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FARMER KNOWLEDGE AS AN EARLY INDICATOR OF IPM ADOPTION: A CASE STUDY FROM COCOA FARMER FIELD SCHOOLS IN GHANA

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ABSTRACT

Researchers assessing post-training adoption of integrated crop and pest management (ICPM) practices in perennial crops face methodological challenges in measuring yield, an expected outcome of improving farmers' knowledge and decision-making capacity. This paper proposes using post-training farmer knowledge as an early indicator of ICPM adoption. Based on knowledge test scores from Ghanaian farmers who graduated from farmer field schools (FFS) on cocoa ICPM, the study show that the training exposed participants to agro-ecological principles and knowledge about biological processes (e.g. what causes black pod disease and how it spreads) not known by most Ghanaian cocoa farmers and suggests that improved knowledge is likely to translate to improved practice. The paper calls for additional research to confirm these findings with field-based data on how effectively farmers apply ICPM practices and discusses some of the circumstances and conditions where farmer knowledge may be a useful indicator of adoption.

Key words: IPM, farmer field schools, cocoa, impact assessment

INTRODUCTION

The farmer field school (FFS) approach was originally designed as a capacity-building investment to improve farmers' knowledge and decision-making skills and foster empowerment. FFS are now widely used to train farmers on diverse topics such as integrated production and pest management (IPPM) of annual and perennial crops, soil management, livestock production, gender awareness and HIV/AIDS (Braun, Jiggins, Röling, van den Berg, and Snijders 2006).As the approach grows in popularity world wide, more attention is being paid to assessing its impact (Braun et al, 2006; van Berg, 2004). Reflecting the flexibility of the FFS approach, which has resulted in it being adapted for various objectives, no framework or methodological guidelines for impact assessment have been developed. Van Berg (2004) groups impact from integrated pest management (IPM) FFS into 3 domains: technical, social and political, and identifies a number of immediate and developmental impacts (Table 1).

Table 1: Some immediate and developmental impacts of IPM farmer field schools

Domain	Immediate impact	Developmental impact
Technical	▪ Knowledge about ecology ▪ Experimentation skills ▪ Improved crop management ▪ Pesticide reduction ▪ Yield increase ▪ Profit increase ▪ Risk reduction	▪ More sustainable production ▪ Improved livelihoods ▪ Ability to deal with risks, opportunities ▪ Innovation ▪ More cost-effective production ▪ Improved biodiversity ▪ Poverty reduction
Social	▪ Group building ▪ Communication skills ▪ Problem solving skills	▪ Collaboration between farmers ▪ Farmer associations ▪ Community agenda setting ▪ Formation of networks ▪ Farmer-to-farmer extension
Political	▪ Farmer-extension linkage ▪ Negotiation skills ▪ Educational skills	▪ Stronger access to service providers ▪ Improved leverage position ▪ Awareness campaign ▪ Protests ▪ Policy change

Source: van Berg, 2004

The desired outcome of IPM FFS is an improvement in farmers' knowledge and decision-making capacity which is expected to lead to a change in input mix and practices used leading to yield increase, lower pesticide use and ultimately, higher farm profits. But as van Berg and Jiggins (2007) note in the context of a review of IPM FFS:

The FFS curricula often have been designed to achieve more than increasing farmers' technical capabilities, and have sought to enhance their educational, social, and political capabilities. This raises the question of what should be considered an impact: the immediate impacts on farmer knowledge, decision capabilities, pesticide use or yield, reduced poisoning, for instance or broader developmental impacts such as innovation, community agenda setting, or policy change?

A review of the IPM FFS impact literature reveals a predominant focus on input use, yield and productivity as impact parameters, with less attention paid to changes in farmers' knowledge and the decision-making skills needed to implement IPM practices. Reasons for the emphasis on production related impacts include a perception and implementation of FFS as a technology transfer approach, methodological difficulties in quantifying and measuring decision making skills and time pressure for concluding impact studies (Braun et al., 2006; van Berg and Jiggins 2007). But despite the near universal reliance on yield as the principal indicator of FFS success, the FFS literature mentions little about difficulties in measuring this parameter.

Besides crop management, multiple factors, including climatic and other abiotic and biotic conditions affect crop yields, making it difficult to link improved productivity to FFS training. There may also be crop specific challenges in measuring yield improvement as an FFS impact. Not being able to assess yields over a full cropping cycle during the course of the FFS, determining an appropriate post-training time lag for assessing yield and difficulties in obtaining accurate yield data in situations where farmers do not know their farm size and have large, multiple, dispersed farms that are difficult and time-consuming to measure, are some of the methodological challenges specific to FFS on perennial crops. Yield assessment may be further complicated by the cyclical yield patterns of some tree crops (e.g citrus and cocoa). These impact assessment challenges justify using a mix of technical and social parameters to measure FFS impact on perennial crops in the short and long term. But where combining social and economic impact assessments in a single study is not feasible due to different requirements in experimental design (van den Berg 2004) and the need to keep interviewing time to a minimum to avoid farmer and interviewer fatigue, it may be necessary to identify intermediary output indicators that can be measured relatively easily. Through a case study of cocoa integrated crop and pest management FFS in Ghana, this paper explores the usefulness of using farmers' knowledge as a predictor for the uptake cocoa ICPM practices.

The paper is divided into four parts. The next section provides a theoretical overview of the relationship between knowledge and technology adoption. This is followed by a background to the cocoa ICPM FFS program and the study methodology. A discussion of the research results on farmer knowledge is followed by conclusions.

USING FARMER KNOWLEDGE AS A PREDICTOR OF IPM ADOPTION

The knowledge intensive nature of IPM means that it is widely assumed that improved knowledge (defined as the outcome of an active learning process) is a key prerequisite for the adoption of IPM practices. Similarly, the literature on agricultural innovation, starting with Rogers (1995), asserts that awareness and knowledge of a new technology is the first step in the adoption process. The agricultural innovation literature suggests that knowledge only translates into adoption if a set of enabling factors and conditions exist, including farmers' positive perception of the technology's benefits (Adesina and Zinnah 1993), access to complementary inputs (e.g. seed, fertilizer) (David, Mukandala and Mafuru 2002), tenurial arrangements and labor availability (Feder, Just and Zilberman 1985). FFS impact studies typically investigate both farmers' adoption and knowledge of IPM practices and most document superior technical knowledge among FFS graduates compared with non-FFS farmers (David 2007; Erbaugh, Donnermeyer and Amujal, 2007; Godtland, Sadoulet, de Janvry, Murgai, and Ortiz 2003; Khalid 2006; Mutandwa and Mpangwa 2004; Rola, Jamias, and Quizon 2002). A few studies go further to assess the relationship between IPM knowledge and adoption or increased productivity. While increased appreciation of natural enemies among Sri Lankan farmers did not translate into reduced insecticide application, a change in knowledge about leaf feeding insects was correlated with reduce insecticide use (Tripp et al., 2005). Regression results from a study of cowpea IPM in Uganda showed IPM knowledge was the most important variable in explaining the adoption of five IPM strategies (Erbaugh et al., 2007:112). Godtland and colleagues (2003) report that improved knowledge about IPM practices significantly impacted potato productivity. These results suggest that technical knowledge among FFS graduates is not only valuable as an outcome impact indicator, but could also serve as a reasonably reliable predictor of the adoption of management practices, particularly for crops and technologies where there is a relatively long time lag between adoption and impact.

CONTEXT

Ghana produced 680,780 tons of cocoa in 2007/2008 (ISSER, 2009), making it the second highest global supplier after Cote d'Ivoire. But while cocoa yields have increased across time, and across all cocoa growing regions of the country, there has been no significant increase in productivity, with yields remaining low at an average of about 400 kg/ha on farms with mature trees (Vigneri 2007). Low yields are due to three principal factors: old farms planted with low yielding varieties, limited use of inputs particularly fertilizers and pesticides and pests and diseases, mainly black pod disease caused by *Pytophthora megakarya*, cocoa swollen shoot virus and mirids. The Ashanti Region, where the present study was conducted, is the second most important cocoa producing area. The crop is grown primarily by men on small farms using household and hired labor. Table 2 shows some socio-economic characteristics of the cocoa farmers surveyed and indicates that there were no significant differences between FFS participants and non-participants.

Table 2: Socio-economic characteristics of FFS participants and non-participants

	FFS graduates (N=70)	Non-FFS farmers (N=70)
Females in the sample (%)	27	31
Age	52.6	50.4
Years of schooling	6.5	6.1
Household size	7.0	7.3
Number of cocoa farms	2.2	2.3
Size of cocoa farm (ha)	4.7	5.3
Received training on cocoa besides the FFS (%)	38.6	52.9

In an effort to boost cocoa production by controlling black pod disease and mirids, the Government of Ghana introduced a mass spraying campaign in 2001 (known as the National Cocoa Disease and Pest Control Program or CODAPEC) and is continuing its program to eradicate cocoa swollen shoot virus. The focus of these efforts is on blanket technical messages and high input technological packages (pesticides, improved planting material, credit) delivered through public and private sector extension agents or paid farmer employees (e.g. spray gangs), and little emphasis is put on improving farmers' ability to manage their own cocoa farms, to make decisions based on their own farming conditions and to use external inputs when economical (Ayenor et al., 2007). To address the lack of attention to improving farmers' knowledge on crop and pest management decision making capacity, the Sustainable Tree Crops Program (STCP), a regional initiative hosted by the International Institute of Tropical Agriculture initiated cocoa integrated crop and pest management (ICPM) farmer field schools in 2003.

Between 2003 and 2007 the program and its partners trained 3590 farmers in Ashanti Region. The objective of STCP supported cocoa ICPM FFS is to increase farmers' yields by encouraging good farm sanitation (pruning, shade management, weeding, phytosanitary harvesting) to reduce black pod incidence and improve farmers' knowledge of diseases and pests. The training also seeks to improve farmers' knowledge of post-harvest operations in order to increase the price they receive for quality. In all, the cocoa ICPM curriculum used in STCP-supported FFS covers fifteen cocoa ICPM strategies. As it was assumed that most cocoa farms would be sprayed by the government supported mass spraying campaign, between 2003 and 2006, the FFS deliberately put little emphasis on pesticide use.

STCP-supported FFS follow the conventional FAO model with certain modifications. Schools of 20-30 participants meet every two week for a four hour session over a period of 10 months (March to December) to carry out discovery learning exercises and field activities guided by a trained facilitator. Farmers trained by the project, but with no previous FFS experience, facilitated the training sessions. To encourage experimentation, observation and decision-making, the FFS farm (belonging to one of the participants) is divided into two adjacent plots: the ICPM plot, where new practices are implemented, and the farmer practice plot, where participants carry out their normal practices. Learning occurs through three types of activities. Discovery learning exercises allow farmers to develop an understanding of concepts and principles related to the topic as well as skills or practices, while field activities focus solely on teaching skills or practices. Through conducting agro-ecosystem analysis (AESA), FFS participants learn how to make close observations on farm conditions and to analyze the interactions between the cocoa trees and other biotic and abiotic factors coexisting in the field. The group learning process, and specifically group dynamic exercises, are designed to increase farmers' communication skills, self-confidence and encourage team building.

The first study to assess FFS impact was conducted in 2005, a year after the first group of farmers completed training (Gockowski et al., 2006). This study, conducted in Mponua District of Ashanti Region, relied on farmers' reports of farm size and yield and did not assess farmer knowledge. Results revealed a net production increase of 14% among FFS participants compared with non-FFS farmers attributed to better pruning, shade management and chupon removal. In the Ghanaian context, where most cocoa trees are beyond their economic life, farmers have limited access to hybrid planting material and few apply agrochemicals at recommended rates, these modest yield gains from cultural practices alone are not unexpected but confidence in the accuracy of yield data as reported by farmers was a much greater concern.

METHODS

The paper relies on data from a formal survey conducted in October 2007 targeting 7 FFS conducted in 2004 (n=4) and 2005 (n=3) in Amansie-West and Mponua Districts of Ashanti Region on farmer knowledge and diffusion behaviour. Since the study did not focus on the adoption of ICPM practices, we draw on data from a 2005 impact study (Gockowski et al., 2011) conducted by STCP in Mponua District on the uptake of ICPM practices in discussing the linkage between knowledge and practice. The schools surveyed for the current study were randomly selected from 26 and 17 FFS conducted in 2004 and 2005 respectively. Locations were selected on the basis of two criteria: the absence of previous studies of STCP activities and the training covered at least 6 technical topics. A total of 70 randomly selected FFS graduates were interviewed, ten from each of the 7 selected FFS. Forty respondents had attended schools in 2004, while 30 had completed schools held in 2005.

Seven non-FFS villages were selected with the aim of matching each village to an FFS village in order to control for socio-economic and biophysical factors. Matching the villages was not always possible, especially in Amansie West District where there had been extensive coverage of FFS training by STCP since 2003. Distances between the FFS locations and non-FFS villages ranged between 4-10 km in Mponua District and 9-49 km in Amansie West District. Ten cocoa farmers were randomly selected from each non-FFS village, yielding a sample of 70. A third purposive sample consists of farmers who informally received knowledge from FFS farmers (referred to in this paper as knowledge recipients). Only 18 of 30 targeted knowledge recipients were interviewed due to refusals and difficulties in locating some farmers.

The questionnaire included a test developed by STCP trainers to assess farmers' knowledge of cocoa ICPM. The test consisted of 16 questions on 6 technical topics: pruning, black pod management, farm sanitation, shade management, pest management, and post-harvest operations. The highest scoring questions covered managing black pod disease, pruning and pest management. All questions were open ended and most required respondents to explain their answers or explain the reason for a certain practices. The test was scored using a numerical score (0.5-3) for each correct answer and 0 for incorrect answers.

FARMERS' KNOWLEDGE OF INTEGRATED CROP AND PEST MANAGEMENT

Evidence from both the present study and the 2005 adoption study indicate that, with the exception of how to dispose of diseased pods, the main ICPM practices covered in the FFS training were known and implemented by FFS graduates prior to the training and by non-trained farmers. It can be hypothesized that FFS training contributed three things: knowledge of *how* and *why* cultural practices help to control pests and diseases and the correct technique and timing for carrying out practices. The last two aspects need field verification and are not discussed here. Overall, FFS graduates performed better on the knowledge test than non-FFS farmers and had significantly higher average test scores in four out of six subject areas (Table 3). Notably, a higher proportion of non-FFS farmers compared with FFS graduates (53% compared with 39%) had received formal training in the past on various aspects of cocoa production practices, mainly from government extension agents, an indication that field schools provided technical knowledge and information on pruning, black pod, shade and pest management that the majority of other farmers do not have access to.

Table 3: Knowledge test score (%) by topic among FFS graduates and non-FFS farmers

	FFS graduates (n=70)	Non-FFS farmers (n=70)
Overall test score (%)		
60-79	20	2.9
50-59	34.3	14.3
<50	45.7	82.9
Overall average test score	**54**	**39**[a]
Test score (%) by topic:		
Pruning	67	55[a]
Black pod management	53	30[a]
Farm sanitation	61	56
Shade management	36	24[a]
Pest management	51	32[a]
Post harvest	49	41

[a] P < 0.00 level for difference between FFS graduates and non-FFS farmers, based on t-test

FFS graduates obtained above 50% on four topics: pruning, farm sanitation, black pod and pest management and achieved their lowest score on shade management. Not surprisingly, topics where FFS participants scored highest were the same ones they recalled learning about and gaining new knowledge. Nearly a third of FFS participants considered pruning cocoa trees (27%) and removing mistletoe (26%) as the most important topics they learned. Non-FFS farmers achieved their highest score on pruning and farm sanitation and their lowest scores on black pod, pest and shade management. Notably, more than 70% of FFS alumni reported that the FFS provided them with new knowledge on these topics. On the other hand, similar test score between the two groups on farm sanitation and post-harvest operations could be attributed to the high proportion of farmers in both groups who received prior trained on the first topic (70% and above in both groups) and to the high level of farmer sensitization in Ghana generally on post-harvest operations.

Although FFS graduates had higher knowledge test scores than non-graduates, their performance was disappointing; nearly half (46%) scored less than 50%, the nominal pass mark, and none scored in the 80-100% range. These results highlight specific areas for improvement with regard to how both farmers and facilitators are trained on certain topics. For example, both FFS graduates and non-FFS farmers misunderstood the relationship between light and mirid infestation, had limited knowledge on how to protect non-harmful insects in a cocoa farm and were confused about the effects of fermentation heap size. The inability of many FFS alumni to remember the recommended spacing for planting cocoa (which contributed to the low scores on shade management) raises the issue of post-training knowledge retention. Farmers attending STCP supported FFS did not receive any written extension material.

We carried out regression analysis to explore in more detail the relative contribution of FFS training and other variables to farmer knowledge of cocoa ICPM among the two samples (Table 4). We hypothesized that knowledge test scores would be positively influenced by FFS training, the farmer's educational level, previous training on cocoa production practices, years of experience with growing cocoa, area planted to young cocoa (a proxy for innovativeness) and negatively influenced by the farmer's age and household size. Performance on the knowledge test was associated with four factors: FFS training, previous training on cocoa, educational level and household size (Table 4). Educational level may affect ICPM knowledge in two ways: educated farmers more easily understand and retain knowledge gained from FFS and prior training events and may be better at understanding and answering knowledge test questions. Notably, the 2005 impact study found a significant and positive effect of education on cocoa output (Gockowski et al, 2006). Knowledge test score was negatively correlated with age, though not significantly so, and cocoa experience and area planted to young cocoa played no role in determining test scores. The relationship between household size and knowledge is unclear but may be caused by correlations between wealth, education and household size. These results suggest that aside from the contribution of training and education to farmers' knowledge of cocoa ICPM, the effects of other socio-economic and personal characteristics appear to be too complex to be measured by easily quantifiable variables.

Table 4: Factors explaining knowledge test scores among cocoa farmers (N=136)

	Coefficient	P-value
Age	-0.181	0.652
Age square	0.0005	0.889
Sex	-1.935	0.352
Years of schooling	0.632	0.007*
Household size	0.561	0.025*
Previous training on cocoa production	3.594	0.044*
Participation in FFS	15.211	0.000*
Years of experience with cocoa farming	0.079	0.474
Farm size	0.197	0.501
Cocoa yields in 2006	0.0005	0.634
Area planted to young cocoa	-0.012	0.984

N=136 R=0.696; Adjusted R squared=0.438

KNOWLEDGE AND THE ADOPTION OF ICPM PRACTICES

Establishing the validity of using farmers' knowledge as an indicator of FFS impact requires linking FFS-derived knowledge improvement to changes in farmers' management practices in the field. Ideally this calls for observing farmers' practices in the field but in the absence of such field-based assessment data, we draw on farmer recall data from the present study and from the 2005 STCP adoption study (Gockowski et al., 2006). With regard to farm management practices, knowledge test scores lead us to expect that FFS graduates are likely to prune their cocoa trees, manage black pod disease and mirids more effectively and at the right time compared with non-trained farmers. Based on low scores on shade management it can be expected that FFS graduates will be unlikely to manage shade of non-cocoa trees correctly in terms of frequency or technique. Table 5 shows two examples of the relationship between knowledge and farmer practice from the Ghanaian data. While there was no significant correlation between weeding frequency and farmers' knowledge about weeding among both FFS and non-FFS farmers, FFS alumni with higher knowledge scores about black pod disease were significantly more likely to dispose of diseased pods correctly compared with farmers with lower knowledge scores. By contrast, non-FFS farmers who disposed of diseased pods correctly did not have significantly higher test scores compared with farmers who did not use the recommended practice, which suggests that their behaviour may be driven by habit or other factors besides knowledge.

Table 5: Relationship between knowledge about weeding and disposal of diseased pods and farmer practice in 2006

	Knowledge test score on relevant topic	
	FFS graduates	Non-FFS farmers
Weeding frequency		
Once	50	56
Twice	62	55
Three or more times	60	58
Within group difference	Not significant	Not significant
Disposal of diseased pods		
Applied recommended practice	57	39
Did not apply recommended practice	44	31
Within group difference	$P \leq 0.05$	Not significant

FFS graduates sampled for the STCP adoption study pruned their farms more frequently and at the correct time, weeded more frequently (Table 6), removed diseased pods from trees in the recommended manner and applied insecticide against mirids independently of the government spraying campaign compared with non-trained farmers (Gockowski et al, 2006). These findings support our expectation, based on knowledge test score trends, and confirm improved understanding of the effects of shade and humidity on the incidence of black pod disease as a key contributor to changes in farmers' management practices. However, contrary to expectation based on the low knowledge test scores of FFS graduates, a high proportion of both trained and non-trained farmers carried out shade management (Table 6) in 2004, with FFS graduates being significantly more likely to carry out this practice. Since shade management is contingent on the amount of shade found on farms at a given time, the frequency of this practice is likely to be less strongly linked to farmer knowledge compared with routine practices.

Table 6: ICPM practices carried out by 2003 FFS graduates and non-FFS farmers in 2004, Mponua District

	FFS graduates	Non-FFS farmers	Prob.
Average number of times cocoa trees were pruned	2.8	1.9	0.000
Pruning done in the dry season (%)	50	21	0.000
Conducted shade management (%)	96	87	0.002
Trimmed/pruned shade trees (%)	44	28	0.003
Weeding frequency in 2003 (prior to FFS) (number)	2.6	2.4	0.07
Weeding frequency in 2004 (number)	2.8	2.5	0.0002

Source: Gockowski et al., 2006

Due to the multiple objectives of FSS, impact assessment should explore changes in several parameters in the short, medium and long term. Identifying ways to measure or predict the adoption of ICPM practices among FFS graduates in the short term is particularly important where perennial crops are involved. Based on case study data, the evidence from this study suggests that the technical knowledge of recent FFS graduates can be a useful predictor of the adoption of management practices, although the relationship between knowledge and practice is clearly a complex one. The study provides conclusive evidence that FFS on cocoa ICPM exposed participants to agro-ecological principles and knowledge about biological processes (e.g. what causes black pod disease and how it spreads) not known by most Ghanaian cocoa farmers and suggests that improved knowledge is likely to translate to improved practice, although more field-based data are needed to confirm how well trained farmers apply ICPM practices. Farmers' disposal of diseased cocoa pods was positively influenced by their understanding of how black pod disease spreads whereas, weeding frequency, a skill-based management practice, was not related to knowledge as measured by knowledge test score. Data from an earlier adoption study showed that topics where FFS farmers demonstrated significantly better knowledge based on the knowledge test largely corresponded to related ICPM practices they carried out more.frequently and effectively compared to non-FFS farmers.

Farmer knowledge is a good indicator of training quality and the case study highlights areas for improvement. Low knowledge test scores by a significant proportion of FFS participants highlight the need to improve training quality and for greater emphasis on knowledge and understanding concepts and principles, hallmarks of FFS training. Without effective training and follow-up of facilitators to ensure that principles of discovery learning and facilitation are being followed, FFS can easily become a high cost method for transferring skills and practices. Low test scores may also be caused by poor knowledge retention and how this affect farmers' correct application of ICPM practices over time. Illustrated printed extension material developed by STCP is intended to improve knowledge retention (David and Cobbah, 2007).

While this case study suggests that the level of farmers' knowledge after FFS can provide early indications of the adoption of ICPM practices, it is important to determine under what circumstances and conditions assessing farmer knowledge can be a useful first step in FFS impact assessment given the complex nature of the relationship between knowledge and practice. In the cocoa case study, improving farmers' understanding of ICPM principles acted as a strong catalyst for adoption because farmers were already familiar with nearly all practices, although they generally lacked an understanding of the underlying processes and concepts. It can be hypothesized that farmers are likely to delay integrating recently acquired knowledge into existing knowledge systems and applying it in their farms where many of the technical skills, information and knowledge farmers acquire from FFS are new, thereby leading to low adoption initially. Secondly, where most of the interventions introduced by the FFS are skills or knowledge based, as was the case with most of the cocoa ICPM practices, farmer knowledge is likely to be a good indicator of uptake. Where input technologies (e.g. new varieties, fertilizer) are the key components of ICPM practices, farmer knowledge is less likely to be strongly associated with technology adoption. The need to develop short-cut methods for assessing FFS impact will continue to be a priority alongside researchers' efforts to fine tune the methods for field-based impact studies.

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