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ORIGINAL RESEARCH PAPER

Changing practice from agrochemical to organic methods in rural Ghana: the Nkabom Organic Farming Project

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Abstract Organic farming is a proven healthy and economical method of farming with the capacity to solve the global food security need, especially in low-income countries. However, in the recent past, many farmers have been practicing non-organic farming at the risk of health and food security. There is the need to elevate to innovative organic-based farming practices. The purpose of this study was to evaluate the success of small-scale farmers converting to organic farming practices in a rural village in Ghana, West Africa, through an intensive training program and supply investment. Forty-two farmers participated in the training conducted by a farm educator from a medical university in Charleston, SC, in partnership with a local farmer who had received individual training in organic methods. One hundred percent of the farmers participated in research interviews before training and 7 months after training. Results indicate that the farmers were highly successful in converting to organic methods. Seven months post-training, 92.9% of farmers reported sole use of organic methods. In addition, their reported average monthly income increased significantly. Farmers were fairly knowledgeable about organic farming before the training but did not have specific skills in organic methods. The provision of comprehensive training in organic methods was highly successful for enabling the rural farmers in Ghana to change their farming practices.

Keywords Ghana · Good agricultural practices (GAP) · Integrated pest management · Organic methods

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Introduction

Lack of food security is a pervasive and persistent problem, especially in Africa where roughly 65% of nations are at a high risk of food insecurity (FAO 2015). Food security involves each person having access to sufficient food that sustains health by eradicating malnutrition (Quisumbing et al. 1995). Food security requires availability of food, access to it, and stability and utilization of the nutrients. Interestingly, in the realm of availability, foreign governments have provided food aid programs. These programs have not been shown to have a significant impact on average dietary energy supply, which is strongly related to malnourishment. This type of aid is generally on an

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emergency basis and is not sustainable (Denny et al. 2018).

Developing a solution for hunger and malnutrition is critical as they are the main causes of mortality in the world, bringing about the death of 25,000 people daily, mostly children and mostly people living in rural areas. Food security for the most vulnerable is becoming increasingly uncertain (Feyder 2013).

Many low-income countries have an agrarian economy. In Africa, in the past, farming has been approached from traditional agriculture practices. These practices have changed over time due to low profits among other things. Modern agriculture that involves use of chemicals has increased food productivity but at the price of soil degradation, food unsafety, biodiversity loss, and contributions to climate change (Zhang et al. 2017). Changes to climate and weather have resulted in a decline in food production and rising food prices (IASC 2010; Ndukwe et al. 2017). A transformation of traditional farming that uses improved whole-system production methods is gaining more attention. Farming methods that respect nature are sustainable and may be the only way to feed the world (Singh and Singh 2017). Organic farming is certified and regulated by private or governmental bodies in the countries where the farming is conducted. For example, in the USA, the Department of Agriculture (USDA) provides guidelines to support organic growers to use natural substances and physical, mechanical, or biological methods to the fullest extent possible. Produce can be considered organic if it was grown on soil with no prohibited substances used for 3 years prior to harvest. When a synthetic substance must be used, that substance must be approved, based on the effect the substance has on human health and the environment (USDA 2020). In Ghana, the Ghana Green Label (GGL) Certification Scheme is the government's standards for producing safe food in an environmentally sustainable and sound way. Consumers recognize GGL foods as safe. The methods approved under GGL create a high standard and are not without the provision of natural or synthetic chemicals if needed (Ghana Green Label 2020). With shifts to organic farming practices, improved soil health, produce sanitation, and safe integrated pest management programs, a healthier environment (free of harsh and sometimes cancer-related chemical contamination) and healthier foods should result in improved health and nutrition (Meemken and Qaim 2018). If organic methods and improved safety produce healthier foods and fertile land, the question which is the focus of this study is, are there effective ways to help farmers who are using non-organic methods convert to organic practices? This question is particularly important to rural farmers in low- and middle-income countries in Africa where agrochemicals have replaced a long history of natural methods. The aim of this study was therefore to determine if local farmers in rural Ghana, provided with 4 days of intensive training on organic farming methods, converted from non-organic to organic farming practices.

Study area

The study was conducted in the rural village of Okurase in the eastern region of Ghana, West Africa. Although Ghana has a vast amount of farmland, in rural areas and even some urban areas, low food security is an issue of concern. In addition, food safety is a growing concern. A national survey conducted across Ghana (Osei-Asari 2009) found that consumers were interested in purchasing organically grown food due to quality and safety. Producers of foods were interested in growing organically because of safety from chemicals, healthiness of products, and the impact of chemicals on the land.

Study context

Okurase comprises about 3500 people and is a farming and drum carving community. The residents have dealt with extreme challenges related to poverty such as lack of safe water, lack of toilets, low health care, limited educational and job opportunities, and low food security (GSS 2014). Malnutrition is high and the village is in a malaria-prone zone. Many people have died due to "small sicknesses," which are treatable by proper medical care and preventable with proper nutrition. The farmers in the community had increased the use of agrochemicals for growing their crops but had not attained proper skills in agrochemical application. They did not wear personal protective equipment (PPE) such as gloves, goggles, face masks, and boots (Naidoo 2010). This led to indiscriminate use of chemicals and increased exposure of hazardous chemicals to people and the environment. The village leaders and the residents had a desire to change their plight but the resources required for change had not been available to them.

Through a Ghanaian/American partnership spearheaded by Yeboah and Swenson, a non-governmental organization (NGO) called Project OKURASE was opened in 2007 to support the village in realizing their vision. As an initial step, Swenson et al. (2018) conducted a qualitative study that served as a needs assessment. The study led to Project OKURASE's mission and 6 objectives that exemplify what the village wants. The stated mission of the NGO is w*hile honoring Ghanaian arts and culture, collaborate with the village of Okurase, Ghana to develop sustainable, replicable solutions to life's biggest challenges and share lessons learned with other disadvantaged villages*. The 6 objectives towards this mission are as follows: (a) water and sanitation; (b) health and nutrition; (c) education and technology; (d) economic self-sufficiency; (e) building the Nkabom Centre; and (f) cultural exchange. Importantly, two key principles underlie all interventions and programs in Project OKURASE. First is the recognition that the people of the village know what is best for improving their lives and how to attain sustainability. Second is the spirit of Nkabom, a word from the Twi language referring to bringing the community together but also expanding the reach of the community to other villages and beyond.

Preliminary pilots: setting the stage for changes in farming practices

In addition to the qualitative study (Swenson et al. 2018) and as a regular part of Project OKURASE, meetings were held on an ongoing basis with the village Chief, elders, and farmers to determine what programs the community desired. The formal knowledge and resources were not available, and it was up to the partnership to look for opportunities and find the resources. The NGO formed the Nkabom Organic Farming Project as a platform to help farmers acquire the needed knowledge and resources. Two activities were conducted to create a local infrastructure for conversion to organic farming in Okurase. These included 6 months of individual training of an Okurase farmer (Owu) at the Medical University of South Carolina (MUSC) Urban Farm and development of an organic demonstration garden near the Montessori school in Okurase for purposes of piloting. Both activities would later serve as resources for consultation to farmers.

The Nkabom Organic Farming Study

A small grant from the Medical University of South Carolina Center for Global Health provided the support needed to conduct the Nkabom Organic Farming Study. The overarching purpose of the study was to provide a hands-on training in organic farming methods and the resources needed to convert to organic farming practices. The outcomes were evaluated. The study was approved by the Institutional Review Board (IRB) of the Medical University of South Carolina and the Health Directorate of the Upper West Akyem District. All research and training staff were IRB-approved volunteers who had completed the Center for Information Technology Integration (CITI) research ethics course.

Method

Recruitment of study participants

Recruitment of study participants was done over the course of a week in November 2018 and the training was conducted in December 2018. Announcements were made over the village public address system that Project OKURASE would be providing training for farmers in organic methods. Farmers were asked to sign up at the NGO office. Forty-two farmers who expressed interest signed up for the training. All these farmers were approached for their voluntary participation in the research interviews. All 42 farmers agreed to participate in the research, yielding a 100% research recruitment rate.

Informed consent

The consent form and all interviews were translated into the local Twi language and approved by a university ethics committee. Farmers who agreed to participate were given a copy of the Project's informed consent in Twi or English according to their preference. The informed consent was presented orally in Twi by a bilingual English/Twi interpreter. Signatures were either the actual signature or a thumb print. Each farmer was given a copy of the signed consent for their records.

Interviews

After signing the informed consent, farmers completed interviews to assess current farming practices. All data were collected by Dr. Swenson and volunteer research assistants. Post-training interviews were conducted 7 months after training. This time period represents a full farming cycle in the village. One hundred percent of the farmers completed the post-training interviews, representing a 100% retention rate. Each interview was completed with the assistance of a Twi interpreter. Research participants received a participant fee for the pre- and post-interviews to cover the time that they were away from their farms and work to be able to complete the interviews. Participants were not made aware of the participant fee before the informed consent was completed.

Data were recorded on paper using pencils and converted to an electronic database as soon as possible. In Ghana, there are frequent electrical outages making use of computers challenging at times.

Measures

The farmer and gardener survey was designed by the study team to assess current farming practices and is available upon request from the first author. A brief demographic questionnaire was used to obtain background information (e.g., age, gender, education, land ownership). Farmers were asked to describe their current crops cultivated and common pests reported. Farmers rated their views on the impact of organic farming on land, vegetables produced, money earned, and health. Critical to this study, farmers self-reported their practices to indicate whether they were currently using full organic methods, partial, or agrochemical only. Furthermore, farmers were asked about their current monthly income and recording (pests, money earned, money spent) practices. Other practice questions were related to seeds and planting stock, pest, weed, and disease management and harvesting and post-harvesting practices, especially those related to hygiene.

Training in organic farming methods

Key to the implementation of this project is that the training was tailored to the desires of the farmers, their particular gaps in knowledge, respect for the local culture, and with great consideration for the local context. The Ghana farmer training was supported by the Urban Farm operated on the Medical University of South Carolina campus in Charleston, SC. This project was their first international outreach through volunteering. The Nkabom Organic Farming Project focuses primarily on transformative agriculture using traditional farming practices in conjunction with safe agricultural advances that maximize production yields with the ultimate goal of using methods free of synthetic chemicals. In the training, the preventative nature of organic methods was stressed. Farmers were taught organic methods that if used should avoid the need for chemicals. However, it is recognized that when a crop pest has reached its threshold (FAO 2015) or is on the brink of not being viable, botanicals (natural oils such as need) or synthetic chemicals in a controlled amount may be needed. If pesticides are to be used, they must be used in responsible and safe ways. For example, weed killers should not be used for insects and farmers must wear protective equipment.

The training in Ghana was conducted by Urban Farm educator Ketron, Ghana garden manager Owu, and Adnan who is a local experienced Twi interpreter. Each farmer completed a knowledge examination as part of the training. The exam was on the first day of training to assess what farmers knew about organic methods. The exam was repeated on the last day of training once the training was complete. Those who passed the exam at the end of training earned a certificate of completion.

Farmer participants identified problems and concerns they wanted to address during the training. From initial discussions with farmers, the following major concerns were identified: (a) use of hazardous industrial agrochemicals without understanding the target problem the chemical was for; (b) incorrect application leading to runoff or development of pest resistance; and (c) lack of proper personal protective equipment (PPE). In addition, there was limited understanding that these persistent chemicals can have long-lasting effects detrimental to human and animal health, if improperly applied by applicators.

Organic farming training aims and content

The aim of the training was to provide education in preventative measures to use fewer chemicals and grow food in a responsible way that was safe for the farmer, the consumer, and the environment. Specific objectives

of this aim were to (a) provide adequate training on improved crop production methods using organic, integrated pest management (IPM), and small-scale production methods to eliminate the need for chemical use; (b) provide farmers who were using chemicals with adequate PPE such as, boots, gloves, and goggles; and (c) provide training on effective and safe chemical application for those who are not able to convert immediately to sole organics. Based on these objectives, part of the grant funds was used to provide boots, gloves, hand chemical sprayers for neem oil, and a sample of botanical neem oil spray. These supplies provided adequate PPE, training in organic-based production methods, and a trial of organic chemicals for people to have access to a small transition or improvement of their operations.

The course was held across 4 days. The design of the program incorporated a mix of organic agriculture, traditional methods, and safe modern approaches to manage problems identified by farmers in their pre-training interviews. The instruction was broken into classroom PowerPoint presentations, a print manual in English, and discussions, as well as hands-on learning demonstrations in the garden.

The training was based on the whole system concept of healthy agriculture ecosystems.

Topics included as follows: (a) the dangers of unsafe and persistent chemical use in current agriculture; (b) seeds, seed starting, and the importance of healthy disease resistant seed sourcing; (c) the improvement and maintenance of soil health and soil testing; (d) IPM, use of an ecosystem approach to provide cultural, biological, mechanical, and smart chemical controls to prevent pests from thriving and affecting yield production (Afreh-Nuamah and Akotsen-Mensah 2015); and (e) use of good agricultural practice guidelines (Mushobozi and Santacoloma 2010; FAO 2010) and case studies (Annor 2017), harvest sanitation, food safety requirements, post-harvest handling, storage, and personal sanitation of harvest personnel. Throughout the 4-day course, the instructors emphasized the need for adequate recordkeeping. This included observation of planting times, crops, and observed pests to determine thresholds. Anecdotal evidence from non-research interviews suggested that the farmers did not keep formal records of the cost of their inputs, yields, and the amount of money made from a crop. Additional suggestions for recordkeeping included increased use of financial recordkeeping as a way to determine their true actualized profitability from the inputs they used on their properties and the yields from their inputs. Farmers were given a weather-resistant recordkeeping book and taught how to record.

Analyses

Analyses were conducted using the Statistical Package for the Social Sciences, IBM SPSS Version 23. Descriptive statistics were computed to understand pre-training characteristics of the farmers. Chi-square statistic was calculated to compare categorical measures. Logistic regression analysis was performed to assess if there were any predictors of farmer conversion to organic farming. However, none was found since almost all farmers converted. A p value of < 0.05 was considered the level of significance.

Results

Participants

Forty-two farmers gave informed consent and participated in the research study. The pre-training demographic information is shown in Table 1. The majority of farmers were male and their average age was 47.15 years. Seventy-six percent were married or living with a partner. Others were either single (16.7%) or divorced (2.4%) or their spouse had died (4.8%). Regarding educational opportunity, the majority of farmers (59.5%) completed Junior high school. Twelve percent completed Senior high and one farmer attended university. More than one-fourth (26.2%) never attended school.

Land ownership

At pre-training, farmers reported on whether they rented or owned their land. Almost half (45.2%) reported owning and 50% reported renting. A small percent (4.8) owned some land and rented also (see Table 1).

Types of crops cultivated

Regarding types of crops, all farmers reported growing diverse crops. Maize (90.5%), cassava (85.7%), yam (50%), cocoa (23.8%), and palm nuts (21.4%) were the most commonly grown crops. In addition, farmers grew a variety of fruits and vegetables such as groundnuts (peanuts), pineapple, paw paw (papaya), and other

Table 1 Demographic characteristics of farmers

Characteristics	*n* (%)
Age	47.15±10.90*
Gender	
Male	37 (88.1)
Female	5 (11.9)
Marital status**	
Married	31 (73.8)
Single	7 (16.7)
Living with partner	1 (2.4)
Spouse has died	2 (4.8)
Education	
Never attended school	11 (26.2)
Junior high school (JHS)	25 (59.5)
Senior high school (SHS)	5 (11.9)
University	1 (2.4)
Land ownership	
Own	19 (45.2)
Rented	21 (50.0)
Both	2 (4.8)
Crops cultivated	
Cassava	36 (85.7)
Yam	21 (50.0)
Cocoa	10 (23.8)
Groundnuts	1 (2.4)
Palm nut	9 (21.4)
Pineapple	1 (2.4)
Others	32 (76.2)
Common pests reported	
Army worm	16 (38.1)
Caterpillar	2 (4.8)
Grasscutter	16 (38.1)
Grasshopper	5 (11.9)
Flying insects	4 (9.5)
Termites	2 (4.8)
Others	11 (26.2)

*Data are presented as mean ± standard deviation

**On marital status one farmer declined to respond

vegetables such as cabbage and garden eggs (eggplant) (Table 1).

Common pests reported

The most common pests reported were army worm (38.1%) and grasscutter (38.1%). Others were caterpillars and winged insects reported by small percentages of farmers.

Views on the impact of organic farming

Farmers were asked how they believed organic farming impacted land, vegetables produced, money earned, and health. At pre-training, the overwhelming majority of farmers reported that organic farming will improve soil fertility (92.9%), production of vegetables and fruits (100%), health of the people who consume the produce (100%), and personal health (100%). Among the farmers, 95.2% viewed organic farming as increasing ability to attain more money for produce. At post-test, all farmers held the view that organic farming would improve soil fertility, amount of vegetables and fruit produced, and the ability to get more money for their produce.

Pre- and post-training changes in farming practices

Agrochemical versus organic strategies

At pre-training, 26.2% of farmers reported sole use of conventional agriculture, which includes use of synthetic agrochemicals, 38.1% reported use of organic methods, and 35.7% reported using a mixture of organic and conventional methods. At 7 months post-training, significantly more farmers were growing with sole organic methods. Zero farmers endorsed sole use of agrochemicals and reported solely practicing organic methods (Table 2).

Income

At pre-training, 88.1% of farmers reported that use of organic methods would lead to more income and 61.9% said that organics would be a more cost-effective way to produce food. The self-reported average monthly income for the group was GHc200 (equivalent of US$34.48; £28.13; €31.97). As shown in Table 2, 7 months post-training, farmers had significantly increased average income to GHc333 (US$57.45; £46.62; €52.84).

Recording practices

At pre-training, a small percentage of farmers reported that they recorded insects or diseases that affected their

Table 2 Comparison of pre-training and post-training practices related to organic farming

Practice	Pre-training, *n* (%)	Post-training, *n* (%)	χ^2 (df*=1, *N*=42)	*p* value
Farming methods				
Conventional only	11 (26.2)	0 (0.0)	28.618	<0.001
Organic only	16 (38.1)	39 (92.9)		
Mix	15 (35.7)	3 (7.1)		
Organic farming leads to more income				
Yes	37 (88.1)	42 (100.0)	5.316	0.055
No	5 (11.9)	0		
Actual monthly income (Ghana cedis)	200 (50–2500)	333 (30–2000)		0.037
Organic farming is a cost-effective way to produce				
Yes	26 (61.9)	40 (95.1)	13.859	<0.001
No	16 (38.1)	2 (4.8)		
Recording practices				
Insects and disease	5 (11.9)	25 (59.5)	20.741	<0.001
Revenue	20 (47.6)	35 (83.3)	11.850	0.001
Expenditure	20 (47.6)	36 (85.7)	13.714	<0.001
Seeds and planting stock				
Sources of seeds				
Purchased from suppliers	30 (71.4)	36 (85.6)	2.545	0.111
Received from family	8 (19.0)	2 (4.8)	4.086	0.043
Received from other farmers	4 (9.5)	1 (2.4)	1.914	0.360
Saved from harvest	36 (85.7)	41 (97.6)	3.991	0.136
Planting stock				
Suppliers	16 (38.1)	20 (47.6)	0.778	0.509
Use splits/bulbs/cuttings	33 (78.6)	38 (90.5)	2.275	0.131
IPM**				
Weed management				
Chemicals	14 (33.3)	1 (2.4)	13.716	<0.001
Hoe	22 (52.4)	33 (78.6)	6.372	0.012
Cutlass	8 (19.0)	16 (38.1)	3.733	0.053
Hand pull	11 (26.2)	0	12.658	<0.001
Pest management				
Biological	7 (16.7)	33 (78.6)	32.264	<0.001
Mechanical	1 (2.4)	11 (26.2)	9.762	0.008
Chemical	26 (61.9)	13 (31.0)	8.264	0.016
Physical	5 (11.9)	25 (59.5)	20.741	<0.001
Harvest and post-harvest practices				
Sanitize hands before working in the farm	9 (21.4)	35 (83.3)	32.264	<0.001
Sanitize hands before harvest	12 (28.6)	36 (85.7)	28.000	<0.001
Wash produce after harvest and before sale	8 (19.0)	27 (64.3)	17.682	<0.001
Use gloves while harvesting	10 (23.8)	40 (95.2)	44.471	<0.001
Soil fertility				
Type of input				
Chicken manure	4 (9.5)	18 (42.9)	12.070	0.001
Cow manure	6 (14.3)	23 (54.8)	15.220	<0.001

Table 2 (continued)

Practice	Pre-training, *n* (%)	Post-training, *n* (%)	χ^2 (df* = 1, $N = 42$)	*p* value
Pig manure	0	9 (21.4)	10.080	0.002
Green manure	10 (23.8)	28 (66.7)	15.570	<0.001
Compost	3 (7.1)	30 (71.4)	36.385	<0.001
Black soil	8 (19.0)	18 (42.9)	5.570	0.018
Crop burning	3 (7.1)	17 (40.5)	12.862	<0.001
Crop rotation	23 (54.8)	37 (88.1)	11.433	0.001
Use of PPE***				
Use gloves	16 (38.1)	42 (100.0)	37.655	<0.001
Wear boots	22 (52.4)	41 (97.6)	22.921	<0.001
Wear facemask	13 (31.0)	36 (85.7)	25.910	<0.001
Wear goggles	12 (28.6)	35 (83.3)	25.553	<0.001
Wear long sleeves	30 (71.4)	42 (100.0)	14.000	<0.001

X^2 = chi-square statistic, *degrees of freedom, **integrated pest, weed, and disease management, ***proper protective equipment

crops (11.9%). Less than half of farmers (47.6%) engaged in recording of expenditures related to farming practices. Likewise, 47.6% recorded earnings from crops. As shown in Table 2, 7 months post-training, farmers significantly increased recordkeeping of crop disease and insects, income earned, and expenditures.

Seed and planting stock practices

At pre-training, the majority of farmers reported obtaining seeds from a supplier (71.4%). Some received from family or other farmers (28.5%) and 16.7% from their own farm. Following training, though not statistically significant, more farmers tended to purchase seeds from suppliers (85.6%). However, from pre- to post-training, farmers increased their saving and using seeds from previous harvests (85.7% pre, 97.6% post). Farmers also increased their use of splits, bulbs, and plant cuttings for new plants (78.6% pre, 90.5% post).

Integrated pest, weed, and disease management

At pre-training, farmers primarily used chemical management for pests. Post-training, they significantly increased use of biological, mechanical, and physical methods and significantly decreased chemical pest management (Table 2). Regarding weed management, prior to training, farmers reported use of chemicals (33.3%), a hoe (52.4%), or cutlass (machete, 19%), or hand pulling (26.2%) to manage weeds. Seven months post-training, farmers were more likely to manage weeds with a hoe (78.6%) and cutlass (38.1%) than chemicals or hand pulling (Table 2).

Harvesting and post-harvesting practices

At pre-training, most farmers reported low sanitation practices. These included a small percent washing or sanitizing hands before working on the farm (21.4%) or harvesting (28.6%). In addition, only 19% washed produce after harvest and before sale and 23.8% reported wearing gloves during harvest. As seen in Table 2, 7 months post-training, sanitation practices significantly improved with respect to washing and sanitizing hands before working, washing hands before harvesting, washing produce before harvest and sale, and wearing gloves during harvest.

Soil fertility practices

A low percentage of farmers used specific organic techniques related to soil fertility at pre-training. These included use of chicken manure (9.5%), cow manure (14.3%), green manure and compost (26.2%), black soil (19%), and crop burning (7.1%). At pre-training, over half of farmers used crop rotation (54.8%). Seven months post-training, farmers significantly increased use of green manure and compost, and crop rotation (see Table 2).

Use of proper protective equipment

At pre-training, a low percentage of farmers reported use of proper protective equipment when using chemicals. These included gloves (38.1%), facemask (31.0%), and goggles (28.6%). A higher number of farmers wore boots (52.4%) and long sleeves (71.4%). Seven months after training, farmers significantly increased use of all proper protective equipment.

Predicting change in farming practices

Multiple logistic models were run with farming methods as outcome variables dichotomized as organic only and mixed practice and income level at pre-training, educational level, gender, age, and ownership as the predictors. None of these variables was found to be significant predictors of whether a farmer would convert from conventional farming methods to organic farming (Table 3).

Discussion

Farmers in a rural village in the eastern region of Ghana had a long-term desire to use organic methods for farming. Despite this desire, they continued to use agrochemicals in a dangerous and inefficient manner, some of which are very toxic to people, animals, and land. An NGO in the village implemented The Nkabom Organic Farming Project that provided training in organic methods and a starter kit of protective gear, recording books, and organic supplies. The purpose of this study was to evaluate the success of changes in farming practices from pre-training to 7 months post-training.

Table 3 Multiple variable logistic regression with land ownership, age, pre-training income, gender, and education as independent predictors of whether a farmer converts to organic methods

Independent variable	Estimate (*B*)	Standard error (S.E)	*p* value
Land owner (own)	−0.650	1.576	0.680
Income	−0.001	0.001	0.585
Age	0.098	0.073	0.176
Gender (male)	−2.709	2.044	0.185
Education (JHS)	0.375	1.960	0.848
Education (≥ SHS)	2.174	2.294	0.343
Intercept	−2.344	3.870	0.545

From the study, more male farmers participated than female. There are female farmers in the village, but women may be more likely to engage in commercial activities that the community undertakes such as gari production and selling at the market in combination with caring for the children. The females are mostly involved with processing of farm produce for sale while men are concerned with keeping the farms (GSS 2014). Education is an important tool for good farming practices. The level of education of the farmers was low as most of them had no education or attained basic education due to lack of opportunity. This is reflected in the poor keeping of farm records and the use of hazardous chemicals at pre-training. The farmers tended to use hazardous chemicals as most had challenges reading the labels because the labels were not in the local language, required literacy, or were in languages that no one in the community understood. When farmers were educated on recordkeeping and provided with the results for recording, the recordkeeping significantly increased.

Study results indicate that 92.9% of farmers were fully using organic methods 7 months after the training and they had significantly increased their reported monthly income. Significant changes in many practices were parts of this conversion. Farmers made significant changes in hygiene related to good agricultural practices, such as washing hands before work and harvesting, washing produce, and using gloves. Farmers made significant changes in recording of insects, disease, income, and expenditures that allowed them to track environmental and financial farm progress. Organic methods that improved soil fertility were significantly increased, including use of green manure, composting, and crop rotation. Farmers made significant changes in use of non-chemical methods for weed management such as hoeing and use of a cutlass (machete). Furthermore, significant changes were made towards organic integrated pest management with strategies such as growing certain plants to deter certain insects.

Following training, farmers were more likely to obtain seeds from suppliers than family or other farmers. This outcome is positive as farmers who must sell their produce for a living will mostly sell the healthiest produce to be able to make more money for survival. The less healthy plants may be saved for seeds, and hence, the family or other farmers' seeds for reuse tend to be of lower quality. Until the shift of saving quality seeds can

be realized, suppliers will be used to assure quality seeds. Additionally, small-scale farmers have limited experience with proper methods for seed storage (Wambugu et al. 2009; Bishaw et al. 2012) and they, therefore, use improper methods which yield less seed quality. Also, during discussions with many of the farmers in Okurase village, they identified that their seed-saving techniques did not select for the best plants or the most disease resistant. They often saved what seeds were left in the field. This is in line with many farmers who had systematically been saving poor-quality seeds season after season and reducing the quality of the yield, the amount of actual yield, and the predictability of their yields (Thurow 2012).

Once farmers have been trained on saving quality seeds and proper storage methods, they can trust their own methods of saving seeds and that of suppliers. Farmers tended to purchase seeds from suppliers that are designed for conventional, high-input operations. The tendency to purchase available seeds speaks to the issue of low availability of organic seeds and quality organic-based supplies such as naturally derived soil amendments and fertilizers. Availability and cost of organic supplies are issues that must be resolved to support the farmers who continued the use of organic methods.

It should be noted that 7 months after training, 31% of farmers reported use of chemicals for pest management as compared to 61.9% pre-training. This outcome is positive as farmers were supplied with neem oil post-training and they reported use of the neem oil as use of chemicals for pest management. Neem oil, although natural, is considered a chemical spray and non-hazardous. This is consistent with the conversion to growing solely organic. Also encouraging is that farmers who used the neem oil spray were wearing proper protective equipment.

Organic farming is becoming more valuable and as a result there have been many studies on training programs around the world (Dubey and Srivastava 2016; Damalas and Koutroubas 2017; Pan et al. 2017; Tiraieyari et al. 2017) and manuals for training on the public domain (e.g., Weidmann and Kilcher 2011). For the Nkabom Organic Farming Project, the training was based on the farmer's relationship with the local NGO, their long-time desire to convert to organic farming but also listening to them regarding their existing knowledge and what they viewed as their need. In addition, farmers needed resources to get started on organic farming but their income did not allow them to purchase additional items such as personal protective equipment or botanicals. The provision of comprehensive training in organic methods and a jump start on supplies and protective gear was highly successful for rural farmers in Ghana who had not been able to convert to organics despite their desire to do so. It is critical to keep in mind that this training was not a regional training using standard manuals that are supposed to apply to multiple countries and contexts. Key to the success was that the training was tailored to the community context, the desires and needs of these particular farmers, their particular gaps in knowledge, respect for the local culture, and with the capacity to demonstrate techniques hands-on in a local demonstration organic garden. The strength among the farmers was being very serious about the training and taking the methods forward on their own farms. The farmers were aware that organic farming is in African farmers' roots and heritage and wanted to follow that heritage. With skills training and support, and development of an affordable market for organic farming inputs and supplies, farmers in rural Africa can convert to organic methods and contribute to nutrition, health, and safety of themselves and their community.

Limitations

Several limitations are important to note. First, the study did not involve a control group. Thus, it is not possible to rule out explanations for improvements other than the organic farming training. Second, the study sample was small ($N = 42$) and a larger scale study could yield different outcomes. Third, the sample was primarily male and so it is not clear if the results generalize to women farmers. Finally, the training included a knowledge examination. This was not planned to be a part of the research but more a strategy to understand gaps in farmer's knowledge to assist the training. The knowledge examination could have been helpful to report in the research.

Future directions

Given the current challenges to global food security, especially in low-income countries, and the effects of synthetic agrochemical-based farming on the environment, this study provides a basis that organic farming is

the option to solving these challenges. Farmers generally appreciate the benefits of organic farming. This study demonstrated that farmers are also ready to adopt good farming practices. However, there is lack of support, investment, and capacity building for many farmers. For a group of motivated farmers with whom an NGO has a relationship, advanced preparation of a local farmer and provision of 4 days of training and a "starter kit" is not an expensive undertaking and the outcome in terms of health and conservation of the land should far outweigh the costs of implementation. In addition, with a supportive NGO-farmer relationship, organic training can be the start of a ripple effect. In the case of the Nkabom Organic Farming Project, farmers have sought out additional education. They recently completed training with Ghana Green Label and are working towards certification. Also, Okurase farmers have been central to recent extensive tree planting in the community as education from a trainer associated with the Ghana Forestry Commission helped them learn the importance of tree planting to mitigating climate change and helping with crop production (Ndukwe et al. 2017).

We recommend scaling up training of farmers on organic farming practices and provision of resource support. In addition, to sustain organic farming in the long term, it is essential to develop supply chains of affordable organic resources which can help people in rural areas obtain supplies and support farmers in diversifying markets for sales. With regard to research, future studies should consider organic and non-organic farmers working side-by-side and how they solve potential conflicts. Furthermore, it would be helpful to understand why farmers do not uptake training in organic methods when that training is available and the impact of peer-to-peer learning.

Okurase farmers showed that they are ready to adopt good farming practices and lead. Supporting such small rural farmers with the information and resources they need to elevate to innovative organic-based farming practices may indeed significantly and positively impact health and food security.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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