

THE IMPACT OF FARMER FIELD SCHOOLS ON PESTICIDE USE AND ENVIRONMENT IN THAILAND

Suwanna Praneetvatakul^{}, Hermann Waibel^{**}*

Abstract

This paper presents an application of a difference in differences model to measure environmental and economic impacts of Farmer Field School on crop and pest management practices of rice in Thailand. Panel data from 241 farm households were collected three times over a period of four years in five rice-producing provinces of Thailand. Data included socio-economic data describing household and farm characteristics, rice input and output data including detailed accounts of pesticide use and other pest management practices and farmers' knowledge of crop management and agro ecosystem factors. Using the concept of environmental impact quotient parameters on the health and environmental consequences of a change in pesticide use was computed. Data analysis was conducted by measuring changes in farm performance, using a two and a three periods growth model. Results showed that trained farmers significantly reduced pesticide use on the short term. It was also found that they retain their reduced pesticide use practices several years after the training. However no significant change in rice gross margin could be detected.

Keywords:

Farmer Field School, Impact Assessment, Multi-Periods Panel Data Model, Pesticide Use, Environment

1. Introduction

Projects on farmer training in Integrated Pest Management (IPM) in developing countries using the Farmer Field School (FFS) approach are widely implemented by donor organizations including for example the World Bank.

* Assistant Professor Suwanna Praneetvatakul, Faculty of Economics, Kasetsart University, Bangkok, Thailand, fecoswp@ku.ac.th,

** Prof. Dr. Hermann Waibel, Institute of Development and Agricultural Economics, University of Hanover, Germany, Königsworther Platz 1, 30167 Hannover, waibel@ifgb.uni-hannover.de. The paper was prepared for the 46. Annual Meeting of the German Association of Agricultural Economists (Gewisola) in Giessen, 4.-6. October 2006.

This is in spite of criticism that such projects are fiscally unsustainable (Quizon et al, 2001) and are not always effective in changing pest management practices or in improving farm performance (Feder et al, 2003) and have only limited diffusion effects (Rola et al, 2002, Feder et al, 2004). On the other hand it was shown that FFS could improve farmer knowledge in pest identification and improve their ecosystems understanding (Godtland et al, 2004, van den Berg, 2004, Tripp et al, 2005). Also it was found that public investments in integrated pest management programs in cotton in Asia showed good rates of return (Erickson, 2003, Ooi et al, 2005). Moreover, in China, where bollworm-resistant transgenic cotton varieties have been widely introduced, FFS was found to be effective in helping farmers to realize the potential of pesticide reduction that Bt varieties offer (Yang et al, 2005).

A common facet of past impact analyses of Farmer Field School projects is that data were being used that did not allow the definition of good counterfactual scenarios because no control area was available or only insufficient baseline data existed. Also comparisons were based on only two observation points before and after the training. In addition, most of these studies concentrated on simple performance parameters like knowledge, pesticide use and yield but did not include for example impact on the environment. In this paper we use a set of panel data collected over a period of four years covering a maximum of 8 rice-growing seasons from three groups of farmers. The analysis presented here is an advancement of an earlier study that analyzed the short-term impact of FFS in Thailand (Praneetvatakul and Waibel, 2003).

2. Data and impact indicators

Data were collected in five pilot sites of the Department of Agricultural Extension (DOAE) in Thailand. In each pilot site a Farmer Field School following the usual methodology with a season long experiential training in the field (Kenmore, 1996) was implemented. The sample included 241 farmers and was composed of three groups: (1) training participants (FFS farmers), on average 20 farmers per FFS; (2) 15 randomly selected non participant farmers per village but exposed to the FFS knowledge because they were living in the FFS village, (non FFS); (3) 15 unexposed farmers, randomly selected from a control village located nearby a FFS village (control farmers). The control villages had similar socio-economic and natural production conditions but there was a low probability of intensive information exchange with the respective FFS village. For example, the control villages had different market places than the FFS villages. The farmers were interviewed at three different points of time: (1) in February 2000 at the end of the wet rice-cropping season, which was before the training had started (2) in February 2001, in the rice growing season after the training, i.e.

where farmers could apply their new knowledge for the first time and (3) in February 2003, two years after the second survey. Thus, trained farmers in the five pilot villages had the opportunity to apply their new knowledge between four to eight rice growing seasons after the training, depending on the intensity of rice production. Unfortunately for the third survey the sample size had to be reduced because of heavy flooding in two FFS villages so that some farmers in the panel could not harvest rice in the survey season.

The questionnaire included information on farm household characteristics, farmer knowledge on rice pest management, data on rice production inputs and outputs, and questions on health issues related to pesticide use. Particular emphasis was given to a detailed account of pesticide use regarding quantity, common and brand names, active ingredients and formulation.

To assess impact of FFS we defined several impact indicators. First, we measured farmers' knowledge of rice and pest management. A score was constructed from a set of knowledge questions developed in cooperation with national IPM experts. Second, total rice yields per farm including sales and home consumption were based on farmers' estimates and divided by the respective area planted to rice. Third, the amount spent on pesticides including insecticides, molluscicides (chemicals used to kill snails), fungicides and herbicides were calculated in \$ per ha. Fourth, the gross margin of rice production in \$ per ha, measured as total revenue above total variable costs excluding the value of family labor. Fifth, as a measure of farmer net benefit we deducted health costs from chemical pesticide use from the gross margin. Since no data on occupational health were collected in this study health costs were accounted for by using a ratio of pesticide costs to health costs of 1:1 based on the results of study by Rola and Pingali (1993). In addition, as a non-monetary measure, the Environmental Impact Quotient (EIQ) was calculated to quantify the environmental and human toxicity effects of pesticides (Kovach et al, 1992). The EIQ index differentiates pesticide use according to crop type, pesticide type and quantity used as well as their toxicity to pesticide applicators, toxicity to consumers and toxicity to the ecology. The index sums up all negative side effects of pesticides; hence a higher EIQ number indicates a higher risk to health and environment.

The EIQ index can be calculated by the following formula (Kovach et al, 1992):

$$EIQ = \{[C \times (DT \times 5) + (DT \times P) + C \times (S + P) / 2] \times SY + L + (F \times R) + [(D \times (S + P) / 2 \times 3) + (Z \times P \times 3) + (B \times P \times 5)]\} / 3$$

where:

C = chronic toxicity, DT= acute toxicity to human, P= half-life on the plant, L= ability of elution and penetration to the underground water, S= time of half-life in the soil, SY=penetration ability to the soil, F=toxicity to the aquatic species, R= surface lost ability, D= toxicity to birds, Z= toxicity to bees, and B= toxicity to beneficial insects.

Hence EIQ can be described as EI farmer + EI consumer + EI ecology, whereas

$$\text{EI farmer} = C \times (DT \times 5) + (DT \times P).$$

$$\text{EI consumer} = C \times ((S+P)/2) \times SY + L$$

$$\text{EI ecology} = (F \times R) + (D \times ((S+P)/2 \times 3) + (Z \times P \times 3) + (B \times P \times 5))$$

With the existing information, the EIQ of almost any pesticide in a defined cropping system can be calculated and available in Kovach et al (1992), whereby higher EIQ indicate high risks to environment and human health.

3. The Model

The analysis applies a difference in difference (DD) model (Greene, 2000). DD models can be used to analyze changes in farm performance comparing a treatment and a control group and which can be attributed to external interventions such farmer training. The change in the growth rate takes account of the fact that the development process influences performance and assumes an exponential path in the rate of change of performance for trained and untrained farmers. Hence, the model accounts for the fact that change is taking place even without the FFS training. The linear shift was measured by applying a paired t-test (Anderson, Sweeney and Williams, 2002), to test for the differences between before and after training for FFS, non-FFS and control farmers. For those performance indicators where we find a significant linear shift we proceed with the two and three period growth model. The rationale for this procedure is that we do not expect significant results as we increase the degree of rigor in the testing procedure, i.e. if we do not get a significant difference in the t-test, a significant coefficient in an econometric growth model is unlikely. Since we have three observation points over time we can apply two alternative models: a two period and a three period panel data model. With the three period model a simultaneous estimation of the time period effects is achieved using a larger sample.

In applying this model we expand the procedure described in Feder et al (2003) and used to measuring impact of IPM in Indonesia. Accordingly, the change in farmers' performance (e.g. yield, pesticide use, environmental impacts, etc.) through training can be modeled as an exponential growth process. This is displayed in equation 1:

$$Y_1 = Y_0 \cdot e^{\{\alpha + \beta D_{nffs} + \mu D_{ffs} + \gamma \Delta X + \delta \Delta Z\}} \quad (1)$$

where:

Y_1 : pesticide use or environmental impacts after the training,

Y_0 : pesticide use or environmental impacts before the training,

α : coefficient for pesticide or environmental growth before the training,

μ : rate of pesticide or environmental growth of FFS farmers after the training,

β : rate of pesticide or environmental growth rate for the non-FFS farmers after training,

D_{ffs} : dummy variable for FFS farmers, for FFS = 1 and zero = otherwise,

D_{nffs} : dummy variable for non-FFS farmers, for non FFS = 1 and zero = FFS and control,

X : vector of farmer characteristics,

Z : vector of village characteristics,

γ and δ : corresponding coefficients of these vectors,

Δ : the differencing operator between before and after the training,

e : the exponential operator.

The specification for an empirical estimation of the model can be obtained by taking the natural log of equation (1) and rearranging it accordingly:

$$\Delta(\ln Y) = \alpha + \beta D_{nffs} + \mu D_{ffs} + \gamma \Delta X + \delta \Delta Z \quad (2)$$

where: $\Delta(\ln Y) = (\ln Y_1 - \ln Y_0)$

Multi-period panel data model

Unlike in models that are based on cross sectional data, panel data allow for the unobserved effects, a_i , to be correlated with the explanatory variables (Wooldridge, 2000) This is because a_i is assumed to be constant over time, hence one can compute the difference in the observed parameters over the two years.

The equations for period 2 (eq 3) and period 1 (eq 4) are as follows:

$$Y_{i2} = (\delta_0 + \alpha) + \gamma_2 X_{i2} + a_i + u_{i2} \quad (3)$$

$$Y_{i1} = \delta_0 + \gamma_1 X_{i1} + a_i + u_{i1} \quad (4)$$

Subtracting the equation (4) from equation (3) results:

$$\Delta Y_i = \alpha + \gamma \Delta X_i + \Delta u_i \quad (5)$$

where:

Δ denotes the change from period 1 ($t=1$) to period 2 ($t=2$), Y_i is the dependent variable, X_i are independent variables and u_i is the error term. The unobserved effect, a_i , does not appear since it has been differenced away. The resulting intercept (α) denotes the change in the intercept between the two periods. γ is the coefficient of the change in X_i .

Extending the analysis to three periods ($t= 1,2$, and 3), the procedure is analogous as shown in equation (6):

$$Y_{it} = \delta_1 + \delta_2 d2_t + \delta_3 d3_t + \gamma_1 X_{it1} + \dots + \gamma_k X_{itk} + a_i + u_{it} \quad (6)$$

Equation (6) includes dummies for two periods, $d2$ and $d3$. The intercept for the first period is δ_1 for the second period it is $\delta_1 + \delta_2$. For period three the definition of intercept is analogous. In the $t=3$ case, time period one is subtracted from time period two and time period two from time period three resulting in Equation 7:

$$\Delta Y_{it} = \delta_2 \Delta d2_t + \delta_3 \Delta d3_t + \gamma_1 \Delta X_{it1} + \dots + \gamma_k \Delta X_{itk} + \Delta u_{it} \quad (7)$$

for $t=2$ and $t=3$. Equation (7) contains the differences in the time period dummies, $d2_t$ and $d3_t$; i.e. for $t=2$, $\Delta d2_t = 1$ and $\Delta d3_t = 0$; for $t=3$, $\Delta d2_t = -1$ and $\Delta d3_t = 1$. Re-writing equation (7) displays the intercept of the equation, which is a measure of the growth in performance of the control group:

$$\Delta Y_{it} = \alpha_0 + \alpha_3 d3_t + \gamma_1 D_G + \gamma_2 D_N + \gamma_3 \Delta X_{it3} + \dots + \gamma_k \Delta X_{itk} + \Delta u_{it} \quad (8)$$

for $t=2$ and $t=3$, the estimates of the γ_j is identical in both equation (7) and (8).

Applying these growth models to those performance parameters, which have passed the test of the linear model, introduces a more rigorous test on the impact of FFS training.

4. Results

When considering the socio-economic characteristics of farmers before participated in FFS, the non-FFS and the control groups in cropping year 1999/2000 (the year before participated the FFS training), their socio-economic performances are similar in all three groups.

4.1 Two period model

Based on the methodology outlined above the analysis was proceeded by testing for change in performance in the growth rates of impact parameters. Here we included just two impact measures, namely quantity of pesticide use and EIQ. Gross margin were discarded from the econometric analysis because t-test results were non significant. Likewise we did not include

yield because of the somewhat ambiguous t-test results. We also did not include results for farmer net benefits because this parameter is a combination of observed variables and an assumption borrowed from the literature. Of course results for this parameter will change as we change the assumption relating pesticide costs to health costs.

The result of the two period growth model using the change in pesticide expenditures as the dependent variable show that FFS training has a significant effect on reducing farmers' pesticide use (see table 2). This result is supported by the significant coefficient for rice and pest management knowledge. The positive sign of the constant term indicates that farmers' pesticide use is likely to continue to increase without FFS. Since the dummy variable for non-FFS is non-significant there is no change in the trend of pesticide use among farmers living in the FFS village but not participating in the training. Summarizing the hypotheses tests in the lower panel of the table shows that a change in the positive trend in pesticide use is attributable to FFS. FFS farmers have significantly lower pesticide expenditures when compared to the non-FFS and control farmers on the short term (Table 1).

Using the environmental impact quotient as a dependent variable in the two period model also confirms the results of the t-test. FFS participation reduces the trend in the negative consequences of pesticides on environment in the short term (Table 1). As measured through the FFS participation dummy, the growth rate in EIQ of the FFS farmers shows a significant decline. It is also interesting to note that the counterfactual scenario (no FFS training) shows growing negative environmental impact from pesticides. This can be concluded from the intercepts of the models, which were significant at the 0.01 % level in the short term. Again, within-village diffusion towards more environmentally benign pesticide use practices does not seem to be sustained as shown by the non-significant variable for Non-FFS.

Table 1: Impact of FFS on pesticide expenditures and environmental impact quotient in the short term, two period growth model

Two periods growth model	Δ in Pesticide costs	Δ in EIQ
Constant (α)	0.248 (1.576)	2.340 (3.096)***
Dummy for FFS (μ)	-0.485 (-2.368)**	-1.685 (-1.715)*
Dummy for Non-FFS (β)	-0.220 (-0.937)	-1.008 (-0.895)
Knowledge in rice and pest managements ($\ln \Delta K$)	-0.030 (-2.593)**	-0.133 (-2.421)**
Total labor use ($\ln \Delta L$)	0.052 (3.911)***	0.160 (2.498)**
R ²	0.109	0.064
F-statistics	7.236***	4.005***
Durbin-Watson statistic	1.853	1.883
N	241	241

Note: data in parenthesis are the t-value. Pesticide expenditures are converted to real value.

4.3 Three period model

To test for the long-term effects of FFS training a three period growth model (see Wooldridge, 2000) was used. Two time period dummy variables are included.

The long-term effects of FFS on farmer's pesticide use confirm the results of the short-term effect (table 2). Hence, FFS farmers retain their improved and more judicious pesticide use practices and continue to reduce pesticide use over time. By contrast, no significant change can be observed for the non-FFS farmers and the farmers in control villages in either period. Again change for both short and long-term knowledge had a significant effect on pesticide reduction.

For the EIQ variable the long-term change followed the results of pesticide use expenditures. On the long term FFS farmers not only reduce pesticide use levels but also continue to adopt safer products. Knowledge seems to be a major driver for this process. On the other hand, no significant change can be observed for non-FFS farmers. The counterfactual scenario however shows ambiguous results as the first time dummy variable shows a significant positive result, which in the second time period the trend is reversing. It is possible that these farmers may finally learn by experience the harmful effects from highly toxic pesticides and thus change their practices. Unfortunately no information was collected in this direction.

Table 2: Impact of FFS on pesticide expenditures and environmental impact quotient in the long term, three period panel data growth model

Three periods panel data growth model	Δ in Pesticide costs	Δ in EIQ
Period 2 Dummy	-0.001 (-0.006)	1.365 (2.798)***
Period 3 Dummy	0.077 (0.730)	-1.894 (-4.063)***
Dummy for FFS	-0.254 (-2.167)**	-1.869 (-3.616)***
Dummy for Non-FFS	0.137 (1.219)	0.041 (0.068)
Knowledge in rice and pest management (ln Δ K)	-0.229 (-2.517)**	-0.073 (-0.181)
Total labor use (man-day) (ln Δ L)	0.445 (10.561)***	1.060 (5.698)***
R ²	0.448	0.294
F-statistics	28.183***	11.505***
Durbin-Watson statistic	1.817	1.467
N	188	188

Note: data in parenthesis are the t-value. Pesticide expenditures are converted to real value.

5. Conclusions

Results of this study show that farmers who participated in the Farmer Field School training retain their knowledge and continue to practice improved IPM practices. Growth rates of pesticide expenditures and environmental impact are significantly reduced by the FFS training both in the short and long term. On the other hand, farmers not trained in FFS tend to continue non-judicious ways of using chemical pesticides. Thus, the Farmer Field School approach is an effective method to reduce uneconomical use of chemical pesticides for rice production in Thailand. It can help farmers to sustainably change pesticide use practices. However, increased yields and gross margins could not be shown in this study but were investigated elsewhere (Praneetvatakul and Waibel 2006). In high productivity rice production yield effects are difficult to detect and may in deed be small. Also in rice pesticide use does not account for a high share of the variable costs and therefore gross margin differences can be confounded by other factors.

However it seems that when it comes to pesticide use small farmers in developing countries may adopt new pest control methods even though the effects on profit may be low, if there are other benefits. Several studies have shown that small farmers show willingness to pay for

safer pesticides (e.g. Cuyno et al 2001, Garming and Waibel 2006). In addition it is also important to point out that changing farmer's pesticide use practices generates additional environmental benefits that accrue to society at large. Finally, on the longer term, more judicious and better informed farmer crop and pest management decision making can reduce the probability of pest outbreaks, These, however, did not occur during the years that the surveys were conducted. Over all the study suggests that a comprehensive assessment of the benefits of IPM that goes beyond only profit effects is necessary.

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