Quarterly Journal of International Agriculture 53 (2014), No. 1: 73-88

The Effects of Integrated Pest Management Techniques Farmer Field Schools on Groundnut Productivity: Evidence from Ghana

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Abstract

This study examines the impact of Integrated Pest Management-Farmer Field School (IPM-FFS) programs on groundnut productivity in Ghana. The program is conducted in the groundnut growing regions of Ghana with the goal to improve groundnut agriculture through the dissemination of information and technology to the producers. We use household data collected in 2011 from multiple villages with and without FFS sites. Treatment effects models are used to control for endogenous selection into FFS participation. The results suggest that farmers who participated in the IPM-FFS program have higher groundnut yields.

Keywords: Farmer Field School, Integrated Pest Management, groundnut, Ghana, treatment effects model
JEL: O13, Q16

1 Introduction

Groundnut is an important crop for both household consumption and cash crop purposes in Ghana (DEBRAH and WALIYAR, 1996). In 2010, groundnut production in Ghana was two and a half times greater than at the beginning of the decade. The sharp rise in production is due to a 75% increase in harvested area and a 50% increase in yield during the same decade (FAOSTAT, 2012). However, several biotic and abiotic stresses, including aflatoxin, Rosette virus, and pests, still limit groundnut output (ATTUAHENE-AMANKWAH, HOSSAIN and ASIBI, 1990). The integrated pest management (IPM) Farmer Field School (FFS) program was initiated as a direct response to the need to combat these agricultural stresses.

Farmer Field Schools are an adult education program used to disseminate information and technology to farmers and allow farmers to share their knowledge with other local farmers (VAN DEN BERG, 2004). It is an interactive and participatory model used for IPM methods that is present around the world, but is particularly common in many developing countries. Today the program covers a variety of farming practices and focuses on the major crops of sub-Saharan Africa (SSA), Asia, and Latin America.[1] With the large undeveloped land area in SSA, the FFS model is used as an effective way to reach remote villages with little development on social, health, and agricultural topics (BRAUN et al., 2006). There have been several studies looking at the effectiveness of FFS with mixed results; some studies find no long-term effects (PRANEETVATAKUL and WAIBEL, 2006; FEDER, MURGAI and QUIZON, 2004; FERNADEZ-CORNEJO, 1996) and others find positive effects (YOROBE, REJESUS and HAMMIG, 2011; GODTLAND et al., 2003). Recent research highlights the need for more studies as the outcomes of these programs are very crop and location specific (e.g. GODTLAND et al., 2003; BRAUN et al., 2006).

While FFS provide training on multiple aspects of crop production, the purpose of this paper is to evaluate the impact of Ghana's IPM-FFS on groundnut yield. We focus on yield improvement since it is one of the most important goals of agricultural research on developing countries. With the growth of Ghana's groundnut production and the IPM-FFS program presence, it is important to determine if the program is contributing to enhanced productivity. While most of the impact studies to date evaluate IPM programs on pesticide use, to our knowledge, there are no prior studies that focus on groundnut yields in Western Africa. We use a unique household dataset collected from Central and Southern Ghana in 2011 which includes villages where FFSs were conducted as well as villages that had no FFS presence to provide a comparison group of farmers.

A treatment effects model is used to address endogenous selection and issues that arise from the fact that program participation is an individual farmer decision to better evaluate the impact of the program. This model is chosen for this ex-post evaluation, because the evaluation did not have control over the assignment of farmers to the program. In addition, several alternative specifications and identifications strategies are also considered.

The rest of the paper is organized as follows. Section two provides a literature review on FFS impacts including studies focusing on Ghana. The FFS experience in Ghana, along with the data collection method and a description of the data, are presented in section three. The model used is discussed in section four. Results and conclusions are provided in sections five and six, respectively.

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[1] The model is also used to spread information on non-agricultural topics such as HIV/AIDS, water conservation, food security, and nutrition (BRAUN et al., 2006).

2 Farmer Field School Literature Review

Although there is an extensive literature on FFS and a variety of analysis reporting its impact on developing countries, the literature is spread thin among crops and regions. Studies generally focus their analysis on the impact of FFS participants against non-participants to examine the effects of FFSs on knowledge, pesticide use, production, income, or poverty (DAVIS et al., 2010; YOROBE, REJESUS and HAMMIG, 2011; GODTLAND et al., 2003). Several methods have been used in previous studies, including instrumental variable (IV) procedures, propensity score matching (PSM), and difference-in-difference (DiD), with most studies accounting for selection and endogeneity bias. Evidence from these studies provides mixed results about the significance of FFS impacts in developing countries. The results differ depending on the setting, evaluation methods, and the assumptions used in the evaluation (GODTLAND et al., 2003).

Most FFS impact studies focus on the impact of the adoption of certain farming practices and input decisions. YOROBE, REJESUS and HAMMIG (2011) use an IV model and find that FFS onion farmers in the Philippines have significantly lower insecticide expenditure compared to non-FFS farmers. GODTLAND et al. (2009) use cross sectional data with PSM and regression analysis methods and find a positive impact of FFS on potato production and IPM knowledge in the Peruvian Andes. FERNANDEZ-CORNEJO (1996) finds that IPM-FFS lower insecticide use in the U.S., causing a small effect on profits, but no effect on yields. In a study conducted by the International Food Policy Research Institute (IFPRI), FFS data was evaluated for Tanzania, Kenya, and Uganda (using a DiD and PSM approaches) to analyze overall effectiveness of the FFS on the farmers' total agricultural productivity in East Africa. The study found an overall significant effect on production and poverty, but found mixed results when broken down by country (DAVIS et al., 2010). Mixed results were also found by FEDER, MURGAI and QUIZON (2004) using a panel data set through a DiD approach to FFSs in Indonesia with no significant impact from FFSs on farmers. While using the same data on insecticide use and productivity, YAMAKAZI and RESOSUDARMO (2008) found an increase in short term rice yields, which were not maintained in the long run.

Some studies assume dissemination of knowledge from a participant to a non-participant in FFS which can alter the measured impact of the program. Studies in Cambodia and Sri Lanka illustrate a situation where information from the FFS did not disseminate throughout the region. The pesticide expenditure was the same for farmers despite no FFS presence in their village (VAN DUUREN, 2003; TRIPP, WIJERATNE and PIYADASA, 2005). While no significant differences were found in Cambodia and Sri Lanka, an assortment of cotton IPM studies showed a 39% reduction in pesticide use for FFS farmers and 26% for neighboring farmers compared to the control group

(BRAUN et al., 2006). FFS participants increased their yield by 10% while simultaneously decreasing their pesticide expenditure.

3 Farmer Field Schools in Ghana

In 2002, groundnut FFSs began at Hiawoanu, in the Ejura-Sekyedumasi district of Ghana, involving farmers from Bonyon, Hiawoanwu, Ejura, and Dromankuma. This location was chosen to initiate the FFS program because of the severity of the damage groundnuts faced from pests and diseases documented from an initial survey (DANKYI et al., 2007). In 2002, a station at Ejura was selected to be the first site for the program for proper supervision with plans to increase to more locations. Each farmer was taken through land preparation, production practices, plant health, seed selection, site selection, and post-harvest handling (DANKYI et al., 2007). After a successful first year in Hiawoanwu, the FFS program expanded to Derma and Atebubu in the Brong Ahafo region as well as the Somanya area of Eastern region. The new sites were selected due to their popular production in groundnuts and groundnut production constraints similar to the initial region (DANKYI et al., 2007). A total of US $58,000 was spent on FFS during the 2002-2010 period with $4,000 per year during 2002 and 2003, $6,000 per year during 2004 and 2005, $7,000 per year during 2006 and 2007, and $8,000 per year during the 2008-2010 period.

During the initial FFS year, in consultation with the Ministry of Food and Agriculture, groundnut farmers were contacted to attend a meeting in order to learn about the purpose of FFS. After the meeting, some farmers volunteered to participate in the program. The first year was limited to 40 farmers, proportionately representing both genders, in order to make the program manageable and effective (DANKYI et al., 2007). No other selection criteria were used and any farmers who did not participate were able to participate in the FFS in later years. IPM-FFS on groundnut production in Southern Ghana has continuously been operating since 2002 and has trained approximately 3,000 farmers through 2011 with technologies from the Council for Scientific and Industrial Research- Crops Research Institute (CSIR-CRI) and Peanut Collaborative Research Support Program (PCRSP) (DANKYI et al., 2007).

There is one previous study that analyzed the groundnut FFSs in Ghana. An early assessment of the groundnut FFSs that implemented PCRSP technology was conducted in 2007. The study focused around one of the early districts to deploy FFS, Ejura-Sekyedumase, and consisted of 28 FFS participants in the 120 farmer survey. The study found higher adoption rates of agronomic practices relevant to groundnuts, such as land preparation and pest management, paired with greater social-economic indicators for FFS participants (DANKYI et al., 2007). The study relied mainly on descriptive statistics without controlling for self-selection issues.

4 Data

For the purpose of this study, data were collected from the Ashanti, Brong Ahafo, and Eastern regions of Ghana. All three regions are common areas for groundnut production and contain villages that participated in FFS and PCRSP activities. The three regions also spread throughout three ecological zones: Forest, Coastal Savannah, and Transitional. Household surveys were used to collect the data in 2011 in six FFS and six non-FFS villages. The six FFS villages for the study are: Hiawoanwu, Bonyon, Kasei, Atebubu, Derma, and Somanya.

The non-FFS villages were randomly selected by compiling a list of all villages that are within a 10 mile radius of each FFS village. Enumerators collaborated with the agricultural extension officer to compile the lists of non-FFS villages within the designated radius of each FFS village. After the list was compiled, each village was given a number from one to the total number of villages. The village numbers were then randomly chosen to decide which village would participate in the household survey. If the village chosen was too small for our sample, less than 30 households, it was discarded and another village was chosen. The following non-FFS villages participated in the household surveys: Monta, Konkoma, Aberewa Ano, Mensuo, and New Somenya.

Thirty households were randomly chosen from each FFS and non-FFS village. Enumerators and the agricultural extension officer compiled a list of groundnut farmers in each village with each farmer receiving a different number. An enumerator chose a random number between 1 and 10 to decide the initial house in which to conduct the household survey. Every fifth household after the initial house on the list was then chosen for the household survey until a total of 30 households were selected. Within each household, all members who are primary cultivators of groundnuts were interviewed and completed a separate household survey.

The distribution of respondents separated into FFS villages and non-FFS villages are included in Table 1. The classification of an FFS village is where the program took place. It does not mean that FFS is limited to the farmers of that village and producers from neighboring villages cannot travel and participate in a FFS class. In fact, 16 farmers participating in the questionnaire from non-FFS villages attended the FFS. These farmers may learn about the FFS from their colleagues and relatives and travel to the villages that offer training. Survey questions ranged from demographics, seed choices, planting decisions, disease and pest control, varieties, and production. The variables used in this study along with their definitions are included in Table 2. The survey questions were carefully selected to measure qualitative and quantitative indicators. Local partners familiar with the PCRSP and FFS programs were consulted to validate the relevancy of each question. After consulting with the local partners, local enumerators pre-tested the questionnaire by randomly selecting groundnut farmers.

Table 1. Sample of households surveyed

	FFS Village	Non-FFS Village	Total
Villages	6	6	12
FFS Participants	72	16	88
Non-FFS Participants	105	164	269
Percent Participating	41	9	25

Source: authors' household survey

Table 2. Definition of variables

Variable	Definition
Yield	2010 Groundnut production (50kg bags/acre)
FFS Farmer	=1 if farmer participated in program, =0 otherwise
Age	Farmers age (years)
Education	Highest education level of the head of household
Household Head	=1 if head of household is respondent, =0 otherwise
Household Size	Number of people living in the household
Year Growing Peanuts	Total years growing groundnuts
Total Farm Acres	Total acreage of the farm
Distance to Market	Distance of house from the main market
Distance to Extension	Distance of house to extension office
Distance to Field	Distance of house to groundnut field
Improved Variety	=1 if farmer uses an improved variety, =0 otherwise
Seed Replacement	=1 if farmer uses seed replacement, =0 otherwise
Monitor Field	=1 if farmer monitors field for pests several times, =0 otherwise
Fungicides	=1 if farmer uses fungicides, =0 otherwise
Plant Extracts	=1 if farmer uses plant extracts, =0 otherwise
Weeding	=1 if farmer does hand weeding, =0 otherwise
Soap Spraying	=1 if farmer sprays with soap, =0 otherwise
Visits from Extension Officer	Visits from extension officer to the farmer in last 2 years

Source: authors' household survey

A variety of agronomic practices are taught in the groundnut IPM-FFS program including site selection, soil assessment, seed testing, proper pesticide use, and disease management. Within the survey, data were collected on the source of information that the farmers received about different IPM practices. The survey asked for the primary sources of information, but it allowed farmers to name multiple sources. An earlier study compared the differences in the quality of practice and found that farmers who claimed FFS as their information source were more likely to perform the agronomic practice properly compared to farmers who learned from other sources (DANKYI et al., 2007).

FFS farmers comprised about 25% of the survey population. For each of the agronomic practices, 17-20% claim FFS as their primary source of information. This is a significant source, since it is likely that some farmers would have information on a few agronomic practices upon participating in the FFS class. Therefore, around 75% of the FFS farmers who participated in the survey learned something new from the FFS class for each agronomic practice.

The non-FFS villages were chosen to be representative and similar to the FFS villages participating in the household survey. The summary statistics for the variables included in the study are presented in Table 3. There are similarities and differences between the FFS and non-FFS farmers which are shown by the p value of a t-test of equality between the means of the variables associated with FFS and non-FFS farmers. One difference is that education is greater for FFS participants, but the average for both groups is still within primary school completion. With the education level that low, it is unlikely to see any strong association between the years of education and FFS participation, (GODTLAND et al., 2003). Second, the visits to and from the extension office are much higher for FFS participants. One possibility is that farmers who interact with the extension office are more likely to know about the FFS school and thus more likely to participate in the program. A second possibility is that farmers interact more with the extension office after they participate in the FFS program. The data collected on the interaction between farmers and the extension office covers a two-year period, 2010 and 2011 and therefore we are unable to identify the underlying cause.

The survey also collected information on improved varieties and the agro ecology of each village (Forest, Coastal Savannah, and Transitional). Finally there are also several distance variables such as distance to extension, distance to market and distance to field. These variables are likely to impact FFS participation but not impact yield. These covariates were selected *apriori* and are consistent with previous studies (YOROBE, REJESUS and HAMMIG, 2011; FEDER, MURGAI and QUIZON, 2004; RICKER-GILBERT et al., 2008; REJESUS et al., 2009). Previous studies typically find the distance to road to be negatively related to FFS participation, but there are mixed results reported for the distance to extension since many FFS demonstration plots are not located at the extension office (YOROBE, REJESUS and HAMMIG, 2011; GODTLAND et al., 2003).

Table 3. Summary statistics-mean (standard deviation)

	All Sample		FFS Farmer		Non-FFS Farmer		T-test
Variable	Mean	S. D.	Mean	S. D.	Mean	S. D.	*p* value
Yield	5.98	3.41	6.28	3.44	5.89	3.40	0.330
Seed Replacement	0.59	0.49	0.77	0.42	0.53	0.50	0.001
Improved Variety	0.29	0.46	0.25	0.44	0.31	0.46	0.296
Soap Spraying	0.12	0.33	0.44	0.50	0.02	0.14	0.001
Monitor Field	0.06	0.24	0.05	0.21	0.06	0.24	0.540
Fungicides	0.02	0.15	0.03	0.18	0.02	0.14	0.395
Weeding	0.10	0.29	0.01	0.11	0.12	0.33	0.002
Plant Extracts	0.01	0.07	0.01	0.11	0.00	0.06	0.405
Household Head	0.65	0.48	0.60	0.49	0.66	0.47	0.344
Household Size	8.74	3.14	8.94	3.06	8.68	3.17	0.473
Age	45.65	14.72	46.36	13.37	45.42	15.15	0.586
Years Growing Peanuts	12.53	10.23	13.23	10.68	12.31	10.09	0.459
Education	4.12	5.15	6.17	5.88	3.44	4.70	0.001
Total Farm Acres	5.25	4.41	5.68	5.00	5.11	4.20	0.290
Distance to Extension	5.08	3.73	4.37	3.33	5.31	3.83	0.042
Visits from Extension	7.01	12.14	12.39	14.94	5.24	10.51	0.001
Distance to Market	5.18	3.78	4.43	3.47	5.43	3.84	0.033
Distance to Field	2.04	1.75	2.16	1.87	2.00	1.71	0.497
Number of Observations	356		88		268		

Source: authors' household survey

5 Methodology

In this paper, the Heckman treatment effects model is used to obtain consistent estimates of the impact of FFS. The need for the use of a treatment effects model in our case comes as a result of potential endogeneity and/or selection bias and the fact that program participation is an individual farmer decision. More specifically, unobserved covariates (e.g. unobserved management ability, skills) can be correlated with the decision to participate in the FFS program (which is voluntary) and also with yield, which is the outcome variable. If unobserved variables are correlated with the decision to participate and the outcome variable, then we cannot use ordinary least squares (OLS) to estimate the effects of FFS on yields since OLS cannot account for endogeneity.

Previous literature on impact evaluation (e.g. YOROBE, REJESUS and HAMMIG, 2011; FEDER, MURGAI and QUIZON, 2004; RICKER-GILBERT et al., 2008) uses distance to road and distance to extension as instruments, however, distance from farms to roads and extension offices could well be correlated with farmer unobservables. In our case, we use presence of FFS schools in the village as an instrument. The instrument needs to satisfy two restrictions; it needs to be correlated with farmer's program participation, but conditionally uncorrelated with farmer unobservable characteristics that affect yields of groundnuts. As seen in Table 1, farmer participation in the program in villages with an FFS site is far greater than that in villages without a site (40.7% vs. 8.9%), thus site presence is a strong predictor of participation. If FFS sites had been randomly assigned to locations, then the presence of an FFS site in the farmer's village would certainly satisfy the second restriction by design. Sites were not assigned randomly, but their location was decided by the FFS program coordinators in the early to mid 2000s. A few points are of interest. First, no individual famer could influence the location of FFS sites, so they are exogenous to individual farmers in this sense. Yet, they could be correlated with unobservable area characteristics that also affect yields. However, location decisions were made a few years before our survey, by focusing on areas that were somewhat worse off in terms of loss due to pests/disease. Thus assignment of sites was made based on fixed general area or region characteristics and they are unlikely to depend systematically on time varying area or specific village attributes. Adding area fixed effects to both equations, in addition to other farmer and site observables (e.g. distance from this market and extension offices) thus helps satisfy the assumption that site presence is conditionally uncorrelated with village-level unobservables that affect yields.

5.1 Treatment Effects Model

The treatment effect model is a two-part model that accounts for the correlation of the error terms of the participation and outcome equation with two stages of regression. The first stage is the participation equation

$$P_i^* = \gamma Z_i + \mu_i \tag{1}$$

which determines the value of participation by

$$P_i = \begin{cases} 1 \; if \; P_i^* > 0 \\ 0 \; if \; P_i^* \leq 0 \end{cases} \tag{2}$$

where P_i^* is a latent continuous index measuring the net utility associated with program participation for the i_{th} farmer and Z_i is a vector of characteristics which affect participation but are uncorrelated to outcome equation error term. In the participation equation, γ is a vector of parameters to be estimated and μ_i is a random error term.

The second stage of the model is the outcome equation

$$Y_i = \beta X_i + \alpha P_i + \varepsilon_i \tag{3}$$

where Y_i is the measure of yields (unshelled groundnut sacks/acre) for each producer, X_i is a vector of observable control covariates (e.g., education, age, experience), P_i represents whether the farmer participated in FFS program and ε_i is a random error term. The treatment effect is derived from the estimation of coefficient α. The selection bias occurs in the model when ε_i and μ_i are correlated.

In order to determine the causal treatment effects of FFS participation, Equation (3) can be expressed into two equations:

$$Y_i^0 = \beta X_i + \varepsilon_{1i} \tag{4}$$

$$Y_i^1 = \beta X_i + \alpha + \varepsilon_{2i} \tag{5}$$

Where Y_i^0 is the yield for farmers who did not participate in FFS and Y_i^1 is the yield of FFS farmers. The causal difference, α, from the treatment is found by taking the difference: Y_i^1-Y_i^0.

Since the dependent variable is observed for both Equations (4) and (5), the regression can be run simultaneously as one equation.

In this model there are two assumptions that are required by the model:

$$(\varepsilon, \mu) \sim N(0,0,\sigma_\varepsilon^2, \sigma_\mu^2, \rho_{\epsilon\mu}) \tag{6}$$

$$(\varepsilon, \mu) \text{is independent of X and Z} \tag{7}$$

Equation (6) assumes that both error terms are normally distributed where the mean of each term is zero and the error terms are correlated with $\rho_{\varepsilon\mu}$ the correlation coefficient. The second assumption, (7), states the error terms are independent from the explanatory variables. Finally, without loss of generality the variance of μ is normalized to one (Var(μ)= σ^2_μ=1) (HECKMAN, 1979). The treatment effects model can be estimated using a two-step procedure or a maximum likelihood estimator. We choose the maximum likelihood estimator.[2]

[2] We also estimate the model using the two-step procedure and the results are very similar to the maximum likelihood procedure. Results are available from the authors upon request.

In this study, we use several control variables including demographics (household head, number of family members, age, years growing peanuts, education, total acres (a proxy for wealth)), and controls for distance (distance to main market, distance to extension office, visits from extension officer, and distance from field to house). These variables are also observed in previous FFS studies (e.g. GODTLAND et al., 2003; YOROBE, REJESUS and HAMMIG, 2001).

In addition, we use controls for agronomic practices (seed replacement, improved varieties, soap treatment, monitor field, fungicide treatment, weed control, the use of plant extracts) as an additional test of our identification strategy. Initially the model is estimated without these 'mediators' and then we include them to see if they explain part of the effect.

6 Results

The main results from the treatment effects model are presented in Table 5. Two sets of results are presented, one without fixed effects (second column) and one with fixed effects (third column). In both specifications, the treatment effect on farmers that participated in FFS training (FFS Farmer) is found to be positive and significant attributing an impact of approximately 3 bags of groundnuts per acre to the treatment. Results also indicate that age, household head status, experience, distance to field, and distance to market are statistically significant only in the model without fixed effects while only experience is statistically significant in both models (with and without fixed effects).

Each specification results in a statistically significant Chi Square ($p<0.001$) (Wald test of all coefficients in the regression (besides the constant) being zero), verifying the goodness of fit. More importantly, the ratio test which compares the joint likelihood of an independent probit model for the selection equation and regression equation on the observed data suggests that the treatment effect model is appropriate for both cases.[3] The specification with area fixed effects is more suitable since it controls for some of the systemic differences (all of which could affect general performance of farmers in these villages) and ensures that they are not at play, and are not misattributed as impact of the training.

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[3] We also estimated models where we decompose FFS farmers by the year of training. About 70% of the farmers attended FFS during 2008, 2009 and 2010. Results are very similar to the main specification and generally the returns for farmers that have attended FFS more recently are slightly higher than the ones that were trained earlier.

Table 5. Treatment effects model

	Without Fixed Effects		With Fixed Effects	
Household Head	0.96 **	0.41	0.62	0.40
Age	0.03 **	0.02	0.02	0.01
Household Size	0.08	0.06	0.04	0.06
Years Growing Peanuts	-0.06 ***	0.02	-0.04 **	0.02
Education	-0.03	0.04	-0.01	0.04
Total Farm Acres	-0.06	0.05	-0.03	0.05
Distance to Market	0.20 **	0.09	0.08	0.09
Distance to Extension	0.13	0.09	0.05	0.09
Visits from Extension	0.01	0.02	0.00	0.02
Distance Field to House	0.30 ***	0.10	0.15	0.10
FFS Farmer	3.74 ***	1.26	2.99 **	1.33
Constant	1.13	0.80	3.77	0.95
Rho	-0.78 ***		-0.66 ***	
Lambda	-2.16		-1.77	
Chi Square	87.07 ***		143.74 ***	
Observations	356		356	

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%.
Source: authors' household survey

In the results from the model without fixed effects, one of the variables indicated a different direction than might be expected. This is the negative estimate on experience. Experience is measured as the number of years planting groundnuts, but does not account for experience with other crops. Therefore, a farmer's knowledge on agri-culture might not be completely captured in their groundnut experience. In addition, it could be the case that younger farmers, with fewer years of experience with growing crops may be more interested to learn about new production practices. However, the magnitude of the coefficient on experience is very small.

It is also important to look at the rho coefficient for each treatment effect model. The coefficient indicates the level of correlation between the error term in the participation equation and outcome equation. In each treatment effect model, the rho is statistically significant at that the one percent level, the null hypothesis that the correlation is equal to zero is rejected, providing further support for the use of the treatment effects model.

Two more variations of the treatment effects model are displayed in the Appendix (Table 1A) to better understand the impact of participating in FFS. Both specifications include additional variables for agronomic practices (seed replacement, improved varieties, soap treatment, monitor field, fungicide treatment, weed control and the use of plant extracts). Again we estimate the model with and without fixed effects. As mentioned above, these 'mediators' are included as an additional test of our identification strategy. Ideally we would expect the magnitude on the FFS farmer participants to decrease as we include additional variables for control practices. Results in Table 1A indicate that, in both models, there is a statistically significant treatment effect and the magnitude of the effects is lower compared to the main specification above.

Finally, we also provide some rough estimates on returns to agricultural research based on our main results. Considering the average household peanut planted acreage of 1.5 acre in our study sample and the fact that 3,000 farmers have attended FFS until 2011, the average annual return (assuming that half of the attendees follow the FFS practices) based on 2010 prices is about $US 675 thousand. Thus, the cost benefit ratio is more than tenfold, suggesting that the FFS program has been effective in generating benefits to farmers and it is a useful tool for disseminating improved agronomic practices in developing countries.[4]

7 Conclusions

This study attempts to shed light on the yield advantages for farmers who participated in groundnut IPM-FFSs in Ghana. Using a treatment effects model we find that farmers who participate in groundnut IPM-FFS have higher yield levels than non-FFS farmers.

The results of this paper suggest that FFSs are an effective tool to spread information and technologies as well as being a medium for farmers to collaborate and share knowledge that increase groundnut yield in constrained geographic areas. The information and lessons learned in FFS are having a direct effect on the program's goals suggesting that FFSs are a good tool that agricultural development institutions can use to spread information and technologies to remote areas of developing countries. In addition, we find significant returns to the overall FFS training costs encouraging continued and increased support for these types of programs.

Along with the contributions of this study, there are areas for future work on quantifying the impact of FFSs. Several areas of future work include analysis on other outcome

[4] The calculations assume a 5% discount rate for the costs related to FFS training from 2002 until 2010 as detailed data was available for each year.

variables and the effect on the region's other crops. Also, research on the long-term effects of FFS is an important topic for further research.

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Appendix

Table 1A. Variations in treatment effect model

	Without Fixed Effects		With Fixed Effects	
Seed Replacement	-0.34	0.40	-0.19	0.39
Improved Variety	-0.28	0.41	-0.30	0.41
Soap Spraying	-0.85	0.83	-0.69	0.80
Monitor Field	2.18 ***	0.77	1.71 **	0.74
Fungicides	0.85	1.17	0.66	1.10
Weed Control	-0.82	0.61	-0.48	0.59
Plant Extracts	-0.67	2.30	-2.20	2.18
Household Head	1.06 ***	0.40	0.74 *	0.39
Age	0.04 **	0.01	0.02 *	0.01
Household Size	0.07	0.06	0.04	0.06
Years Growing Peanuts	-0.06 ***	0.02	-0.04 **	0.02
Education	-0.03	0.04	-0.01	0.04
Total Farm Acres	-0.03	0.05	-0.01	0.04
Distance to Market	0.16 *	0.09	0.06	0.08
Distance to Extension	0.10	0.09	0.03	0.09
Visits from Extension	0.00	0.02	-0.01	0.02
Distance Field to House	0.30 ***	0.10	0.16	0.10
FFS Farmer	3.32 ***	0.98	2.78 ***	0.96
Constant	1.51 *	0.81	3.77	0.96
Rho	-0.90 ***		-0.78 ***	
Lambda	-2.28		-1.96	
Chi Square	115.73 ***		163.84 ***	
Observations	356		356	

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%

Source: author' calculation