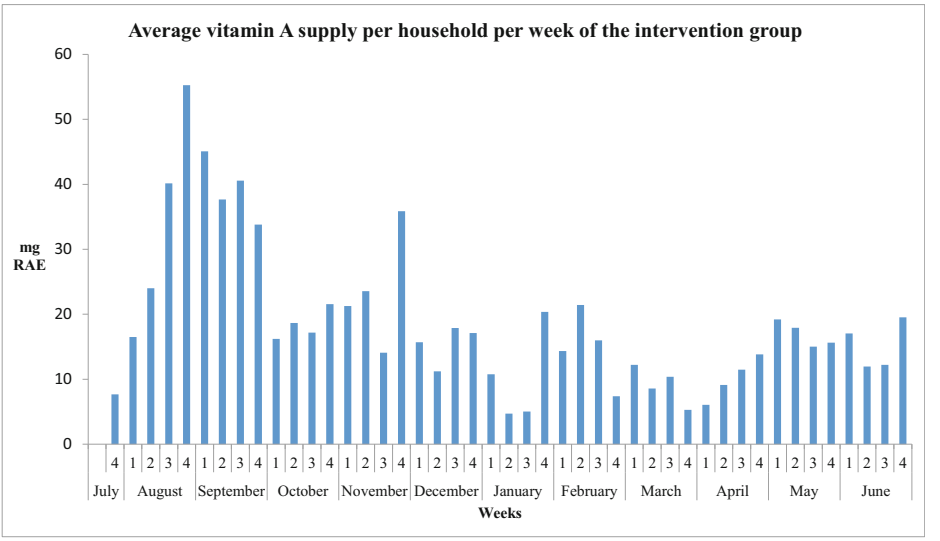

Fig. 2 Vitamin A supply of the intervention group from weekly harvests during the study period

Table 5 Daily protein, vitamin A, B, C, E, calcium, iron and zinc supply and percentage daily requirement of the intervention group

Household	Vitamin A		Vitamin B1		Vitamin B2		Vitamin B3		Vitamin B6		Vitamin C		Vitamin E	
	μg RAE	RDA%	mg	RDA%	mg	RDA%	mg	RDA%	mg	RDA%	mg	RDA%	mg	RDA%
1†	2979	96	0.51	9	0.74	13	2.89	4	0.72	13	193	62	15.7	30
2†	3135	152	0.39	11	0.39	11	3.19	7	0.73	20	205	98	10.3	29
3†	2293	148	0.47	17	0.51	18	3.60	10	1.01	37	250	160	11.9	45
4†	1220	34	0.20	3	0.22	3	1.98	2	0.34	5	108	30	5.87	10
5†	1758	68	0.33	7	0.30	7	2.11	4	0.36	8	136	52	6.67	15
6‡	2687	65	0.71	10	1.01	14	4.55	5	1.09	15	316	76	10.5	15
7‡	3143	153	0.98	27	1.31	36	6.00	12	1.44	40	409	197	10.8	31
8‡	3628	88	0.98	13	1.27	17	5.85	6	1.63	23	427	103	15.2	22
9‡	1098	36	0.40	7	0.66	12	2.51	3	0.54	10	196	63	6.92	13
10‡	1244	48	0.45	10	0.67	15	2.73	5	0.66	15	216	83	4.81	11
Thong Village Average	2277	100	0.38	10	0.43	10	2.76	5	0.63	17	179	81	10.1	26
Xum Village Average	2360	78	0.70	13	0.99	19	4.33	6	1.07	20	313	104	9.64	18
Total Average	2318	89	0.54	11	0.71	15	3.54	6	0.85	19	246	92	9.86	22
Household	Protein			Ca			Fe				Zn			
	g	RDA%		mg		RDA%	mg		RDA%		mg		RDA%	
1†	21.7	8		416		9	6.0		7		3.07		9	
2†	20.5	11		404		13	7.2		12		3.35		14	
3†	26.0	18		537		22	8.0		18		4.02		22	
4†	6.75	2		176		3	3.3		3		1.38		3	
5†	16.9	7		284		7	4.8		6		2.04		7	
6‡	15.8	4		539		8	9.8		8		4.77		10	
7‡	21.6	11		695		22	12.3		20		5.93		25	
8‡	21.8	6		742		12	12.9		11		5.98		12	
9‡	9.54	3		281		6	5.0		6		2.37		7	
10‡	10.7	5		334		8	6.0		8		2.97		10	
Thong Village Average	18.4	9		363		11	5.8		9		2.77		11	
Xum Village Average	15.9	6		518		11	9.2		10		4.40		13	
Total Average	17.1	8		441		11	7.5		10		3.59		12	

† Households from Rung Thong village, Muong Bon commune

‡ Households from Xum village, Chieng Mung commune

calcium, iron, and zinc. Households with more land and less family members usually could meet more of their nutrient requirements from their garden produce. However, the garden did provide more essential nutrients than non-intervention households, and improve household diet.

Vegetables also provided phytochemicals important to health, which was not examined in this study. It would require food databases with complete phytochemical information for each vegetable to calculate. At the time of the study, this information was not yet completed.

Limitation and Future Prospects

The pilot study's purpose was to test the feasibility of a multi-approach home garden intervention in increasing household food production and consumption. The targeted sample selection and size may not be representative of ethnic groups in Northern Vietnam or allow comparison between ethnic minorities. However, it does prove the model is effective in improving the amount, diversity and continuity of household food supply and diet diversity. A study at a larger scale with an adequate sample size and random selection can provide a more representative population.

A major constraint to home food production is a reliable water supply. The H'mong who live in the higher areas of the villages relied only on rain water for their home gardens. Dry seasons where rain water is limited or non-existent can pose a threat on year-round food production and nutritional security. Basic infrastructures to provide irrigation water is necessary for the success adoption of home gardens.

One of the aims of the intervention is to target women as the main beneficiaries in establishing home gardens and receiving nutrition education. In reality, due to ethnic gender roles, the study team had barriers directly communicating and interacting with household women. Women in these ethnic villages typically worked 12 h outside of their homes on their commercial farms and took care of food preparation, child-rearing and household chores. Moreover, they spoke mainly in ethnic dialects and were shy to engage with the study team. The men, on the other hand were more socially active in the villages and made decisions on women's social activities. As a result, no women and men instead attended the home garden training. Men interacted more with the study team and also helped in gardening while the women were away. Another point is that home gardens should not increase the burden on women's labor and physical health. However, in practice, women had to spend extra time and effort on gardening activities. To overcome these ethnic roles for men and women, interventions should be designed to also include men and children to encourage their involvement in maintaining the garden.

To achieve a holistic and balanced diet, a mixed garden approach which includes raising animals such as chicken, rabbits, dairy cows, and fish could provide protein food sources for the family. Vegetable parts not used for household consumption could be used to feed the animals, and manure from animals can help fertilize the garden soil.

The home garden model in this study is successful in improving household food production and consumption. The model is worth scaling up and could be modified for other malnourished rural regions to improve household nutrition. Sustainability of the home gardens can be achieved with the support of agricultural, rural development, and nutrition policies and programs. Areas of focus and commitment by government and non-governmental initiatives should be on providing budgetary assistance, infrastructure building to create access to roads and water supply, human resources for training and technical assistance, and sufficient monitoring and evaluation of the home garden programs. Research and development of

high-yielding vegetable seed kits for different regions and subsidized prices for the seeds would encourage the adoption of home gardens.

Acknowledgements We are grateful to the gardeners providing their time and collecting data, to Vietnam National Institute of Nutrition developing and providing nutrition trainings for the study. This research was funded by CGIAR Humidtropics Program and by long-term strategic donors to the World Vegetable Center: Republic of China (Taiwan), UK aid by the UK government, United States Agency for International Development, Australian Center for International Agricultural Research, Germany, Thailand, Philippines, Korea, and Japan.

Compliance with Ethical Standards

Ethical Approval The informed consent for the training program and providing yearly harvest data was obtained from all the study participants and the community leaders.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix

Common name	Scientific name
Amaranth	*Amaranthus*
Banana	*Musa sp.*
Basil	*Ocimum basilicum,*
Bulbostylis barbata	*Bulbostylis barbata*
Chilli	*Capsicum*
Chinese cabbage	*Brassica rapa*
Chinese kale	*Brassica oleracea*
Choy Sum	*Brassica chinensis*
Chrysanthemum garland	*Chrysanthemum coronarium*
Cockscomb mint	*Elsholtzia ciliata*
Common cabbage	*Brassica oleracea*
Coriander	*Polygonum odoratum*
Cucumber	*Cucumis sativus*
Dill	*Anethum graveolens*
Eggplant	*Solanum melongena*
French bean	*Phaseolus vulgaris*
Garlic	*Allium sativum*
Ginger	*Zingiber officinale*
H'mong mustard	*Brassica juncea*
Indian mustard	*Brassica juncea*
Indian taro	*Colocasia esculenta*
Kang Kong	*Ipomoea aquatica*
Kidney bean	*Phaseolus vulgaris*
Kohlrabi	*Brassica oleracea*
Lemon grass	*Cymbopogon citratus*
Lettuce	*Lactuca sativa*
Lolot	*Piper sarmentosum*
Luffa	*Luffa aegyptiaca* Mill
Malabar spinach	*Basella alba*
Nightshade	*Solanum nigrum*
Onion (bulk onion)	*Allium cepa*
Onion (green onion)	*Allium fistulosum*
Onion (spring onion)	*Allium ascalonicum*
Onion (welsh onion)	*Allium fistulosum*

Common name	Scientific name
Pak Choi	*Brassica rapa*
Pepper	*Capsicum*
Pumpkin, fruit	*Cucurbita maxima*
Star gooseberry	*Sauropus androgynus*
Sweet potato	*Ipomoea batatas*
Tomato	*Solanum lycopersicum*
Yardlong bean	*Vigna unguiculata*
Yellow ginger (Vietnamese ginger)	*Curcuma longa*

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