The Impact of the FAO-EU IPM Programme for Cotton in Asia

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The Impact of the FAO-EU IPM Programme for Cotton in Asia

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List of Abbreviations

AESA	Agro-Ecosystem Analysis
DD	Double Delta
EIQ	Environmental Impact Quotient
EU	European Union
FAO	Food and Agricultural Organization
FFS	Farmer Field School
GM	Gross Margin
ha	Hectar
hrs	Hours
IPM	Integrated Pest Management
IRR	Internal Rate of Return
kg	Kilogramme
ml	Milliliter
NATESC	National Agro-Technical Extension and Service Center
NFFS	Non-FFS farmer
NGO	Non-Governmental Organization
No.	Number
NPV	Net Present Value
OECD	Organization for Economic Cooperation and Development
RMB	Renminbi Yuan, Chinese Currency, 1US$ = 8.26 RMB
SPI	Sensitive Price Index
ToF	Training of Facilitators
USDA	United States Department of Agriculture

Preface

The FAO-EU Integrated Pest Management Programme for Cotton in Asia has addressed the challenges of sustainable agricultural development of cotton farmers in Asia. Through education, following the Farmer Field School (FFS) concept, the Programme sought to empower poor farmers to make better production management decisions and thus take greater control of their lives. An integral part of the Programme design was to foster a culture of impact assessment from the very beginning. Impact assessment was not only used as an instrument to measure the Programme's benefit, but also as a tool for strategic planning and organisational development.

In preparation for the seven impact assessment studies conducted by independent investigators, each country's project stakeholders engaged in an intensive dialogue to define the impact targets and to formulate objectively verifiable indicators for successful implementation. This process was extended to FFS implementation by engaging farmers in monitoring and evaluation of changes in the fields and their communities. Thus, systematic progress and quality monitoring supplemented formal impact studies in assessing the direction and success of the Programme. Through this, impact assessment created a culture of accountability and learning that penetrated all levels of Programme implementation.

It is acknowledged that the true impact of a development programme cannot always be expressed in quantitative terms. Some effects such as changes in yield increase, pesticide use and profits are measurable while changes in attitudes, farmer critical thinking and confidence are more difficult to capture especially on the short run.

The papers in this book represent some key impacts that have been observed during programme implementation. They deal with a wide range of impacts on income, poverty, human capacity, health and environment.

The results show that well-targeted investment in Farmer Field Schools can be effective in changing farmer behaviour and can result in a high rate of return.

It is hoped that the results and the lessons learned from these studies contribute appreciably to the ongoing discussion about the impact of public investment in IPM in developing countries. It is also hoped that this book may lead to further improvements in programme effectiveness and refinements of the Farmer Field School concept in IPM and beyond. Finally, we hope that this collection of case studies will contribute to the discussion on conducting practical impact assessment of rural development programmes.

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1 Concept of Impact Assessment in the FAO-EU IPM Programme for Cotton in Asia

Gerd Walter-Echols[1] and Peter A.C. Ooi[2]

1.1 Introduction

From 2000 to 2004, the FAO-EU Integrated Pest Management (IPM) Programme for Cotton in Asia and associated country institutions qualified 1,540 extension workers and 945 farmers as farmer field school (FFS) facilitators, who in turn conducted a total of 3,660 FFS for 93,700 farmers in Bangladesh, China, India, Pakistan, Philippines and Vietnam. To determine the impact of these farmer education activities, the project conducted seven impact assessment studies in five countries, i.e. Bangladesh, China (three studies), India, Pakistan and Vietnam. The objective of these studies was to collect scientific evidence on IPM-FFS impacts. A recent review of 25 IPM farmer field schools impact evaluations concluded that these studies varied greatly in focus, approach, methodology and robustness and did not always include proper control samples or baseline data as a reference (van den Berg, 2004). While many studies reported significant impacts on farmer income, pesticide reduction, human and social gains (Pincus, 2000; Pontius *et al.,* 2002; van de Fliert, 1993), an analysis by Feder *et al.* (2003) concluded that the IPM-FFS programme on rice in Indonesia showed no long-term evidence of yield increases or pesticide reduction; however, the control villages in that study were not rigorously separated from the FFS treatment areas and this could have affected the results. Therefore, more studies and improvements in methodology are needed to determine the impact of IPM-FFS activities that are founded in farmer education rather than technology transfer.

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In its broadest sense, impact assessment measures the economic, social and environmental effects of a project. Instead of conducting impact studies as a requirement sometimes demanded by donors, the Cotton IPM Programme aimed to use impact assessment as a tool for organizational development and strengthening management skills and critical thinking in all aspects of project implementation, thus creating a "culture of impact assessment". This required that the same management principles which were taught to farmers in farmer field schools also needed to be practiced by project staff, i.e. regular observations and measurement of key performance factors, their analysis in a systematic manner and the subsequent use of the results for decision making and planning (Figure 1-1). In this way, IPM-FFS would not only improve the management skills of farmers, but also those of extension agents, researchers and project administrators.

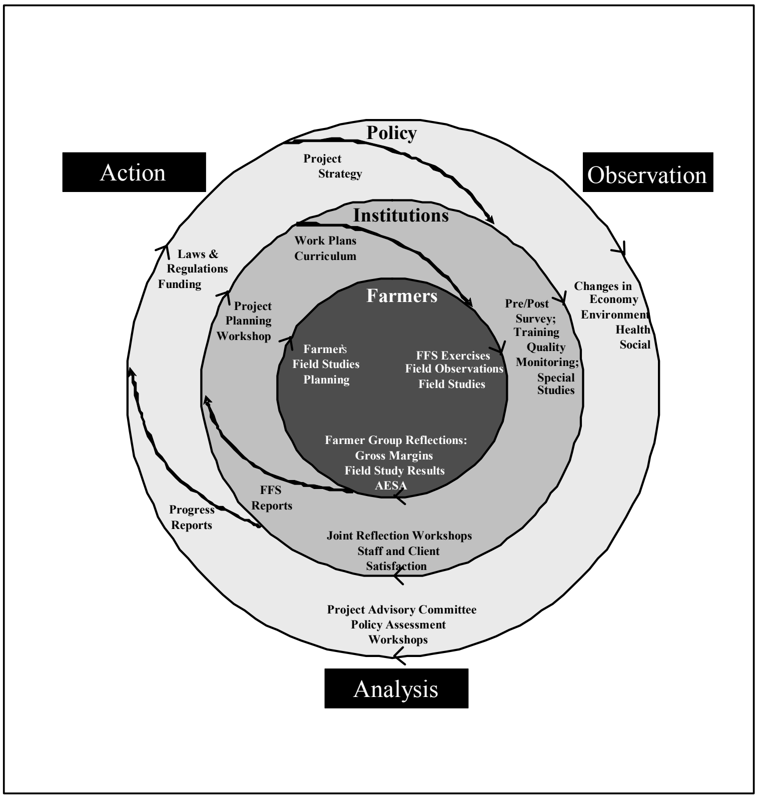

Figure 1-1: Learning/Management Cycles

During FFS, farmers learn to make exact field observations, discover the biology of pests and natural enemies in insect-zoo exercises and verify new technologies and crop management practices in field experiments. With the help of cotton ecosystem analyses, field observations are systematically analysed and results are discussed with fellow farmers. Finally, farmers arrive collectively at decisions regarding crop management practices or needs for further field studies. By following this basic learning cycle farmers succeed to improve their production and pest management skills.

The same learning/management cycle can also be applied at the institutional level. Exact observation data would come from farm-household surveys, monitoring of training quality and learning achievements, and special studies, e.g. on health or biodiversity. The findings from these studies are then analysed and jointly assessed by project staff and farmer clients. As a result, training curricula and work plans would be improved depending on the progress made toward specific impact targets.

On the level of national IPM policy, the observed economic, environmental, health and social changes need to be summarized and reviewed at project advisory committee meetings and forwarded as policy briefs to the attention of political decision makers. Based on the analysis and assessment of results, particularly whether and how much the project contributes to the national development objectives, the project strategy may be revised, the national IPM policy amended or new rules and regulations proposed.

This paper describes how this holistic impact assessment concept was developed and implemented in the Cotton IPM Programme. The project implementation agreement and other project documents provided only a rough framework for impact assessment since the formulated goals and objectives were quite general and mostly referred to outputs rather than outcomes. In addition, the narrow focus of the project design on a single commodity and in several countries having cotton production companies as implementing institutions posed obstacles to a more holistic farmer education approach. Therefore impact assessment provided a means to make the project design more development focused and responsive to farmer needs.

1.2 Methodology

Impact assessment activities started in 2001 with a regional workshop that involved the country project teams and independent study investigators. At this meeting, the design of the proposed impact studies was discussed and it was decided to collect pre- and post-FFS data from FFS graduates, exposed farmers in the same village and a separate control group. This design allows assessing both the differences between before and after training and with and without FFS (double difference or double delta model, Feder *et al.,* 2003).

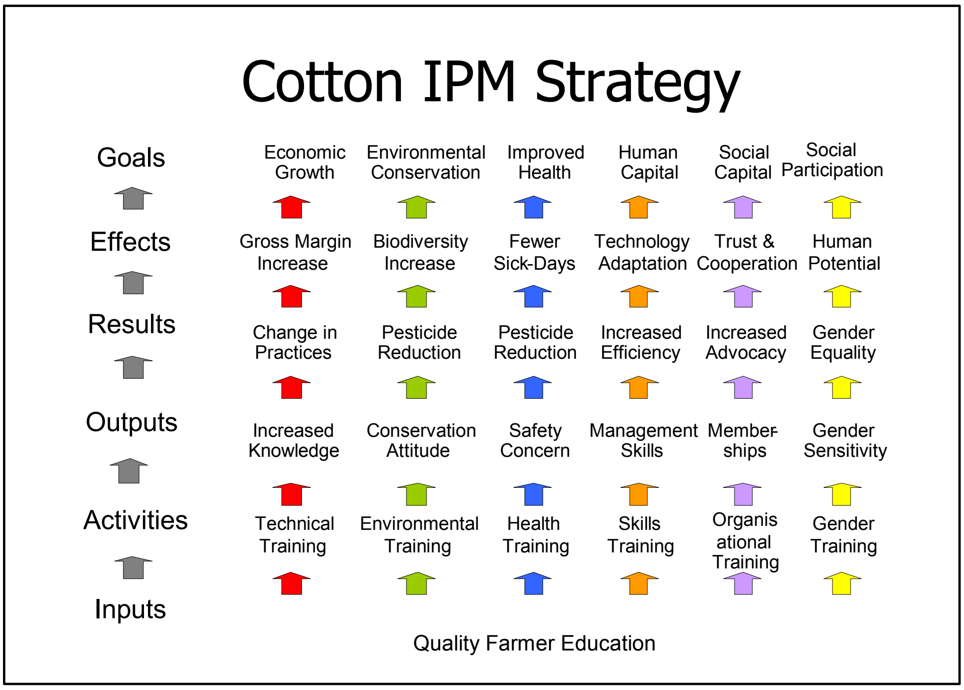

Figure 1-2: Cotton IPM Strategy

For a follow-up workshop, each country programme was asked to present its long-term implementation strategy. The meeting showed that member countries had clear ideas on how to schedule Training of Facilitators (ToF) and farmer field school activities; however, the project's role in relation to the country's long-term development goals or cotton sector targets appeared to be less clearly understood. Therefore a planning matrix of impact chains was developed to link FFS curriculum components with specific livelihood results, effects and goals (Figure 1-2). Each country team then listed their ultimate goals and impact targets, and the activities specifying the paths toward each goal achievement. The workshop concluded that there was a need to further develop each country's longer-term cotton IPM strategy by clearly defining impact targets, expansion plans and timeframe for the national IPM programmes. It was also realized, that minimum quality standards for both ToF and FFS needed to be established and incorporated in the project activities as routine self-assessment measures.

In preparation for the baseline farm-household surveys, each country team conducted a series of meetings and workshops with the impact study investigators to define the desired impact targets and to formulate objectively verifiable indicators for their successful achievement. At a regional meeting, these individual country targets were compared and a consensus was reached toward a list of common targets that should be included in all country studies. This process narrowed down the scope of information to be collected to the specific areas where project activities were most likely to produce changes. It was realized, that not every impact area could be covered by farm-household surveys and that additional methods needed to be employed, particularly for environmental and health effects. General socio-economic data was limited to key parameters that showed whether samples were representative of the targeted small-scale cotton producer population. The clearly defined goals and corresponding indicators for goal achievement helped in streamlining the impact assessment surveys by focusing on the changes that were directly targeted by project activities, rather than looking for unintended or accidental results.

To further harmonize the different country studies, additional regional workshops were conducted. One workshop focused on the analysis of baseline data and established the criteria for the final impact assessment reporting. During a final workshop, the different country results were compared and summarized, and presented to the management of the implementing country institutions and political decision makers.

All impact studies followed the same basic design that was decided during the first regional workshop. It compared farmer practices in the year before farmer field school training with those in the year after. As soon as FFS groups were formed in the selected study sites, a sample of participating farmers was interviewed about their previous season’s cotton cultivation practices and other related background information. The survey was repeated in the year after the FFS when the participants were by themselves again and were no longer guided by an FFS facilitator. The post-training data collection was conducted in intervals over the entire crop cultivation season in order to minimize errors from recalling information. In China and India the studies covered the years 2000 and 2002, while in other countries the years 2001 and 2003.

The studies were conducted by local investigators from universities (Bangladesh, Vietnam), an NGO (India) or the Social Sciences Institute of the National Agricultural Research Centre (Pakistan); only in China did the implementing institution also conduct the impact assessment (National Agro-technical Extension and Service Center, NATESC).

The FFS baseline farmer sample comprised of 60-120 farmers from mostly 3-4 randomly selected FFS out of a total of 27-85 FFS that were conducted in the countries during the respective years (overall total of 340 FFS). All FFS were "normal" FFS conducted by previously graduated facilitators and not associated with any ToF course. The sampling areas were those locations where most of the FFS were implemented. From the same communities as the FFS farmers, a sample of a minimum of 60 farmers was interviewed in an identical manner to assess the degree of diffusion of knowledge and practices to neighbours of the FFS graduates. This sample was labelled "non-FFS" (NFFS) or "exposed" farmers. In addition, another 60 farmers were selected from 3-4 communities in a cotton growing area where no FFS were held nor were scheduled for the coming years. The control area was generally at a distance of 30-60 km from the nearest FFS and care was taken that the two sets of communities did not share a common market place where information could be exchanged.

For the post-FFS impact sample, only those farmers that grew cotton in both the pre- and post-FFS year were included. Otherwise, all FFS participants, regardless whether they fully graduated or only partially attended, were included. Because not all farmers grew cotton in both years or were available for a second interview, the post FFS sample size shrank from 1,511 to 1,060 (Table 1). For impact analysis, differences between the years were determined for each farmer individually. To account for changes in environmental conditions between the study sites and years, the results for FFS and NFFS farmers were adjusted by the changes observed in the control group over the same period of time. This difference in difference procedure eliminated the influence of other confounding factors that could have biased the observed differences. Results were summarised as overall means and standard deviations for the three sample groups and the differences between the FFS and NFFS farmers to the respective control sample. The statistical significance of differences was determined through analysis of variance, Chi-square and Student t tests.

Table 1-1 reveals great variation in the differences between the pre- and post-FFS sample sizes. While a loss up to 15% of the respondents can be explained in terms of normal sampling variation due to inability to find the same farmer again or other difficulties, bigger reductions need explanations and analysis. In Vietnam, Bangladesh and India only 61%, 45% and 33% of the baseline farmers made up the post-FFS sample. In India, this was due to the late onset of monsoon rains in 2002, which prompted many baseline respondents not to grow cotton that year. In Vietnam, farmers chose not to grow cotton because of lower than world market prices for their harvest. In Bangladesh, the reduction was due to sampling problems.

Table 1-1: Pre- and Post-FFS Sample Sizes

	Pre-FFS				Post-FFS				%
Study Sites	FFS	NFFS	Control	Total	FFS	NFFS	Control	Total	remaining
Bangladesh	100	60	60	220	52	31	15	98	45%
China-Anhui	60	60	60	180	60	60	60	180	100%
China-Hubei	60	60	60	180	60	60	60	180	100%
China-Shandong	60	60	60	180	56	52	60	168	93%
India-Karnataka	97	97	97	291	37	30	30	97	33%
Pakistan-Sindh	90	70	60	220	78	59	53	190	86%
Vietnam	120	60	60	240	63	42	42	147	61%
Total	587	467	617	1,511	406	334	320	1,060	70%

The increased awareness about impact targets also encouraged a continuous review of ToF and FFS curricula with respect to their suitability to achieve the desired outcomes. Two regional curriculum review workshops and regular annual curriculum planning meetings aimed to align the training activities more and more with the project's impact targets.

Country programmes quickly realized a need for more information about the type of farmers attending FFS, the process of group formation, the quality of FFS facilitation, achievement of learning objectives and proficiency of acquired skills. Consequently, impact assessment lead to an improved monitoring and reporting of FFS activities and encouraged FFS facilitators to experiment with ways to improve project performance and to feel responsible for the quality of farmer education activities.

Profile of FFS Participants and Beneficiaries

The question has been posed whether FFS participants are better educated and have more resources than their fellow farmers and therefore achieve better results which cannot be extrapolated to the farming population in general. Most country studies did not compare the sample socio-economic characteristics with those of the general cotton farmer population because specific profiles of cotton farmers were not available. However, the survey sample allows for a comparison between FFS and non-FFS farmers from the same village, and a comparison between FFS and control villages. In addition, profiles of regular FFS participants were available and could be compared with the impact study sample.

Except for gender, the FFS sample matched the profile of 2003 FFS graduates in terms of age, education and farm size (Table 1-2). A comparison of the FFS and NFFS sample from the same villages showed that FFS farmers were an average of 3 years younger than their neighbours, were slightly more educated, had 0.4 ha larger farms and 13% more household income; due to the great variability between farmers these differences were noticeable but not statistically significant. A comparison of the FFS and control villages showed that control villages had slightly lower cotton yields and used less pesticide than FFS villages, but were comparable in terms of age, education, farm size and household income.

These comparisons show that trained and untrained farmers were similar in their socio-economic characteristics and production parameters. Hence the possibility of a selection bias is small.

Table 1-2: FFS Graduate Characteristics in Comparison to NFFS and Control Farmers[3]

Category	2003 Average[a]	FFS	NFFS	FFS Village[b]	Control Village
Age [years]	35.8	36.3	39.3	37.8	38.3
Gender [% female]	22.7	8.9	5.4	7.2	1.7
Education [years]	6.5	6.8	5.6	6.2	5.6
Farm Size [hectare]	2.1	2.0	1.6	1.8	2.0
Household Income [US$]		1,613	1,431	1,522	1,532
Cotton Yield [kg/ha]		2,580	2,531	2,555	2,467
Insecticide Use [kg/ha]		14.7	14.3	14.5	11.2

[a] Bangladesh, China and India (average of 12,000 FFS participants)
[b] Average of FFS and NFFS values

[3] Bangladesh, China (Anhui, Hubei, Shandong), India and Pakistan

1.3 Results

Impact Targets

The common impact targets that were agreed-upon after the lengthy process of country and regional harmonisation meetings are listed in Table 1-3. Together with additional country-specific targets they formed the basis for designing the farm-household survey questionnaires. Quantifiable indicators for each target achievement provided further information on the dimensions and level of accuracy required from the studies.

This list revealed that not all targeted impacts could be or needed to be assessed through a farm-household questionnaire survey. For example, to determine the impact on environmental conservation required special studies in post-FFS farmer fields or an analysis of FFS records. On the other hand, impacts on farmer's social capacities or policy impacts could be determined by routine monitoring and reporting. Consequently, further studies and a monitoring and reporting system were designed to supplement the impact assessment studies.

Table 1-1: Common Impact Targets

Area	*Common Impact Targets*
Poverty Alleviation and/or Economic Well-Being	Increase in cotton gross margins Reduction in expenditures for agricultural inputs Increase in expenditures for productive assets, such as children's education, etc. Profile of FFS beneficiaries matches the normal socio-economic distribution among cotton farmers
Pesticide Reduction	Reduction in amount of formulated product and number of applications Reduction in the use of certain toxic pesticides, OP and pyrethroids (IPPM 2015 list)
Environmental Conservation	Increase in number of species and population levels of natural enemies Increase in number of species and population levels collected in soil samples
Improved Health	Reduction in number of pesticide-related lost work-days (hours) of the farmer the farmer family Reduction in pesticide-related health expenditures, treatment, etc.

Improved Education	Increase in field experiments by farmers Increased advice giving to fellow farmers Increased attitude and practice score on safety and health incl. storage and disposal Increased scores in giving reasons behind crop management decisions
Increased Social Capacity	Increase in FFS farmers' active participation in community groups Increase in farmer-to-farmer training activities Increase in number of women beneficiaries Increase in farmers' feedback on research recommendations and policy issues
Policy Support	Cotton IPM is fully integrated into a functional national IPM programme Increase in country-financed ToF and FFS activities in cotton and other crops

Monitoring and Reporting

Participatory efforts to improve the monitoring and reporting system identified which information was needed to supplement the farm-household surveys and which impacts could be assessed by facilitators and farmers themselves. This led to a two-page reporting format with fill-in spaces, blank tables and assessment scales to capture key information about each FFS and the participating farmers. Pests and natural enemies' data from ecosystem analyses and results from field experiments were sampled from a selection of FFS only. The formats were designed so that they could easily be summarized and compiled electronically, if required.

The list of project impact targets provided a useful guideline for identifying the information to be collected. Besides basic FFS implementation statistics, it contained a profile of graduating farmers in terms of gender, age, farm size and education in order to assess whether the right group of beneficiaries were encouraged to participate. Attendance records gave clues of loss of interest or periods of pressing labour demands. Furthermore, FFS reports included quality criteria to detect implementation problems and whether the field activities generated useful and recognizable results.

Thus the monitoring and reporting system provided FFS facilitators and coaches with a format to self-reflect whether the programme was reaching the right farmers in terms of poverty orientation and disadvantaged groups, whether the self-declared FFS objectives have been achieved, and whether implementation was cost-effective and efficient. Field staff was encouraged to organize themselves in district-level 'quality circles' that became collectively responsible for the quality of farmer education, FFS implementation and follow-up in their area.

Curriculum Review

The impact targets also provided guidelines for evaluating the curricula by directly linking FFS activates with specific impact targets. An analysis of cotton FFS in seven project regions showed that the average length of a season-long FFS was 75 hours (range: 51-91; Figure 1-3). About half the time was devoted to enhance farmers' ecological understanding through cotton ecosystem analysis (CESA), field trials and insect zoos. Special topics made up 14% of the time, while about 25% went into the end-of-session reviews, FFS organizational matters, ballet-box tests and the final field day and graduation ceremony.

A comparison of impact targets with the FFS curriculum revealed that a number of subjects may not have been given enough emphasis to achieve the desired effects. For example, little time was spent to organise farmers into sustainable alumni groups that would conduct field experiments for a deeper understanding of ecological relationships, to optimise management practices or to evaluate new technologies such as improved seeds.

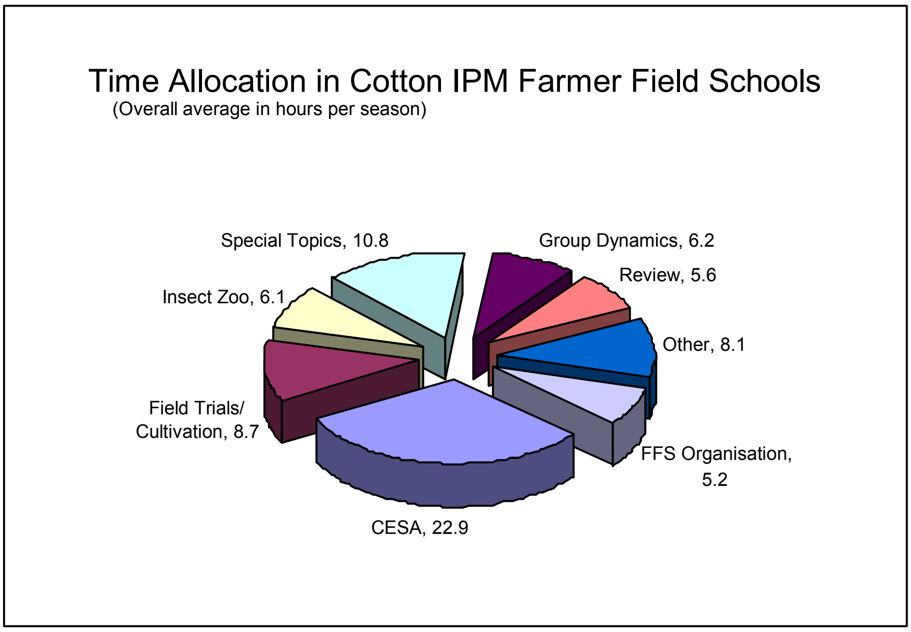

Figure 1-3: Time Allocation in Cotton IPM Farmer Field Schools

Policy Support

The Cotton IPM Programme planned to use the impact assessment results for entering into a dialogue with political decision makers about government support to IPM-FFS activities. Unfortunately, the project ended just as the impact assessment results became available. However, preliminary findings from the studies were presented to a panel of decision makers from member countries on 4 June 2004 to demonstrate the potential of the IPM-FFS approach for contributing to several of the internationally recognized Millennium Development Goals (UN, 2000), international treaties and conventions. The average combined results from the seven impact assessment studies showed:

- Average gross margins increased by US$ 175 per hectare (+23% relative to control) for FFS farmers and $54 (+7%) for exposed farmers (Figure 1-4); this demonstrates the potential of IPM-FFS for reducing rural poverty (Millennium Goal No.1);

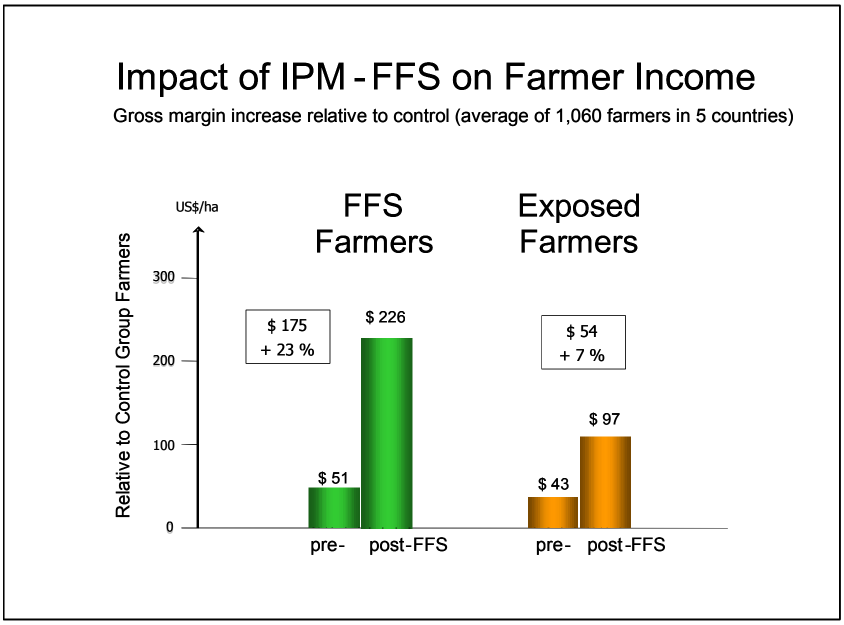

Figure 1-4: Impact of IPM-FFS on Farmer Income

- Insecticide use was reduced by 6.0 kg per hectare (-43 %) for FFS farmers and 5.0 kg (-34 %) for exposed farmers. An accumulated total of 1,800 tons of insecticide was estimated to be saved on about 250,000 ha during the first year after FFS; thus IPM-FFS would contribute to the International Programme on Chemical Safety (IPCS) by helping to protect children from harmful effects of chemicals and by collecting information about human exposure to chemicals;
- A positive impact on the environment could be shown through more natural enemies and higher species diversity in IPM fields; thus IPM-FFS would contributes to environmental sustainability (Millennium Goal No. 7) and the implementation of the Conventions on Biological Diversity (CBD);
- The programme promoted gender equality and the empowerment of women as stipulated in Millennium Goal No.3;
- The programme contributed to the implementation of the Stockholm Convention on Persistent Organic Pollutants and the Rotterdam

Convention for Prior-Informed Consent which were ratified to eliminate or restrict certain severely hazardous chemicals.

Furthermore, the Programme successfully encouraged farmers and facilitators to set-up local organisations and to play an active role in a country's development efforts (Ahmad *et al.,* 2004) which positively contributes to a strengthening of civil society functions.

1.4 Conclusions and Recommendations

Experience of the Cotton IPM Programme has shown that a holistic approach to impact assessment can bring benefits to a development project beyond mere data collection and study reports. By practicing a "culture of impact assessment" on all levels of project implementation, the Programme not only improved the management skills of farmers, but also those of extension agents, researchers and project administrators. This is particularly important as IPM-FFS projects move out of a pilot phase mode into systematic scaling-up when hundreds of facilitators would organize thousands of FFS. At this stage, organisational matters become more important than technical ones, and a clear understanding of the impact targets can help in setting-up an efficient monitoring and reporting system. Furthermore, impact assessments help focussing the farmer education curriculum on the intended outcomes and maintain its quality standards. Following the participatory nature of FFS it is better to place the responsibility for quality in the hands of facilitators by grouping them into 'quality circles' than to establish a controlling system. This, however, requires facilitators that are not only trained in adult education methods but know how to coach farmer groups to form self-reliant organisations for change.

The regional set-up of the Cotton IPM Programme created an inductive environment for exchange between the countries and to learn from each other. Finding consensus on a common set of impact targets created both a feeling of common goals as well as competition between different countries. This would be particularly important as development projects focus more and more on policy issues, international harmonisation and trade.

The experience of the Cotton IPM Programme has also shown that the capacity to conduct impact assessment studies needs to be strengthened in many countries. Investigators may have experience in collecting socio-economic baseline data for feasibility studies, but impact studies require a much more focussed approach and in-depth data analysis beyond mere descriptive statistics. Building such capacities is vital as countries move to more efficient agricultural systems and governmental organisations.

Through the process of impact assessment, the country programmes became more focused and task-oriented, which in turn made project implementation more efficient, transparent and accountable. Thus, the impact assessment activities of the Cotton IPM Programme contributed to building learning organisations in the member countries which will be able to meet the challenges of the future.

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2 The Costs and Benefits of the FAO-EU IPM Programme for Cotton in Asia

Suwanna Praneetvatakul[1], Gerd Walter-Echols[2] and Hermann Waibel[3]

2.1 Introduction

Investment in rural education and farmer training has become an important component of development assistance. During the past, these activities were considered as public goods whose benefits were often just taken for granted. Sometimes, cost-effectiveness analysis has been applied with the aim to maximize the effectiveness of limited public funds through targeted placement of education programs. Most studies on rural education used the criterion of cost per trainee (farmer) to assess the relative advantage of the project. More recently, however, the question of investment efficiency has also been raised with farmer training activities (Quizon *et al.,* 2001). Hence, training is considered an investment with an identifiable stream of benefits that occur over time. Especially, a publicly funded training program that follows the Farmer Field School (FFS) approach should be subjected to rigorous analysis and scrutiny because of the widespread perception that this concept is too expensive. Thus, treating an FFS program in the context of cost-benefit analysis can help to answer the question of whether FFS is a justifiable investment from the point of view of the donor and implementing countries.

The objective of this paper is to investigate the economic efficiency of investment in training farmers under the FFS approach as undertaken by the FAO-EU IPM Programme for Cotton in Asia.

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2.2 Methodology

The results of a cost benefit analysis for a development programme such as the FAO-EU IPM Programme for Cotton in Asia depend on the quality of the data available and the analytical method used. First, in the case of the FAO-EU IPM Programme data collection is not necessarily representative for the entire project area of the five participating countries because data are derived from the impact assessment studies mentioned in Chapter 1 of this volume. Second, the analytical method was kept simple and only a financial analysis was conducted. Due to limitations in time and resources it was not possible to derive shadow prices for all the different country situations. Thus, in the financial analysis actual prices converted at the official exchange rates were used and the benefits at country level were aggregated.

Analytical Method

Benefit-cost analysis is a method to assess the economic desirability of competing alternatives, where desirability is measured as the economic worth to society as a whole (Sinden and Thampapillai, 1995). Because resources are scarce, not all desired projects can be undertaken. Ex-ante and ex-post evaluation of development projects are useful tools for accountability purposes and for decision-making of resource allocation. By calculating the net present value (NPV) and the internal rate of return (IRR), a measure of the efficiency of the investment is obtained. The general procedure starts with the identification of the benefits and costs of the project. The second step is to quantify and value costs and benefits using market prices for the financial analysis and shadow prices for the economic analysis (Gittinger, 1982). Costs and benefits are tabulated on an annual basis over the defined project period. The annual costs and benefits are then discounted and a cumulative cash flow, which is the difference between benefits and costs, is calculated resulting in the NPV of the project investment. The net present value (NPV) is the present value of the total net gain of the project, calculated by the present value of benefits (B) minus the present value of costs (C) using a discount rate that normally reflects the opportunity costs of capital. The internal rate of return (IRR) is the discount rate at which the present value of benefits equals the present value of costs, i.e. the rate at which net present value is zero (Sinden and Thampapillai, 1995). When applying the IRR criterion all benefits and costs are discounted at the internal rate of return as shown by the following equation:

$$(B_0 - C_0) + \frac{(B_1 - C_1)}{(1 + IRR)^1} + ... + \frac{(B_t - C_t)}{(1 + IRR)^t} = 0$$

Data

Both primary and secondary data sources were used for the analysis. Primary data came from the seven impact assessment field surveys that were conducted in Bangladesh, China (3 studies in three different provinces), India, Pakistan and Vietnam. The individual datasets were combined into a regional database. For each of the participating countries, the average benefit in terms of increase in farmer's income has been applied to the respective total area covered. In addition, health benefits were calculated based on the amount of pesticide reduction. The data on project costs are based on project planning documents and country reports. Price data for cotton output and wages were taken from national agricultural statistics.

2.3 Results

In this section the results of the financial benefit-cost analysis for the FAO-EU IPM Programme for Cotton in Asia are presented. An outline is provided of how program costs and benefits are calculated.

2.3.1 Program Costs

The program costs consist of the project's operational costs which include the costs of carrying out farmer training, the overall technical assistance by the project management unit, the planning and evaluation workshops, travel, equipment such as vehicles, the costs for management and administration in the six countries and the program management unit at the regional FAO office in Bangkok.

Table 2-1: Project Costs of the FAO-EU IPM Programme for Cotton in Asia

Year	Total actual project costs [US$]
2000	937,844
2001	2,332,468
2002	3,216,086
2003	4,012,160
2004	1,790,390
Total	12,288,948

Source: FAO-EU IPM Programme for Cotton in Asia, 2004

Project costs are listed in detail in Table 2-1 over the project period resulting in a total budget of about US$ 12.3 million for 5 years. These cost do not yet include the opportunity costs of farmers' time. Adding these costs, which were estimated at US$ 1,119,360 for the 55,968 farmers trained by the programme until 2004 (see Table 2-2), brings the total program costs to over US$ 13 million or about US$ 2.68 million per year. Costs of farmer participation in the training were assessed by calculating the opportunity cost of farmer's time of participating in FFS. Considering that participants attend a season-long training equivalent to 14 - 20 weekly sessions depending on the country an average of US$ 20 per participant was added.

Table 2-2: Opportunity Costs for Farmers Participating in the FAO-EU IPM Programme for Cotton in Asia

Year	Total FFS farmers[a]	Total opportunity costs of FFS farmers[b] [US$]
2000	2,027	40,540.00
2001	7,727	154,540.00
2002	17,661	353,220.00
2003	23,039	460,780.00
2004	5,514	110,280.00
Total	55,968	1,119,360.00

Remarks: [a] based on October 2004 estimates;
[b] is FFS farmers multiplied by US$ 20

2.3.2 Program Benefits

In general, the expected benefits from the FAO-EU IPM Programme for Cotton in Asia were as follows:

- Enhanced farmer knowledge, skills and practices
- Increased farmer income
- Reduced use of pesticides
- Improved farmer health
- Enhanced agro-biodiversity
- Reduced rural poverty

Not all of the listed benefits, however, can be quantified. Therefore, this analysis is only based on the benefits from the two main impacts: (1) income increase and (2) improved health resulting from pesticide use reduction. Two sources of information were used for benefit assessment:

a) Data measured based on impact study results
b) Assumption based on literature for health cost reduction and diffusion effects.

Productivity Benefits

The impact of the programme on farmer income was evaluated by calculating the difference of post- and pre-training gross margins (GM) of FFS graduates minus that of control farmers. The calculation of benefits starts from calculating the change in gross margin per hectare (GM/ha). The change in GM/ha is the difference of GM of post- and pre-training between FFS and control farmers. Then, the change in gross margin per household (HH) was estimated using GM/ha multiplied by farm size. Finally, total gross margin increase was calculated from GM/HH multiplied by the number of trained farmers per country.

The average increase in GM for farmers participating in FFS across all countries was calculated at US$ 170.58 per HH (Table 2-3). Depending on the country this is between a 2.5% – 425% increase in the pre-training gross margin. Of course, benefits varied from country to country depending on farm size, number of farmers practicing IPM and GM increase as derived from the impact studies. For example, the increase in GM was highest in Hubei province in China with close to US$ 500 per ha. This increase in farmer income from FFS training compares well with those levels reported from the introduction of transgenic cotton varieties in China (Huang *et al.,* 2002). In all but one country the change was positive. Bangladesh was the only exception. Here the GM of the trained farmers declined relative to those in the control villages, but not relative to the untrained farmers in the same village. The main reasons for this unexpected outcome were 16% higher yields in the control villages. This can be attributed to the highly diverse cropping system where cotton is often not the main crop and some administrative problems in programme implementation.

Table 2-3: Average Increase in Gross Margin of Farmers Participating in the FAO-EU IPM Programme for Cotton in Asia

Countries	Sample size	Total No. of Farmers trained [a]	GM change [US$/ha[b]]	Farm size [ha/HH][a]	GM [US$/HH][c]	Total GM increase[d]
Bangladesh	91	3,700	-37.81	0.35	-13.23	-48,951.00
China-Anhui	180	3,772	27.28	0.28	7.63	28,780.36
China-Hubei	180	3,983	489.30	0.22	107.64	428,730.12
China-Shandong	175	7,411	329.03	0.15	49.35	365,732.85
India	97	12,043	77.18	1.78	137.38	1,654,467.34
Pakistan	190	10,471	214.28	2.68	574.27	6,013,181.17
Vietnam	147	10,615	51.6	0.78	40.25	427,253.75
Total	1,060	51,995				8,869,194.59
Average per HH[e]						170.58

a Source: FAO-EU IPM Programme for Cotton in Asia, 2004. The number of farmers is lower than in table 2-2 by the number of FFS conducted in the Philippines and in some other provinces in China where no impact studies were conducted.
b calculated from the regional database. GM/ha is the difference of GM of post- and pre-training between FFS and control farmers.
c calculated from GM/ha multiplied by farm size in ha per household (HH).
d calculated from GM/HH multiplied by no. of farmers.
e calculated from total GM divided by total number of farmers.

Health Benefits

The benefits resulting from an improvement of farmer health were estimated through the reduction in pesticide costs. The study by Pingali *et al*. (1994) showed that health costs resulting from chemical pesticide use ranged from 0.5 to 1 times the pesticide costs. In this study, the lower value of this ratio was used as a proxy to value health benefits. Thus, the average benefit from improving farmers' health equalled US$ 21.20 per FFS graduate (Table 2-4).

Table 2-4: Average Reduction in Pesticide Costs of Farmers Participating in the FAO-EU IPM Programme for Cotton in Asia

Countries	Sample	No. of farmers[a]	Pesticide Cost [US$ /ha][b]	Farm size [ha/HH][a]	Pesticide Cost [US$ /HH][c]	Health Benefits [$/HH/year] [d]
Bangladesh	91	3,700	25.29	0.35	8.85	16,375.28
China-Anhui	180	3,772	57.63	0.28	16.14	30,433.25
China-Hubei	180	3,983	54.89	0.22	12.08	24,048.96
China-Shandong	175	7,411	14.30	0.15	2.15	7,948.30
India	97	12,043	88.57	1.78	157.65	949,317.17
Pakistan	190	10,471	5.20	2.68	13.94	73,102.24
Vietnam	147	10,615	0.22	0.78	0.17	827.97
Total	1,060	51,995				1,102,053.16
Average Health benefit ($/HH)						21.20

a Source: FAO-EU IPM Programme for Cotton in Asia, 2004
b calculated from the regional database. Pesticide cost/ha is the difference of total pesticide costs of post- and pre-training between FFS and control farmers.
c calculated from pesticide cost/ha multiplied by farm size (ha/HH).
d calculated from total pesticide costs/HH multiplied by no. of farmers, divided by two.

Total Programme Benefits

Total programme benefits consist of the benefits from income increase and improved health as discussed above. In most countries, the benefits from productivity increase exceed those from reduced health costs (Table 2-5). Nevertheless, health benefits on average account for almost 20% of total benefits. In India, where the programme focused on pesticide health effects (see Chapter 6, this volume) health benefits account for over one third of total benefits. In Bangladesh, the programme has probably produced a net loss of almost US$ 9 per farm household in spite of positive health effects from pesticide reduction, which compensated for some of the productivity losses.

Table 2-5: Total Annual Benefits and Composition of Benefits by Crop Income and Health

Countries	Composition of Benefits (%)		Annual Total Net Benefits at Farm Level [US$]	Annual Total Benefit per Farmer [US$/HH/year]
	Gross Margin	Health Cost Reduction		
Bangladesh	0	100	-32,575.72	-8.804249
China-Anhui	48.6	51.4	59,213.61	15.6982
China-Hubei	94.7	2.3	452,779.08	113.6779
China-Shandong	97.8	2.2	373,681.15	50.4225
India	63.5	37.5	2,603,784.51	216.2073
Pakistan	98.8	1.2	6,086,283.41	581.2514
Vietnam	99.8	0.2	428,081.72	40.328
Total			9,971,247.75	191.7732

In the calculation of the IRR the benefit stream was assumed to start in the year after farmers participated in an IPM-FFS. Then, the assumption was made that farmers would continue their new practices for just one more year. This very conservative assumption is based on the observation that unless follow-up activities take place, farmers may dis-adopt the technology, which they have acquired in the farmer field school training. Since the project was terminated after its initial phase, follow-up activities by the national programes are uncertain. The unitary benefits of some US$ 190 per household and year were multiplied by the number of IPM practitioners as shown in Table 2-1. A further deduction was made in assuming that 20% of the FFS participants did actually not change their practices after training, i.e. they did not adopt IPM. Thus the total benefits of the project are calculated on a yearly basis as presented in Table 2-6.

Table 2-6: Benefits of the FAO-EU IPM Programme for Cotton in Asia [in US $]

Year	IPM Practitioners	1 year benefits		2 year benefits		Total Benefits
		Income	Health	Income	Health	
2000	1,621.60	0	0	0	0	0
2001	6,181.60	275,672.00	34,053.60	0	0	309,725.60
2002	14,128.80	1,050,872.00	129,813.60	275,672.00	34,053.60	1,490,411.20
2003	18,431.20	2,401,896.00	296,704.80	1,050,872.00	129,813.60	3,879,286.40
2004	4,411.20	3,133,304.00	387,055.20	2,401,896.00	296,704.80	6,218,960.00
2005		749,904.00	92,635.20	3,133,304.00	387,055.20	4,362,898.40
2006				749,904.00	92,635.20	842,539.20

2.3.3 Net Present Value, Benefit Cost Ratio and Financial Rate of Return of the Programme

In the base case scenario which used the assumptions described above and presented in Table 2-7, results show a positive net present value of US$ 575,548 and a benefit cost ratio of over 1 using a discount rate of 12%. The Financial Internal Rate of Return was 16%. As shown by the positive cash flow in Table 2-2, the pay-off period is reached in 2005, the very year that the project was closed.

Results of this analysis indicate that the public investment of the EU to implement the IPM Programme for Cotton in Asia was economically justified. This judgment can be made with some confidence since the analysis uses rather conservative assumptions. In reality, the viability of the investment may be stronger. If the national programs continue to support IPM under their regular extension activities, farmers are likely to continue to practice IPM beyond the two years assumed in this analysis. Also, national governments may undertake additional investments in IPM-FFS resulting in further scaling-up of the program. For example, the Government of Pakistan has committed significantly more of its budget for IPM expressing its' willingness to diffuse the program further. In order to account for the consequences of other possible scenarios, sensitivity analysis was performed.

Table 2-7: Benefits and Costs of the FAO-EU IPM Programme for Cotton in Asia

Year	Benefits	Costs	Net Benefits	Discounted cumulative cash flow
2000		978,384.00	-978,384.00	-873,557.14
2001	309,725.60	2,487,008.00	-2,177,282.40	-2,609,273.34
2002	1,490,411.20	3,569,306.00	-2,078,894.80	-4,088,989.60
2003	3,879,286.40	4,472,940.00	-593,653.60	-4,466,267.19
2004	6,218,960.00	1,900,670.00	4,318,290.00	-2,015,953.48
2005	4,362,898.40		4,362,898.40	194,426.63
2006	842,539.20		842,539.20	575,548.58
		NPV (r=12%)	575,548.58	
		BCR	1.06	
		FIRR	16%	

Note: NPV: Net Present Value, BCR: Benefit-Cost Ratio, FIRR: Financial Internal Rate of Return, r is the discount rate.

2.3.4 Sensitivity Analysis

In order to determine whether the project was still worth the investment under different assumptions, three additional scenarios were tested as follows:

- Scenario B[4]: farmers practice IPM for 3 years
- Scenario C: diffusion effect to neighboring farmers at a rate of 1 exposed farmer to 1 FFS farmer; it is assumed that benefits to exposed farmers are only 1/3 that of FFS graduates and they only last for 1 year
- Scenario D: same as Scenario B but without health benefits

Results of these scenarios are shown in Table 2-8. The first observation is that if farmers continue to practice IPM for just one year longer than in the base scenario the FIRR rises to 36%. Furthermore , taking the same retention period of the base scenario but assuming diffusion effects to the non-trained farmers living in the same village (exposed farmers, scenario C), the FIRR also goes up to 27%. Finally, even when ignoring health

[4] The base scenario (scenario A) was kept in the table for easier comparison.

benefits but assuming a 3-year retention of IPM practices (scenario D), the FIRR becomes 28%. Overall, the analysis shows that the critical factor for project success is that farmers retain the IPM practices. This seems possible, provided the national programs show the necessary commitment and reform their extension system in order to accommodate participatory approaches such as FFS on a large scale (Fleischer *et al.,* 2002).

It should be mentioned that the results for the FAO-EU IPM Programme are comparable to those calculated for an ADB-funded IPM project in Pakistan despite the more optimistic assumptions made in the ADB analysis (Erickson, 2004). In this analysis, the rate of return was in the order of 26%. Hence, in conclusion, there is little doubt that the FAO-EU IPM Programme for Cotton in Asia was an economically viable investment. The rate of return of the project investment and the sustainability of the benefits would have been considerably higher had the programme been continued for another phase, as originally planned.

Table 2-8: Scenario Analysis of the Rates of Return for the FAO-EU IPM Programme for Cotton in Asia

Scenario	Number of IPM practitioners	Diffusion number of farmers	Retention of IPM practice years	Income benefit [US$/farm]	Health Benefit [US$/farm]	FIRR [%]
A	44,774	0	2	170	21	16
B	44,774	0	3	170	21	36
C	44,774 44,774		2 1	170 56.67	21 7	27
D	44,774	0	3	170	0	28

Note: FIRR: Financial Internal Rate of Return

2.4 Summary and Discussion

This brief analysis of the benefits and costs of the FAO-EU IPM Programme for Cotton in Asia has shown that even under conservative assumptions, the investments made by the project did pay off. Also, as shown in a study by Yang *et al*. (2005) investment in farmer training may effectively augment the introduction of new pest control technologies such as transgenic cotton varieties. There is now an increasing amount of evidence indicating that farmer education through FFS is effective in changing farmer behavior (van den Berg, 2004). Furthermore, the findings of this analysis confirm the results of an economic analysis of a similar IPM program in Pakistan (Erickson, 2004).

Overall, this study has shown that in order to conduct meaningful benefit-cost analysis, a well-designed impact assessment scheme is a necessary pre-condition to obtain the basic data required for such analysis. To sustain the benefits from FFS programs, it is crucial that enabling policy conditions are in place in order to create incentives for farmers to continue IPM practices. Moreover, institutional models for up-scaling IPM and the role of FFS thereof need to be developed. Furthermore, a long-term ex post impact analysis is needed to verify the critical assumptions of the analysis presented here.

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3 The Impact of FFS on Yield, Pesticide Cost and Gross Margin in Shandong Province, P. R. China: an Econometric Approach[1]

Lifeng Wu[2], Suwanna Praneetvatakul[3], Hermann Waibel[4] and Lanying Wang[5]

Abstract

This paper uses a "difference in difference" model to evaluate the impact of FFS on important farm-level socio-economic performance indicators of cotton production such as yield, pesticide cost and gross margin. Analysis results of panel data collected before and after the introduction of FFS indicate that there is a significant effect of FFS on its graduates' performance as compared to the control group. The FFS graduates had higher growth rates for gross margin and yield while cost of pesticides decreased significantly. For the exposed farmers, no significant difference was found with respect to the growth rates of gross margin and yield as compared to the control farmers, but pesticide costs were significantly reduced.

3.1 Background

Substantial investments in FFS training call for a comprehensive assessment of its impact. Several recent studies reported encouraging impacts of FFS training such as reduction in pesticide use (or cost) and increase in yield (van den Berg, 2004). Praneetvatakul and Waibel (2002)

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showed that rice farmers in Thailand who participated in FFS training reduced their insecticide costs by 58% and costs of molluscicides by 59%, while costs among farmers who were not trained remained unchanged during the same period. Jiang and Liang (1997) reported farmers' profit from rice cultivation in China increased by 23.2% after participation in FFS, while pesticide use was reduced by 38.5%. Godtland *et al*. (2003) showed that for the case of Peru that participation in FFS on potatoes significantly enhanced farmers' knowledge of pests, fungicides and resistant varieties.

However, controversy exists about the reported impacts. Owing to the complexity of impact evaluation, there is no agreed conceptual framework for measuring FFS impact (van den Berg, 2004). Since FFS usually follows certain criteria for project placement and participant selection, it is contended that most previous studies have not accounted for econometric problems that arise in estimating program impact when the placement of the program across villages and selection of farmers for participation in the program are not done at random. These and other econometric issues are likely to bias estimates of program impact and the significance of the impact may result from the existing difference (Feder *et al*., 2004).

Regarding the bias problem, meaningful work has been done by Feder *et al*. (2004) through adopting the DD model for FFS impact assessment. In their study this model was applied to panel data collected in Indonesia and no significant improvement in economic performance was identified. However, sample design and data collection methods are still being questioned. Since the authors pointed out that FFS program design and rapid scaling-up might have affected the impact, caution should be exercised when citing the result of that study. More cases should be studied before the outcomes can be applied. The DD model is an appropriate tool to solve the problems rising from non-random selection of FFS participants and non-random placement of project; it is worthwhile to utilise this approach to evaluate the impact of FFS conducted elsewhere.

3.2 Objective

The overall objective is to investigate whether there is significant impact of FFS on graduates and exposed farmers. The specific objectives of this paper are to:

1. describe important socio-economic parameters of graduates, exposed farmers and control farmers;
2. analyse the impact of FFS on cotton yield, gross margin and pesticide cost using the “difference in difference” (DD) model.

3.3 Theoretical Framework

A commonly used approach for FFS impact assessment is to regress farm level outcomes on variables indicating a farmer’s participation in or exposure to the FFS training and other relevant variables. For farmer i in village j and time period t, the model can be constructed as follows:

$$\ln(Y_{ijt})=\alpha+\beta D_{Nijt}+\mu D_{Gijt}+\gamma X_{ijt}+\delta Z_{jt}+\lambda_i+\eta_j+\varepsilon_{ijt} \qquad (1)$$

where Y stands for a farmer level outcome such as gross margin or pesticide costs, D_G and D_N are dummy variables for graduates and exposed farmers (with control farmers implicit). Variables X and Z denote vectors of household and village characteristics respectively that may change over time, λ_i and η_j are unobserved determinants of Y that are fixed over time within a household and village, respectively.

Since non-random participant selection leads to correlation between D_N, D_G and λ_i, while non-random program placement leads to correlation between D_N, D_G and η_j, the orthogonality between graduate and exposed dummies and the residual is likely to be violated. As a result, there is no guarantee for unbiased estimates of μ^{OLS} and β^{OLS} and hence no strong conclusion can be drawn about the causal effect of FFS on graduate or exposed farmers (Feder *et al.,* 2004).

To solve the bias problem, the DD model is an appropriate tool. Derived from an underlying exponential growth assumption with regard to farm level outcomes:

$$Y_1=Y_0\, e^{\{\alpha + \beta DN_{ijt} + \mu DG_{ijt} + \gamma \Delta X_{ijt} + \delta \Delta Z_{ijt}\}} \qquad (2)$$

a general DD model can be specified as :

$$\Delta(\ln Y_{ijt})=\alpha+\beta D_{Nijt}+\mu D_{Gijt}+\gamma\Delta X_{ijt}+\delta\Delta Z_{ijt}+\Delta\varepsilon_{ijt} \qquad (3)$$

where e denotes the exponential operator, Δ denotes the differencing operator between times of the 2 surveys, α measures the pre-program growth rate in performance for all groups; β measures the post-program difference of growth rate between exposed farmers and control farmers, μ denotes this difference between the graduates and control farmers and the other symbols have the same meaning as in equation (1).

With the DD model the program impact is estimated in a way that any time invariant unobservable household or village characteristics that may affect participant selection or program placement are differenced out, and therefore do not bias the estimates. Yield, cost of pesticide and gross margin are chosen as performance indicators (Y) at farm level. In order to control the effect of factors other than FFS participation or exposure, costs of inputs such as labour, fertilizer, pesticide, irrigation and seed are also included as independent variables. Since the size of the cotton area of the household might have a scale effect on the indicators, it is included as a variable in the analysis. With F denoting the cost of fertilizer, L the cost of labour, P the cost of pesticide, S the cost of seed and C the cotton area, the model can be specified as:

$$\Delta(\ln Y)=\alpha+\beta D_N+\mu D_G+\gamma_1\,\Delta F+ \gamma_2\,\Delta L+\gamma_3\,\Delta P +\gamma_4\,\Delta S +\gamma_5\Delta C+ \Delta\varepsilon_{ijt} \qquad (4)$$

Because FFS trains farmers to adopt integrated pest management instead of a chemical-oriented pest control, it is expected that the growth rate of pesticide use of FFS graduates is lower than that of control farmers. Since knowledge from FFS may improve graduates' agricultural practice, these farmers are supposed to have higher growth rates in gross margin and yield as compared to control farmers. Since exposed farmers may have access to FFS knowledge indirectly from their FFS graduate neighbours, it is expected that their performance will be improved to some extent. In all cases, a significant β exhibits a significant difference between exposed farmers and control farmers, while a significant μ shows a significant difference between graduates and control farmers. In order to test whether there is any difference of the growth rates between graduate and exposed farmers, the regressions are re-estimated with exposed farmers implicit, and the test of the coefficient for graduate dummy will give the answer. Since the re-estimation is in essence the same as the original one, only statistics relative to the constant term (exposed farmers), control farmers and graduates are reported.

3.4 Data Collection

The data were collected in Lingxian, a big agricultural county located in the northwestern part of Shandong Province, China. Cotton is the most important cash crop in this county. In the early 1990s, Lingxian ranked among the 10 biggest cotton producing counties in China, while from 1992 onward the cotton area declined until Bt cotton was introduced in 1999. With a 100% adoption of Bt cotton in 2001, the cotton area had expanded to 30,800 hectares. As a traditional cotton growing area, Lingxian County was included into the FAO-EU IPM Program for Cotton in Asia at its inception and since 2001, 170 FFSs have been conducted and 4,700 farmers trained.

At the beginning of the 2001 cotton season, a baseline survey was carried out during which retrospective data for the 2000 season (before the training activities) were collected. Most farmers keep records of their agricultural activities, and those records helped to ensure the precision of the information. The survey covered economic, environmental, health, education and social information, but only economic data will be reported-on in this paper.

The surveys were organized by the National Agro-technical Extension and Service Center and the Shandong Provincial Plant Protection Station. Enumerators were local agricultural technicians, consultants from universities and research institutes and some FFS graduates. In order to follow a standard surveying procedure, workshops were held to train these investigators. Questionnaires for the survey were collectively designed and pre-tested in a pilot survey.

Six villages within the two townships of Mi and Dingzhuang were included in the survey. FFSs were only conducted in Mi Township while Dingzhuang served as the control area. The two townships are 50 kilometers apart and no FFSs were conducted in-between; this distance was assumed sufficient to prevent possible diffusion of FFS knowledge or practices to the farmers in Dingzhuan. Three villages in each township were sampled as replicates. The selection of the sample villages was based on the analysis of secondary data and considered factors such as cotton production, distance from the city, infrastructure, etc. In each sample village in Mi Township, 20 FFS and 20 exposed farmer households were randomly selected for the survey, while in each of the 3 villages in Dingzhuang, 20 farmer households were taken as the control. Thus, 60 households were investigated for each group (FFS graduates, exposed farmers and control farmers). Due to some missing data, only 51 graduates, 59 exposed and 58 control farmer households were included in this analysis.

The second survey was conducted by the same enumerators season-long in 2002 and the same set of data was collected using a double-checking system, i.e. monthly visits by the enumerators in combination with farmers' book keeping.

3.5 Results

In order to test whether the farmers in different groups had similar starting points, a descriptive analysis of relevant data collected in 2000 was done first. According to the results listed in Table 3-1, farm household size and composition, labour availability and educational level of the interviewees were similar across all groups. More important results came from the comparison of the 3 indicators of concern, i.e. gross margin, yield and pesticide cost. There was no significant difference in the gross margins across the groups and no significant difference could be found in cotton yields either, which consequently resulted in similar cotton revenues. Since the project gave priority to areas with more pesticide use, pesticide cost was significantly higher in the FFS group than in the control group. Control farmers, however, spent more on plant regulator, while costs of fertilizer, seed, labour and irrigation were similar for all farmers. There were also significant disparities in land tenure and cotton area. FFS graduates and exposed farmers contracted for more land and in turn grew more cotton. In China, land is state-owned and allotted to farmers on a village basis; uneven distribution of land over villages leads to this difference. Land is not a private asset of individual households and farmers just contract it and pay taxes in proportion to its size.

Table 3-1: Descriptive Statistics by Farmer Category in 2000 (before training)

	Farmer Category		
	Controls	**Exposed**	**Graduates**
Household size	4.12 (0.98)	4.19 (0.99)	4.39 (1.18)
Male [%]	49.88 (13.50)	53.50 (15.86)	51.00 (18.01)
Female [%]	50.12 (13.50)	46.50 (15.86)	49.00 (18.01)
Labour [%][6]	67.98 (21.93)	62.88 (20.27)	60.99 (19.83)
Educational level [years]	6.95 (1.92)	6.49 (2.51)	7.20 (2.26)
Cotton yield [kg/ha]	3498.22 (546.43)	3588.71 (514.66)	3627.32 (597.64)
Cotton gross margin [US$/ha][7]	790.63 (373.57)	806.19 (370.03)	886.54 (405.99)
Cotton revenue [US$/ha]	1676.97 (257.99)	1674.25 (275.22)	1723.56 (295.90)
Pesticide cost [US$/ha]	13.77^{A} (10.30)	17.51^{AB} (15.57)	20.04^{B} (14.98)
Plant regulator cost [US$/ha]	1.59^{B} (0.87)	0.93^{A} (0.91)	0.98^{A} (1.27)
Fertilizer cost [US$/ha]	115.08 (45.22)	120.32 (56.77)	133.43 (92.93)
Seed cost [US$/ha]	47.16 (21.42)	48.26 (34.04)	54.32 (35.29)
Labour cost [US$/ha]	683.53 (237.85)	655.74 (235.46)	601.35 (323.74)
Irrigation cost [US$/ha]	25.22 (9.61)	25.30 (9.46)	26.90 (10.74)
Land tenure [ha]	0.46^{A} (0.14)	0.58^{B} (0.15)	0.53^{B} (0.18)
Cotton area [ha]	0.13^{A} (0.06)	0.19^{B} (0.08)	0.18^{B} (0.10)

Notes: Standard deviation reported in parentheses.
Superscript capital letters denote results of Duncan's test (0.05), no superscript no significant difference.

[6] Labour refers to the number of family members who belonged in the age group between 16 and 60, but students in school and those adults who were not involved in farm work were excluded.

[7] Gross margin is the difference between cotton revenue and the sum of all variable costs, including costs of pesticide, plant regulator, fertilizer, seed, labor and irrigation. Opportunity cost of labor was 9 Yuan RMB per manday and the exchange rate between US$ and RMB used in this paper was 1:8.26. Price indices are used to inflate 2000 prices of cotton and inputs to 2002

Table 3-2: Impact of FFS on Cotton Yield, Pesticide Cost and Gross Margin

Dependent variable	Variable	Coefficient	Std Error	Prob.
Yield R^2=0.14, F=8.79	(Constant)	-0.0447	0.036	0.215
	EXPOSED	0.0178	0.031	0.569
	GRADUATE	0.142	0.032	0.000
Pesticide cost R^2=0.26, F=14.23	(Constant)	0.627	0.140	0.000
	EXPOSED	-0.680	0.169	0.000
	GRADUATE	-0.921	0.174	0.000
Gross margin R^2=0.43, F=30.69	(Constant)	0.103	0.090	0.253
	EXPOSED	0.0973	0.108	0.367
	GRADUATE	0.210	0.111	0.060

Note: Sample size in all regressions is 167

For the regression, the dummies of participation in and exposure to FFS and those independent variables which have significant effect on the dependent variables (using a stepwise selection procedure) were finally included. The estimates of the growth rates of the control farmers (coefficient of constant), the differences of the growth rates between the graduates and control farmers (coefficient of graduate) and the differences of the growth rates between the exposed and control farmers (coefficient of exposed) are reported in Table 3-2.

According to the results of the yield analysis, graduates had a significantly higher growth rate as compared to the control farmers, while no significant difference existed between the exposed and control farmers. The non-significant constant bears a negative sign, which ambiguously indicates that yields may decrease over time without FFS. The results of the pesticide cost analysis give evidence to both direct and diffusion effects of FFS. The change rates of graduates and exposed farmers were significantly different from control farmers. The coefficient of constant (denoting the growth rate of control farmers) was positive, indicating that pesticide use in this group increased during the period under study. Contrarily, the coefficients showed negative signs for exposed farmers and graduates, indicating that pesticide cost decreased over time in those two farmer groups. As for the gross margin, the significant positive value of the coefficient for graduates shows the growth rate of graduates was higher than that of control farmers while the non-significant coefficient for exposed farmers shows that there was no significant difference between this group and the control farmers.

The results from the re-estimation of the three regressions are presented in Table 3-3. For the regression on yield, the growth rate of FFS graduates was significantly higher than that of exposed farmers, while no significant difference existed for the growth rates of pesticide cost and gross margin between those two groups. The relationship presented here between the control and exposed group was the same as for the previous corresponding regression. Except for pesticide cost, no significant difference could be identified between those two groups.

Table 3-3: Results from Re-estimation

Dependent variable	Variable	Coefficient	Std Error	Prob.
Yield R^2=0.14, F=8.79	(Constant)	-0.0269	0.037	0.469
	CONTROL	-0.0178	0.031	0.569
	GRADUATE	0.124	0.032	0.014
Pesticide cost R^2=0.26, F=14.23	(Constant)	-0.0524	0.129	0.685
	CONTROL	0.680	0.169	0.000
	GRADUATE	-0.241	0.166	0.149
Gross margin R^2=0.43, F=30.69	(Constant)	0.200	0.082	0.016
	CONTROL	-0.0973	0.108	0.367
	GRADUATE	0.113	0.106	0.290

Note: Sample size in all regressions is 167

Taking the whole scenario into consideration, the change rates of pesticide cost in the graduate and exposed groups were at the same level, both significantly lower than the growth rate of the control group. No significant improvements of cotton yield and gross margin could be identified with the exposed farmers as compared to the control farmers. Does this negate a diffusion effect of FFS knowledge on the exposed farmers? Although the curriculum was designed as straightforward as possible, it was obviously easier for neighbours of graduates to reduce pesticides than to acquire the capability of ecosystem analysis and better decision-making and thus achieve higher growth rates of yield and gross margin. It might just take more time for exposed farmers to observe, practice and then master such skills. Thus, despite the non-significant coefficients, the positive sign of the coefficients for the exposed farmers in Table 3-3 is meaningful since it shows the correct “direction” and permits prospects for future improvement.

3.6 Conclusion and Recommendations

The empirical results from the analyses above provide evidence of significant impacts of FFS on graduates’ performance. For exposed farmers, diffusion effect on pesticide use was apparent and desirable tendencies were also noticeable with regard to yield and gross margin. Based on these findings, it is reasonable to conclude that in the Lingxian case, IPM-FFS presents an effective approach for technical extension and can contribute to the objective of achieving sustainable, profitable and environmentally sound crop production.

Even though encouraging results for FFS were reported in this study, it is risky to extrapolate the findings. Being of case study character, this study has of course limitations that could be overcome by following the recommendations listed below:

1. A much larger sample of FFS is needed. This paper is based on only 3 FFS villages, which is obviously insufficient for strong conclusions. To get more general results, a much larger sample (include more villages) of different FFS is crucial.

2. Additional village and township level information is needed. Although it might have little influence on the results in this specific case, for a rigorous analysis, it is indispensable to account for village or township

characteristics. Information like wells for irrigation, access to schools and road quality should be supplemented.

3. Long-term impact assessment is needed. This paper presents results of a “short run” analysis that does not yield information on what the impact will be in the long run. To capture the long-term impact of FFS training, data from an additional sampling (several years after the training intervention) is required.

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4 Impact of an FFS-based IPM Approach on Farmer Capacity, Production Practices and Income: Evidence from Pakistan

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4.1 Background

Pakistan is the world's fourth largest producer of cotton and a major exporter. Cotton is grown largely in Punjab and Sindh Provinces. The majority of cotton farmers are smallholders and there are many tenant cotton-growing households meeting only bare minimum household sustenance needs. Pest outbreaks during the early 1990's have enhanced pesticide-based farming. Also, the liberalization of generic pesticide import has resulted in a many-fold increase of pesticide use. However, this has neither increased cotton productivity nor the prosperity of the poor cotton growers (Poswal and Williamson, 1998; and Ahmad and Poswal, 2000).

In Pakistan, research and development in IPM was initiated in the 1970's. However, efforts to implement IPM at the farm level were not very successful. Pesticides became a major instrument of production leading to a 'pesticide treadmill' situation (Irshad, 2000). An analysis of pesticide policies through the UNDP-FAO Policy Reform Project paved the way for the establishment of a National IPM Programme and provided instruments to scale up farmer-led IPM through joint international and national efforts on various fronts. A pesticide policy study estimated environmental and social cost of pesticides in Pakistan at US$ 206 million per year (UNDP, 2001). About 49% of these external costs were attributed to pest resistance problems, while 29% to loss in bio-diversity, and nearly 20% occurred to human and animal health. On the other hand, damage prevention

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expenditures for residue monitoring and raising public awareness on the dangers of pesticides is less than 2% of the total social costs of pesticides.

The study indicated that over- and misuse of pesticides has led to tremendous economic losses and hazards to human health (Azeem, 2000; Feenstra *et al.,* 2000; Orphal, 2001; and Ahmad *et al.,* 2001). The results of the pesticide policy analysis and the onset of the FAO-EU IPM Programme for Cotton in Asia led to the establishment of a National IPM Programme of Pakistan in December 2000. During 2001, Training of Facilitators (ToF) and Farmers Field School (FFS) activities were implemented in the cotton growing areas of Sakrand and Khairpur Districts of Sindh Province, which was expanded to other areas and provinces, i.e. Punjab and Balochistan. The FFS approach aims at generating a deeper understanding of the important interactions of agro-ecosystems as well as on a sustainable farming, with particular emphasis on the reduction of chemical pesticide use (Berg *et al.*, 2004). A change in crop management practices of FFS farmers is expected as a result from this training process. Discovery based learning methodologies used for the training are expected to foster experimental and analytical capacities of FFS farmers for making rational decisions under complex and changing circumstances. Each FFS participant learns improved crop management skills through group activities by attending around 22 FFS sessions. The ultimate purpose of this rigorous training is to achieve a significant improvement in the crop and pest management knowledge and practices of the FFS farmers. The community neighbours of the FFS participants are expected to benefit indirectly through knowledge spill-over. The purpose of this study was fourfold:

i. To measure changes in farmers beliefs, attitude and decision making capacities for a sustainable use of IPM practices
ii. To determine to what extent farmers retained the FFS training knowledge
iii. To assess farmers ability to practice skills they learned in the FFS
iv. To quantify the income effects from FFS training

4.2 Methodology

Sample Area and Size

IPM impact assessment was conducted in the cotton growing areas of Sindh Province. Khairpur District in northern Sindh was purposively selected over Nawabshah District because of the presence of a large number of small and tenant farming communities and increasing pesticide use scenarios. The low income and high poverty profile was another factor behind this selection.

At a second stage, 4 FFS villages were selected from four different clusters of FFS situated in 4 adjacent Tehsils. Finally, 4 control villages within a 20 km radius were selected in the adjoining Sukkur District, which were nearly 60 kilometer away from the nearest FFS project areas of Khairpur District. The list frame on structural and operational variables including farmers' age, education, farm size, cotton area and irrigation sources was developed to determine similarities in the overall profile of project and control area farms as cautioned by Casely and Kumar (1987).

About 100 FFS-participating farmers (all 25 farmers per FFS), 60 non-FFS (15 from each FFS village) from 4 IPM villages and 60 control farmers from 4 non-IPM villages (15 farmers per village) were interviewed.

Data Collection and Transformations

The baseline survey was conducted during July 2002 immediately after the formation of the FFS training groups and information was collected about the 2001 cotton crop. The post FFS-impact survey was conducted during the 2003 cotton season through multiple visits in three rounds. A set of both qualitative and quantitative impact assessment indicators was determined for data collection (Guijt, 1998; Abbot and Guijat, 1998).

A biodiversity score was derived from responses to questions on crop losses estimated by the farmers. Scoring of the attitude towards the environment was done based on six statements, which indicated the extent of agreement of respondents. These statements, which were weighted included belief in cultural and biological methods of crop protection, consideration of pesticide use as sole crop protection solution, perceptions on biodiversity losses, understanding on pesticide threat to natural environment, know-how on pesticide hazards to all living organisms, and beliefs on health risks of spraying.

Scoring on field experimentation skills was assessed through giving weights (see number in parentheses) to experimentation initiatives undertaken by farmers including early planting (10), late planting (10), trap crops (20), change in variety (20), physically controlling pests (10) and experimentation on pesticide chemical alternatives such as water spray, plant extracts sprays, detergent spray etc (30). The decision-making empowerment scoring was performed on using different decision aids like self-conducted ecosystem analysis including pest scouting (40), consulting fellow farmers (20), relying on own knowledge (10), reading labels (20) and watching/listening agriculture programme on TV and radio (10), and understanding the relationship between health problems and pesticide use (10).

Social recognition of the farmers was assessed through assigning different scores for contacting farmers for discussion on social and technical matters, which was categorized as contacted by less than 5 farmers (10), contacted by 5 to 10 farmers (20) and contacted by more than 10 farmers (40), office bearer (20) and just member (10) of a farmer group.

Analytical Methods

Beside single difference comparisons of change in production practices between trained and non-trained farmers, the difference in difference (DD) method (Feder *et al.*, 2003) was used for comparisons among FFS farmers, exposed farmers and un-exposed farmers from control villages. As a first explorative step, group means of relevant economic parameters were compared by using T-test for the before-after comparison and using F-test for the between-group comparison (Praneetvatakul and Waibel, 2001). The DD method was used to compare mean, standard deviation and paired T-test statistics to test for differences in gross margin, production practices and input use level among IPM, non-IPM and control farms. Variable inputs were valued based on market prices. Opportunity costs were estimated for the operations performed by own farm machines, family labour and farm inputs (farm yard manure and seed). Monetary costs arise for inputs such as fertiliser, herbicide, insecticide, fuel, improved seed, casual hired labour, picking and transplanting. The cotton activity's gross margin is estimated as the difference between per-unit revenue and total variable input costs.

4.3 Results

Differences in Capacity Building

Table 4-1 shows performance parameters in terms of human capacity aspects of farmer training. The separate before-after comparison among the three farmer groups indicates that in general FFS training has enhanced the human capacity of the participants. The F-values showed significant differences in all variables after the training. While for three out of five variables such differences existed already before the training the level of significance was higher after the training. Also, the mean scores of FFS farmers increased for all variables, in some cases it doubled. This was different for control farmers where the change was small and in some cases even negative. The same pattern of before-after difference observed for the control group could be observed for the exposed farmers (Non-FFS) indicating that enhancement of human capacity is depended on training participation and is not likely to spread by other communication channels.

To better illustrate the differences in the human capacity performance parameters as indicated in Table 4-1 paired comparisons were undertaken for the three groups of farmers before and after the training. Results are shown in Table 4-2. Furthermore, the respective before and after differences were compared between FFS and control as well as Non-FFS and control. These comparisons demonstrate the positive change for FFS farmers while the differences were comparatively small and highly variable between the two other groups.

Table 4-1: Change in the Human Capacities for Practice Changes

Year	Types	N	Decision making skill score [%]		Field experiments Score [%]		Observed biodiversity score [%]		Attitude towards environment score [%]		Social Recognition	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	16.0	11.1	11.03	14.6	52.44	16.69	37.95	21.82	14	13.9
	Non-FFS	59	10.3	8.3	7.80	12.7	51.19	19.48	36.10	22.82	9	10.5
	Control	53	14.9	10.3	5.28	11.7	45.66	12.25	33.77	18.83	7	8.1
	Overall	190	13.9	10.3	8.42	13.4	50.16	16.71	36.21	21.32	10	11.8
	Sig.		0.004		0.050		0.063		0.548		0.002	
2003	FFS	78	34.5	25.4	15.26	15.5	72.05	14.80	75.90	32.85	27	27.9
	Non-FFS	59	9.5	12.7	11.19	14.9	54.75	17.87	39.15	33.44	8	15.8
	Control	53	9.4	10.8	6.79	12.7	46.32	18.06	29.81	19.46	8	19.2
	Overall	190	19.7	22.3	11.63	14.9	59.50	19.94	51.63	36.22	16	24.3
	Sig.		0.000		0.006		0.000		0.000		0.000	

Table 4-2: Difference of Difference Estimates of the Qualitative Attribute of Farmers' Education that Contributes Towards Changes in Production

	Pre/post FFS Diff.			FFS vs Control			Non-FFS vs Control		
	FFS	**Non-FFS**	**Control**	**Pre**	**Post**	**Diff.**	**Pre**	**Post**	**Diff.**
Decision making score	18 (27)	-1 (13)	-5 (13)	1	25	24	-5	0	5
Experimentation score	4 (18)	3 (20)	2 (18)	6	8	2	3	4	1
Biodiversity score	20 (20)	4 (26)	1 (21)	6	26	20	5	9	4
Attitude score	38 (34)	3 (32)	-4 (23)	4	46	42	2	9	7
Social recognition score	14 (26)	-1 (17)	2 (22)	7	19	12	2	0	-2

Note: Figures in parenthesis are Standard Deviations

Practice Differences

Following the concept of human capacity variables the same comparisons were undertaken for input use and production practices. Table 4-3 shows that before FFS training no significant difference among the three groups of farmers existed in seed management and in the time spend on field observations. This had changed after training. Control farmers tended to overuse seeds while both FFS and Non-FFS farmers remained at reasonable levels. Excessive use of seeds is often a response of farmers to control weeds although the effect of this practice is questionable. Most importantly, FFS farmers significantly increased the time spend on field observation as compared to the other two groups. This illustrates that one of the main messages of the training, i.e. to regularly observe the cotton field was taken up by the participants.

No practice change however was observed in fertilizer management. The significant difference that had existed before the training had disappeared in 2003. In irrigation management results also reversed, i.e. there was a significant difference before the training but there was none in 2003. This could be attributed to change in microclimatic factors and is not necessarily associated with the training.

Application of irrigation was almost identical in absolute terms, but varied in relation to timing and volume of application.

The paired comparisons make the changes after the training more transparent (Table 4-4). For example, also Non-FFS farmers have increased the time spend on field observations suggesting some diffusion effect. Comparing these differences for FFS and Control shows that material inputs among FFS farmers declined relative to the control farmers. Also, the differences were generally larger as those between Non-FFS and Control. The most pronounced change as indicated above was in the time spent on field observations.

Table 4-3: Input Use and Field Management Practices Before and After FFS Training

Year	Types	N	Seed [kg/ha]		N fertilizer [kg/ha]		P fertilizer [kg/ha]		No. of Irrigations		Field Observation [hrs/season]	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	21	6	181	51	52	19	9	4	36	66
	Non-FFS	59	21	6	171	47	54	24	9	5	32	53
	Control	53	23	3	228	65	67	24	6	2	17	18
	All Farmers	190	22	5	191	59	57	23	8	4	29	53
	Sig.		0.108		0.000		0.000		0.006		0.117	
2003	FFS	78	23	8	197	66	45	30	8	3	66	60
	Non-FFS	59	23	8	184	57	49	35	8	3	44	50
	Control	53	31	9	279	86	89	52	8	2	16	14
	All Farmers	190	25	9	216	80	59	43	8	3	45	52
	Sig.		0.000		0.000		0.000		0.928		0.000	
2003	FFS plot	26	18	10	85	47	13	10	6	4	145	49

Table 4-4: Paired Difference in Production Practices by Farmer Group

	Pre/post FFS Diff.			FFS vs Control			Non-FFS vs Control		
	FFS	**Non-FFS**	**Control**	**Pre**	**Post**	**Diff.**	**Pre**	**Post**	**Diff.**
Seed Rate [kg/ha]	1.4 (6.5)	1.8 (7.9)	7.8 (9.1)	-1.53	-7.97	-6.44	-1.82	-7.82	-6
N [kg/ha)]	16.3 (81)	13.3 (65)	51.5 (91)	-46.96	-82.2	-35.24	-57.28	-95.48	-38.2
P [kg/ha]	-7.5 (31)	-4.3 (37)	22.4 (54)	-14.97	-44.8	-29.8	-13.2	-39.9	-26.7
Field Observations [hrs/ha]	29.7 (85)	12.4 (65)	-0.8 (21)	19	49	30	15	28	13

Note: Figures in parenthesis are Standard Deviations

Difference in Pesticide Use

Pesticide use is a major variable in the assessment of FFS training. Therefore, detailed account of pesticide use practices was taken before and after the training. As shown in Table 4-5 there was a significant difference in the total number of pesticide applications before the training. Control farmers were those with the highest application frequency. In terms of pesticide quantity used, FFS farmers had the highest input among the three groups of farmers. However, looking at the distribution during the season no clear pattern of differences can be observed.

As the year 2003 was wet and had pest outbreaks at the boll formation stages, pesticide use had increased on all types of sample farms during this crop stage. While FFS farmers also sprayed more during this period the increase was smaller than for the two other groups of farmers. This indicates that FFS farmers have gained confidence from conducting their field observations.

As shown in Table 4-6, pesticide use of FFS farmers declined for both frequency and dosage while this was only the case for pesticide dosage for Non-FFS farmers. Again, the differences were more pronounced when comparing FFS and Control versus Non-FFS and control farmers. These differences in the number and dosage of pesticide application can be explained with a better understanding of the pest situation in the field by the trained farmers.

Table 4-5: Pesticide Use in Terms of Number per Season and Doses at Different Crop Growth Stages

Year	Types	N	Pesticide applications		Total Pesticide Doses [ml/ha]		Vegetative stage applications		Flowering stage applications		Boll stage applications	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	4.33	1.34	8371	2944	1.17	0.61	1.08	0.58	1.88	1.13
	Non-FFS	59	3.85	1.68	7482	2768	1.10	0.64	0.97	0.56	1.58	1.16
	Control	53	5.15	1.26	6986	1877	1.89	0.85	1.13	0.59	2.08	1.27
	Overall	190	4.41	1.51	7709	2683	1.35	0.77	1.06	0.57	1.84	1.19
	Sig.		0.000		0.010		0.000		0.291		0.078	
2003	FFS	78	3.76	1.93	4927	3095	0.17	0.44	0.73	0.75	2.62	1.68
	Non-FFS	59	4.22	2.07	6122	4557	0.25	0.60	0.69	0.79	3.05	1.63
	Control	53	6.21	1.78	9299	3658	0.64	0.76	1.26	0.68	4.30	1.61
	Overall	190	4.58	2.18	6518	4150	0.33	0.62	0.87	0.78	3.22	1.78
	Sig.		0.000		0.000		0.000		0.000		0.000	

Table 4-6: Paired Difference Comparisons for Pesticide Usage

	Pre/post FFS Diff.			FFS vs Control			Non-FFS vs Control		
	FFS	Non-FFS	Control	Pre	Post	Diff.	Pre	Post	Diff.
Insecticide [No/season]	-0.6 (1.9)	0.3 (1.7)	1.1 (2.0)	-1.02	-2.68	-1.66	-1.44	-2.21	-0.77
Insecticide dose [kg/ha]	-3495 (3642)	-1524 (4300)	2312 (3633)	1	-4.8	-5.8	0.2	-3.6	-3.8

Note: Figures in parenthesis are Standard Deviations

Gross Margin Differences

The comparison of the economic performance of the three groups of farmers before and after the training is depicted in Table 4-7. No significant difference in yield and gross margin existed before the training, i.e. during crop year 2001. However, for pesticide and fertilizer costs such differences existed. Performing the same tests after the training showed that for all parameters group differences were significant. The data show that 2003 was a year with low yields. This was mainly related to high pest infestation and excessive vegetative growth.

Table 4-8 portrays the differences for yields and gross margins more clearly. Even though yields declined for all three groups the gross margin of FFS farmers increased. FFS farmers experienced relatively lower reduction in cotton yield, while at the same time reducing pesticides and fertilizer inputs. Table 4-8 further shows that for FFS farmers the positive gross margin difference was more pronounced among smaller farmers. Similar to the previous performance parameters the difference between FFS farmers and control farmers was higher and more uniform than those between Non-FFS and Control. While yield difference was negative for the second comparisons the difference in gross margin was less than one fifth of the difference between FFS and Control (see Table 4-8).

Table 4-7: Cotton Yields, Revenue, Gross Margin and Cost Comparisons

Year	Types	N	Yield (kg/ha)		Revenue (US$/ha)		Gross Margin (US$/ha)		Pesticide cost (US$/ha)		Fertilizer cost (US$/ha)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	2137	697	708	237	140	218	74	31	94	38
	Non-FFS	59	1985	754	671	260	125	244	72	37	95	34
	Control	53	2111	687	694	240	50	286	144	207	121	39
	Overall	190	2083	712	693	245	111	248	93	117	102	39
	Sig.		0.444		0.686		0.107		0.000		0.000	
2003	FFS	78	1487	393	925	248	391	267	48	37	105	38
	Non-FFS	59	1079	373	660	223	151	250	61	48	100	46
	Control	53	1242	552	688	335	25	320	123	66	160	59
	Overall	190	1292	469	777	294	215	317	73	59	119	54
	Sig.		0.000		0.000		0.000		0.000		0.000	
2003	FFS plot	26	1482	563	941	369	513	322	000	000	38	28

Table 4-8: Differences of Difference Estimates for Crop Production and Income

	Pre/post FFS Diff.			FFS vs Control			Non-FFS vs Control		
	FFS	**Non-FFS**	**Control**	**Pre**	**Post**	**Diff.**	**Pre**	**Post**	**Diff.**
GM [US$/ha]	251 (338)	26 (337)	-25 (380)	90.09	366.26	276.17	75.08	126.24	51.16
Yield [kg/ha]	-650 (771)	-906 (837)	-869 (735)	25.73	245.27	219.54	-125.47	-162.52	-37.05
GM [<2 ha farmer]	322.0 (355)	0.1 (339)	62.0 (344)	0	414	414	66	158	92
GM [>4 ha farmers]	211 (418)	133 (209)	-6 (441)	158	376	218	-55	85	140

Note: Figures in parenthesis are Standard Deviations

4.4 Conclusions and Recommendations

FFS-type farmer education implemented in Pakistan has provided farming communities with opportunities to learn in a participatory way. As a result of the season-long training, farmers' skills for making rational and informed decisions were significantly enhanced. Field observation, analysis and decision making capacities have improved to a greater extent among FFS farmers. This may have contributed to more cost effective and environmentally friendly crop management decisions. As shown by the high input costs, the management of major inputs like seeds, fertilizer and irrigation scheduling were noticeably neglected at control farms. These issues have received more attention by the FFS farmers. It is thus plausible that the difference in gross margins has increased in FFS farms relative to the non-FFS and especially control farms.

These first results indicate that farmers' dependence on the use of highly toxic chemicals can be reduced through training and the adoption of various cultural and biological methods. However, further analysis and data collection is warranted to confirm these indicative results. Planning, record keeping, analysis and interpretation aspects of these experiments by farmers needs further backup support to strengthen this crucial component of sustaining IPM practices.

In order to enable farming communities to draw valid conclusions from their own experimentation as initiated by FFS, a well-planned technical backup support mechanism should be established. In this context, the integration of the research system and farming communities in Pakistan is the pre-requisite to establish a sound foundation for such collaborative experimentation. At the outset, the researchable issues should be well conceived during FFS training sessions through asking critical questions on major differentials in the data generated during agro-ecosystem analyses (AESA) by the farmers.

In order to assure that the farmers will sustain FFS activities, farming communities should be given the right kind of incentives to continue working as a group. Institutionalised collective action is vital if cotton pest management in Pakistan is to become safer, more efficient and more environmentally friendly. Finally, a strategy for transforming the extension service in Pakistan towards a more participatory and self-reliant system should be developed.

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5 Impact of Farmer Field School Approach on Acquisition of Knowledge and Skills by Farmers about Cotton Pests and Other Crop Management Practices - Evidence from India

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5.1 Introduction

Background

In India, cotton is one of the most important agricultural commodities in the country, but the area has declined since the early to mid nineties. The main reason for this reduction was an increased cost of cultivation, particularly due to the heavy use of pesticides. Recognizing the drawbacks of over-dependency on chemical pesticides, integrated pest management (IPM) is considered as an alternative.

The Food and Agriculture Organization of the United Nations (FAO) has supported IPM training through farmer field schools (FFS) under the FAO-EU Cotton IPM Programme in Asia since June 2000. One of the objectives of FFS training is to build human capacity especially in knowledge and skills and bring about behavioural changes in the use of chemical pesticides through discovery-based learning. The state governments of Karnataka and other states in India are interested to replicate the FAO model if shown successful. Hence, this study was conducted to investigate the extent of knowledge gains and the acquisition of skills and improved performance of crop management practices.

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Objectives of the Study

i) To measure changes in the knowledge of farmers about cotton pests and other management practices as a result of IPM-FFS.

ii) To identify changes in the acquisition and performance of diagnostic and other management skills of farmers through IPM-FFS

5.2 Methodology

Study Design

A before and after, with and without i.e. double delta (DD) design was followed for the present study. Five FFS villages from two districts i.e. Raichur and Bellary of Karnataka State were selected for the investigation. In addition, another five villages having at least a distance of 30 km from the FFS village as well as a sufficient number of cotton growing farmers were selected as control villages.

Selection of Respondents

For the baseline sample, 97 farmers who regularly attended FFS training in 2001 were selected and interviewed about their 2000 cotton cultivation practices. In addition, 97 non-FFS (NFFS) farmers from the same villages, and 97 farmers from control villages, all with matching characteristics such as age, education and landholding as the FFS respondents, were sampled. Because of a late onset of monsoon rains in 2002, not all baseline farmers planted cotton in the year after attending a FFS. Therefore, only 97 (37 FFS, 30 NFFS and 30 control) farmers could be included in the impact study.

Data Collection Methods

For measuring the respondents' knowledge, a testing schedule was developed which included knowledge items about pests, diseases, natural enemies, pesticides, ecosystem information, pest management and other crop management practices. The total scores on the knowledge items were computed for each respondent and classified as high, medium or low knowledge levels according to exclusive class intervals. In addition, a differentiated content (item) analysis of the knowledge was conducted to draw meaningful conclusions.

Skills are understood as practiced abilities or efficient ways of performing a practice. The skills investigated in the study were both complex (difficult to practice) and simple (easy to practice). Simple skills were measured by identifying the degree of the farmer's confidence. The extent of confidence expressed by respondents in performing various management skills were rated as 'fully confident', 'partially confident' or 'not confident'. If respondents were fully confident in performing a skill, a score of 2 was given, '1' if they were partially confident and '0' if they were not confident. Complex skills were assessed through participatory methods using transacts, seasonal calendars, ranking methods and Venn diagrams. Diagnostic skills were tested by showing pictures of particular damage symptoms, pests or natural enemies, and by observing the diagnostic capacity and confidence. This was revalidated by use of focused group discussions and by observing field conditions and farmer's performance.

Analytical Procedures

Frequency and percentages of the responses were calculated for each of the three groups of farmers. Respondents were classified into various categories i.e. low to high knowledge levels and performance of skills. T-tests were used to determine the significance of differences among the three categories (FFS, NFFS and control groups) before and after the FFS training. The correlation coefficients (r values) were calculated to find out the association between knowledge and skills with regard to the adoption of practices.

5.3 Results and Discussion

5.3.1 Changes in Knowledge

Knowledge of Cotton Pests, Diseases, Natural Enemies and Ecosystem

As shown in Table 5-1, the majority of the FFS and NFFS farmers were in the category of medium knowledge before the training started, whereas the control group had low knowledge about cotton pests & diseases. After the training, 27 percent of the FFS farmers moved from low/medium knowledge categories to the high knowledge category. There were no ‘high knowledge’ scores among NFFS and control farmers and only modest overall gains. A graphic representation is given in Figure 5-1.

The content analysis indicated that before training, the majority of respondents expressed that pesticides were always essential to get higher yields (83%); that mixing chemicals would effectively control the pests; and that pesticide applications always protects the crop from pest damage. After the training, the percentage of respondents having such opinion was less. Besides, FFS farmers’ understanding of the life cycle of pests and nature of damage was better compared to other groups. While before the training, all the respondents had no knowledge about the effect of pesticides on livestock and birds nor about agro-ecosystem and its analysis, a large majority of FFS farmers gained such knowledge during the FFS training.

Furthermore, it was also observed that there was a statistically significant gain in knowledge about pests and diseases in the FFS group after training as revealed by t-tests. There were also significant differences in the knowledge among the three groups before and after training. Further content analysis could help identify areas of more emphasis in the curriculum.

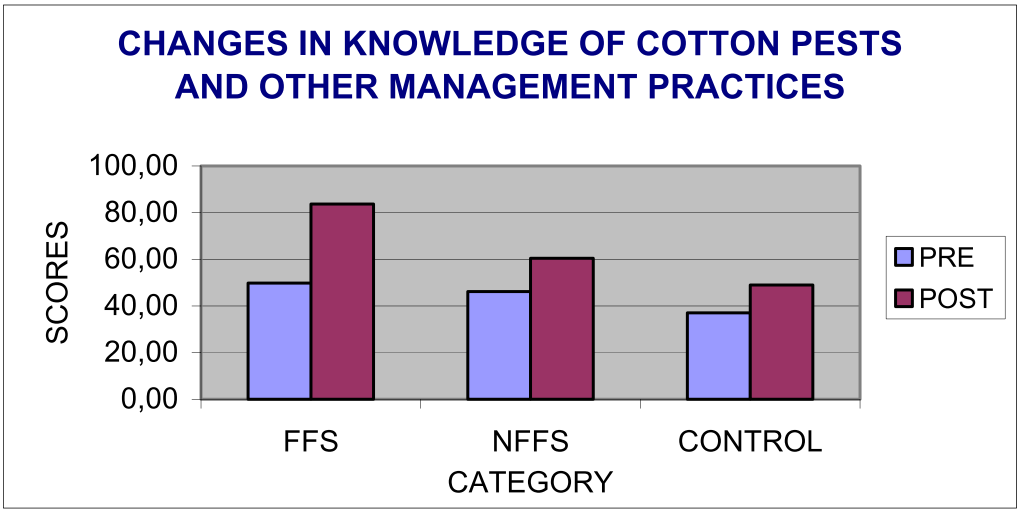

Figure 5-1: Graphic Representation of Changes (Gain) in Overall Knowledge

Knowledge of Cotton Pest Management Practices

As presented in Table 5-1, all baseline respondents were in the category of low-level knowledge about pest management practices. After training, 41 percent of FFS and 3 percent of NFFS farmers moved from low to medium level of knowledge, indicating that most of FFS and some of the NFFS respondents had improved their knowledge about pheromone traps and their use, yellow sticky traps, bird perches, Trichogramma, use of NPV and neem products, roughing of affected plants, stage of detopping, crop residue destruction, and collection and destruction of fallen and damaged fruiting bodies. There was no change in the control group. However, comparisons of mean scores indicate more knowledge gains among FFS farmers than in NFFS and control groups after training. There was no significant difference between FFS and NFFS groups regarding knowledge on pest management before the training whereas there was a significant difference between FFS and NFFS after training. A close examination of the reasons why the majority of FFS farmers fell into the medium knowledge category revealed that they did not have sufficient knowledge about the rationale behind the use (why and how aspects) of the practices and products.

Table 5-1: Change in Knowledge of Respondents towards different Aspects of Cotton IPM and Production Practices through FFS.

Category	FFS (N=37)		NFFS (N=30)		CONTROL (N=30)	
	Before	After	Before	After	Before	After
Cotton pests & diseases, natural enemies and ecosystem						
Low knowledge (1-26)	8	2	30	16	60	53
Medium Knowledge (27-52)	92	70	70	83	40	47
High knowledge (53-78)	0	27	0	0	0	0
Total score	1823	1765	936	977	790	835
Mean	35.74	47.70	31	33	26	28
SD	7.41	8.93	7.8	7	10	9
t`value	6.76**		0.76 NS		0.701 NS	
Pest management practices						
Low (1-13)	100	59	100	97	100	100
Medium (14-26)	0	41	0	3	0	0
High (27-39)	0	0	0	0	0	0
Total scores	165	467	113	184	63	117
Mean	5	13	4	6	2	4
SD	2	3	2	3	3	2
t`value	13.20**		3.81**		2.59**	
Other crop management practices						
Low Knowledge (1-11)	63	0	40	0	73	20
Medium (12-22)	37	38	60	47	27	60
High (23-34)	0	62	0	53	0	20
Total score	354	862	336	650	259	518
Mean	9.57	23.30	11.20	21.67	8.63	17.27
SD	4.17	5.27	4.32	1.69	4.44	5.82
t`value	15.49**		7.89**		10.01**	

Cotton pests & diseases, natural enemies and ecosystem: F` Value among FFS, NFFS and Control groups before training 10.4**, after training 59.1**

Pest management practices: F ValueFFS, NFFS and Control groups before trainig 7.4**, after training 86.8**

Other Management practices: F Value FFS, NFFS and Control groups before training 2.7*, after training 9.3**

*Significant at 5% level ** Significant at 1% level.

Knowledge of Other Crop Management Practices

Regarding other crop management practices, 63 percent of FFS farmers, 40% of NFFS and 73% of control group fell into the low knowledge category in the baseline. After FFS training, 62% of FFS and 53% of NFFS farmers moved from the low to the high knowledge group. It must be noted that the knowledge on other crop management practices of the control group also increased significantly after the training. This might be due to external interventions. However, the knowledge score as well as the increase in knowledge of the FFS group was significantly higher than that of the control farmers. The content analysis indicated that more FFS farmers became knowledgeable about trap cropping, use of manures, nitrogen management, summer deep ploughing, etc. which were directly related to IPM. A similar trend was also observed among NFFS farmers indicating a diffusion effect. Further analysis through F-tests indicates that there were significant differences among FFS, NFFS and control groups with respect to changes in knowledge on other crop management practices.

Changes in Overall Knowledge Level

Table 5-2 shows the changes in overall knowledge of respondents towards cotton pests and other crop management practices.

Table 5-2: Changes in Overall Knowledge of Respondents About Cotton Pests and Other Crop Management Practices (all knowledge item scores in percentages)

Category	FFS (N=37)		NFFS (N=30)		Control (N=30)	
	Before	After	Before	After	Before	After
Low knowledge	8.10	0.00	16.66	0.00	56.66	13.34
Medium knowledge	91.90	13.51	83.34	83.34	43.34	83.33
High knowledge	0.00	86.49	0.00	16.66	0.00	3.33
Mean	49.77	83.62	46.15	60.38	37.05	48.98
SD	10.57	12.86	11.28	10.56	15.60	11.01
t-value	15.831**		5.397*		5.077*	

** Significant at 1 percent level ; * Significant at 5 percent level

In Table 5-2, comparisons of mean scores of overall knowledge items indicate higher knowledge gains among FFS farmers (33.9) than NFFS (14.2) and control groups (11.9). The difference of differences between FFS and control groups amounts to 21.92 whereas the difference between NFFS and control was only 2.3. The difference of differences between control adjusted FFS and control adjusted NFFS scores was 20. This trend is attributed to limited diffusion of knowledge from farmer to farmer and the influence of cotton technology mission demonstrations on IPM undertaken in the study area. There was also a significant difference among the FFS, NFFS and control groups regarding overall knowledge of cotton pests and other crop management practices.

Knowledge vs. Adoption

In the sample there was a highly significant correlation between the knowledge on pest management and the adoption of IPM practices (r value of 0.76, significant at the 1% level). Also, there was a significant correlation between the knowledge on other crop management and the adoption of IPM practices (r value of 0.32, significant at the 1% level). Adoption scores were quantified based on the number of practices adopted by the farmers.

The correlation between knowledge and adoption shows that knowledge of pest management and other crop management practices was significantly correlated with adoption across all groups. This shows that knowledge is a prelude to the adoption of improved practices. On the other hand, the correlation values between knowledge and other independent variables like age, education, landholding, and net returns were not significant. Thus FFS training was successful in imparting knowledge about cotton pests and production aspects.

5.3.2 Changes in Skills

The confidence of skills as expressed by respondents about diagnosing cotton pests and performing other crop management skills shows (Table 5-3) that before IPM-FFS training the majority of FFS farmers (70%) had a low level and 30% a medium level of skills performance.. After FFS training, 54 percent of the FFS farmers moved from the low to the medium and high level category, whereas only 37 percent of the NFFS farmers and 7 percent of the control farmers moved to the medium confidence category.

The analysis of variance (F values) indicates that there were significant differences among FFS, NFFS and Control groups with respect to confidence levels on pests and other crop management skills. Furthermore, the t-value indicates that there was no significant difference between NFFS and Control groups before training whereas a significant difference was observed after the training.

Table 5-3: Distribution of Respondents According to Their Confidence Levels on Pests and Other Crop Management Skills (percentages)

Category	FFS (N=37)		NFFS (N=30)		CONTROL (N=30)	
	Before	After	Before	After	Before	After
Low Skills (1-8)	70	16	100	63	100	93
Medium (9-18)	30	60	0	37	0	7
Highly (19-26)	0	24	0	0	0	0
Total score	150	529	6	244	0	125
Mean	4.05	14.30	0.2	8.13	0	4.17
SD	5.18	5.04	0.8	3.35	0	2.119
t`value	9.03**		13.04**		1.57**	

Note: F value among FFS, NFFS and Control groups before training 17.1**

F value among FFS, NFFS and Control groups after training 60.0**

* significant at 5% level ** Significant at 1% level

Skills vs. Adoption

Moreover, a correlation in the pests and other crop management skills and theadoption of IPM practices exists among FFS farmers. The results of the analysis show, that the pest management skills of FFS farmers are highly correlated with the adoption of IPM practices (r value of 0.52, significant at the 1% level). Also, there was a correlation between the crop management skills and the adoption of other crop management practices (r value of 0.34, significant at the 5% level).

The results show that among FFS farmers the levels of confidence about pest management and other crop management skills were significantly correlated with the adoption corresponding practices. Conversely, in the NFFS and control groups the skills were not correlated with adoption.

5.3.3 Content Analysis

Content analysis (Table 5-4) of the extent of confidence expressed by the respondents revealed that NFFS and control group farmers acquired only simple skills, whereas the majority of the FFS farmers were able to acquire simple as well as complex skills.

Table 5-4: Extent of Confidence Expressed by the Respondents in Performing Selected Skills on Pests and Other Crop Management Practices (percentages) – Content Analysis

Skills	FFS			NFFS			Controls		
	FC	PC	NC	FC	PC	NC	FC	PC	NC
Simple Skills									
Detopping									
Pre	30	0	70	7	0	93	0	0	100
Post	95	5	0	90	10	0	70	20	10
Use of pheromone traps									
Pre	41	10	49	0	0	100	0	0	100
Post	48	47	5	37	40	23	6	27	67
Seed treatment									
Pre	22	2	76	0	0	100	0	0	100
Post	76	8	16	20	23	57	6	13	81
Roughing									
Pre	3	5	92	3	0	97	0	0	100
Post	54	38	8	43	30	27	0	27	73
Release of Trichogramma									
Pre	30	8	62	0	0	100	0	0	100
Post	54	24	22	10	13	77	0	0	100
Use of NPV									
Pre	38	0	62	0	0	100	0	0	100
Post	43	30	27	10	23	67	0	0	100
Prep of Neem Products NSK									
Pre	24	8	68	0	0	100	0	0	100
Post	38	32	30	3	17	80	0	17	83
Complex Skills									
AESA									
Pre	0	0	0	0	0	100	0	0	100
Post	8	62	30	3	50	47	0	6	94
Experiments									
Pre	0	0	100	0	0	100	0	0	100
Post	21	33	46	10	30	60	6	7	87
Communication skills									
Pre	0	0	100	0	0	100	0	0	100
Post	11	57	32	0	13	87	0	20	80
Facilitation skills									
Pre	0	0	100	0	0	100	0	0	100
Post	11	32	57	0	3	97	0	3	97
Diagnostic Skills									
Pre	0	8	92	0	0	100	0	0	100
Post	27	54	19	20	67	13	3	63	34

FC: Fully Confident, PC : Partially Confident, NC: Not Confident

The findings of Table 5-4 were supported and validated by projected and participatory techniques and observations conducted by the study team. The findings also showed that the majority of FFS farmers could acquire complex skills (agro-ecosystem analysis (AESA), diagnosis, experiments, communication and facilitation skills, etc.) and more than 50 percent of FFS farmers were able to make correct pest control decisions based on AESA, correctly design and interpret simple experimental results, identify more than 6 pests and an equal number of natural enemies, and had good communication as well as facilitation skills. In contrast, only about 10 - 15 percent of NFFS farmers were able to perform these skills. However, NFFS and control farmers learned simple skills such as detopping, rouging, seed treatment, etc. This indicates that some NFFS and a few control farmers acquired skills through farmer-to-farmer diffusion.

5.4 Conclusion

The study findings revealed that there was significant gain in knowledge about pests, natural enemies, ecosystem, and pest management and also in some crop management practices among FFS farmers. However, based on focused group discussions, there appears to be a need for more emphasis on the `how` and `why` aspects of technologies in FFS programmes.

Due to a systematic training approach, the FFS farmers were able to learn simple as well as complex skills. In contrast, NFFS and control farmers only learned simple skills through farmer-to-farmer diffusion. The improved skills enabled the farmers to make cost-effective and environmentally friendly decisions. This demonstrates the potential of FFS as an extension tool to impart complex skills, thus contributing towards human capital development.

Furthermore, the knowledge and skills on pests and crop management practices were positively and significantly correlated with the adoption of key practices such as use of botanical pesticides, biocontrol agents, cultural practices, detopping, etc. This indicates that behavioural changes in terms of knowledge and skills are preludes for adoption. FFS as an extension tool has the promise and potential to bring about desirable changes in human behaviour.

To conclude, farmers of Karnataka are poised to adopt IPM. This may be an important contribution towards poverty alleviation and environmental conservation. To achieve such impact, however, a need for rationalizing and harmonizing resources and facilitating policy change is needed.

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6 Incidence of Acute Pesticide Poisoning Among Women and Men Cotton Growers in India

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6.1 Introduction

Background

In India, pesticides are primarily used to protect specific commercial crops. For example, cotton receives more than 60% of the total pesticides used, but still the crop's productivity is considerably lower than the world average (Jayaraj, 1996). In cotton 20 pesticide applications per season are sometimes reached. The negative consequences of such intensive pesticide use have become a concern to the Indian public. Alarmingly high levels of pesticide residues were found in drinking water and in soft drinks (CSE, 2003). Evidence from the literature suggests that in addition to risks to consumers, there are also the hazards to persons who are directly exposed to pesticide applications (Kishi, 1995; Murphy, 1999; Wesseling, 2001; Kunstadter, 2001; Maumbe, 2003). Agricultural labourers and farmers work in a highly unsafe environment since few protective measures are used. They mostly work barefoot, barehanded and wear only short-sleeved cotton tee shirts and traditional sarongs (lungi). During a normal spraying session, farmers are directly exposed to pesticides for three to four hours through leaking spray equipment, dripping plants and wind drift. Concentrated chemicals are often mixed with water sometimes using bare hands. Such risky behaviour of farmers cannot simply be explained by a lack of awareness. On the contrary, even though farmers have only partial

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and often inexact knowledge - they are aware of pesticide hazards (Aragon, 2001; Clarke, 1997; Eisemon, 1990; Kishi, 2002a; McDougall, 1993). Furthermore training seems to do little to change the practice of using hazardous pesticides. For example, a programme conducted by Novartis to train farmers in the safe use of pesticides in the Coimbatore District of Tamil Nadu, India in 1992 failed to achieve substantial and sustainable changes in farmers' practices (Atkin, 2002). Since protective equipment is expensive, unavailable and cumbersome, it is rarely used in the tropics (Kishi, 1995). Therefore, farmer education on the safe use of pesticides alone is unlikely to be a viable solution to eliminate occupational risks.

To date, studies on health risk from pesticides have mostly focused on the adverse health effects on the people directly involved in the application of pesticides. However, in addition, women and children often play supportive roles in the spraying operations and are at risk to a similar extent. In India, use of female labour is high in cotton production. Mixing of pesticides with water and refilling the sprayer tanks are typical female tasks (Mancini, unpublished). Other activities with a high probability of pesticide exposure are time-consuming operations such as weeding, which are often performed by women and children during the peak of the spraying season when there are high levels of residues in the fields.

Pesticides are commonly applied by low-income marginal farmers and landless workers. Malnutrition and infectious diseases associated with this group makes them more vulnerable to poisoning (London, 2000; WHO, 1990).

Objectives

In 2003, the FAO-EU Integrated Pest Management Programme for Cotton in Asia initiated a season-long study that aimed to assess the degree of acute pesticide poisoning among cotton growers in the Indian State of Andhra Pradesh. The assessment was planned as a season-long monitoring activity to be undertaken in three villages that also had IPM[6] farmer field schools (FFS)[7].

The purpose of this is to document the human health consequences caused by the currently applied pesticides use practices on cotton in India. The intent was to include not only the farmers directly involved in spraying, but also exposed women and marginal farmers. Women perform supportive activities that have often been neglected in studies dealing with direct exposure. Marginal farmers are often hired to do spraying and therefore prone to more continuous exposure. Because previous studies focused on male farmers who apply chemical products, this study concentrated on women as the main respondents.

6.2 Methodology

The study was conducted in three villages with cotton FFS in Andhra Pradesh. Selection criteria for the FFS were: a high female participation (over 50%) and a high share of marginal farmers (over 50%) and a community interest in the self-monitoring activity. Two of the villages (Sairedapalli and Srinagar) were located in Warangal District and one (Darpalli) in Mahbubnagar District. Darpalli is a small village of marginal native farmers with a low level of education, which is typical for the State where in 1997 some 70% of the rural people were illiterate. In contrast, Srinigar and Sairedapalli villages are inhabited by migrant communities who moved from the State coastal area in search of fertile land. In these villages farmers have more resources and better education as compared to Darpalli.

[6] Integrated Pest Management (IPM) is based on preserving natural enemies and growing healthy crops to control pests

[7] Farmer Field School (FFS) is an adult educational approach to empower farmers developed in Indonesia in the early Nineties

Data collection method

Self-monitoring started in August 2003, the second month of the cotton season when pesticides are first applied, and lasted until December 2003. Farmers were assisted in generating information on:

- The degree of acute pesticide poisoning occurring among male and female cotton farmers
- The exposure of women performing supportive roles during spray operations
- The vulnerability of low-income groups involved in pesticide application

All the fifty women farmers who attended the FFS in their respective villages were trained in filling-in the health-monitoring forms after any potential exposure to dangerous substances. In addition to reporting their own poisoning signs and symptoms, the women interviewed one male family member (total of 47) who had applied pesticides. Respondents were asked to fill-in a form after every potential pesticide exposure regardless whether they had experienced adverse effects or not. Forms were filled after any of the following activities:

- Spraying pesticides in the field
- Mixing chemical solution and re-filling spray tanks
- Working in a field that was sprayed earlier in the day

Only the signs and symptoms that occurred immediately or within **24 hours** after exposure were recorded. At each weekly FFS meeting the forms were reviewed.

The reporting format was pictorial to facilitate participation of illiterate respondents (Figure 6-1). Facilitators provided the necessary assistance to review the forms throughout the monitoring.

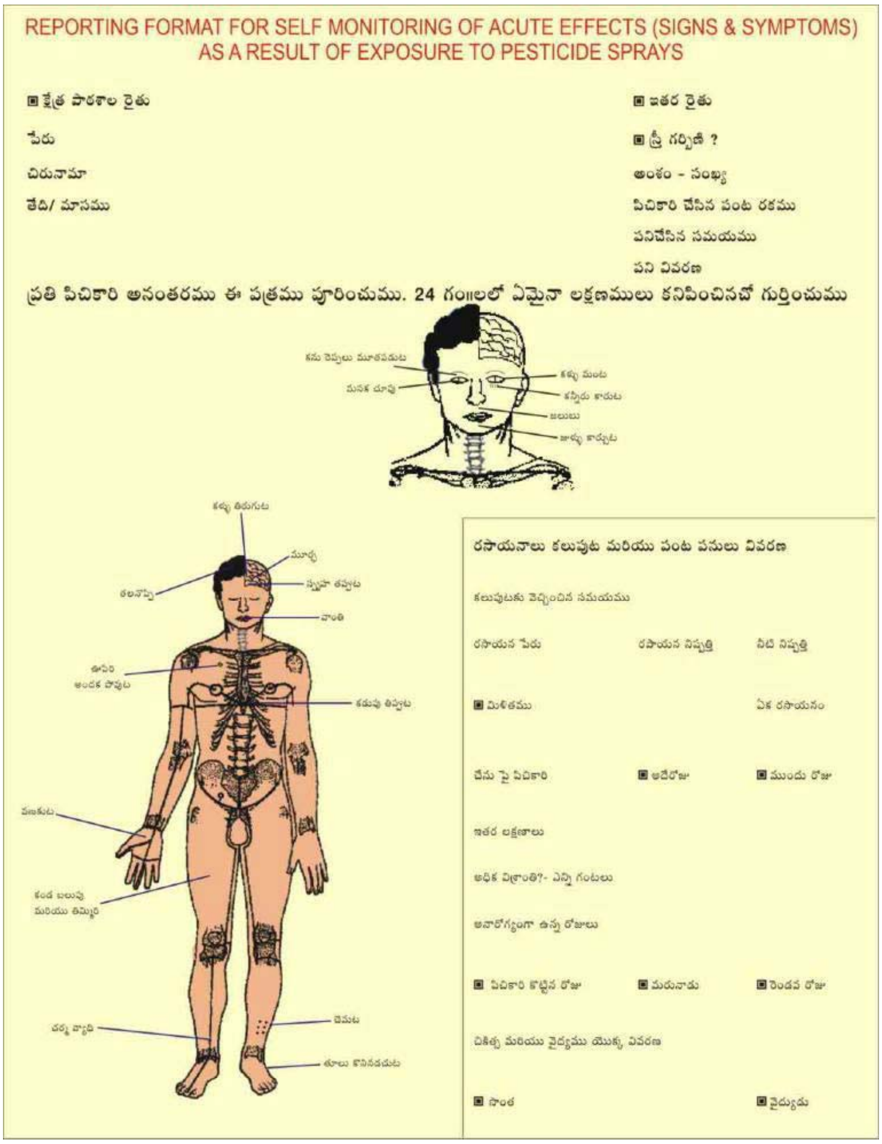

Figure 6-1 Reporting Format in Telegu Local Language

The form allows for the reporting of the following:

- A list of 18 signs and symptoms of acute pesticide poisoning[8]
- Type of chemical products used
- Quantity of chemical products used
  (ml formulated product / litre of water)
- Hours spent in performing the operation

[8] Developed by Keifer (1996) and adopted by Murphy (2002)

- Hours extra-rest taken due to illness
- Number of sick days not worked as a consequence of the illness
- Use of medical treatments and homemade remedies
- Operation performed

The following socio-economic parameters were collected in separate interviews from each respondent: age, gender, formal education, landholding and income level.

Scoring System

Following Murphy's methodology (2002), the forms were scored on a 0-3 scale according to the signs and symptoms reported. Localized effects were considered consequences of mild poisoning and rated in category 1. In the same category were also some systemic or neurotoxic effects that are ill defined (headache, dizziness, difficulty breathing) or effects that could be confused with environmental factors such as heat exposure (excessive sweating, excessive salivation). The other neurotoxic effects such as nausea and vomiting, which might reflect cholinesterase depression, were classified as category 2 or moderate poisoning. Category 3 included loss of consciousness and seizure as effects of severe poisoning. Each form was given a final score (*severity score*) equivalent to the highest category marked).

Data Analysis

Linear trend analysis (frequencies analysis and chi-square test) was performed to describe pairs of variables (men versus women and small landholdings versus large). Correlations between the *severity score* and the social, economic and exposure variables were also analyzed.

6.3 Results

6.3.1 Respondents' Profile

Data was obtained from a total of 97 farmers, including the main 50 main respondent women participating in the health self-monitoring (Table 6-1) and 47 men who were interviewed by the women. . The average age of the reporting farmers was 36.5 years for women and 37 years for men. As a result of the purposive selection of the villages, the sample included 70% small farmers (<2 ha). Almost half of the respondents fell under the class "marginal" (<1ha). Forty-one percent of the farmers lived below the national poverty line of 10 rupees a day.

Table 6-1: Distribution of Respondents Among the Villages

Village	Women (respondents)	Men (indirect reporting)	Total
Darpalli	25	23	48
Sairedapalli	14	14	28
Srinagar	11	10	21
Total	50	47	97

6.3.2 Spraying Operations

The women reported on 165 self-exposure sessions as well as 158 similar sessions by their male relatives. The women's health form were filled-in after the following agricultural activities: mixing concentrated chemicals with water and filling spray tanks (47%), mixing and subsequently working in the field (24%), working in a recently sprayed field (17%), applying pesticides (9%) and other activities (3%)[9]. The application of pesticides referred to spreading phorate granules (organophosphate, WHO 1B hazard class) on maize and chilli plants.

Men's forms were filled-in after spraying pesticides (75%), spraying and subsequently working in the field (22%) as well as mixing concentrated

[9] Other activities included supervising labour and harvesting intercrops.

chemicals with water and filling spray tanks (3%). The working sessions were similar for both the men and women in terms of their average duration (4 h 30 minutes) and the volume of applied and/or mixed pesticide solution (201 mg).

Twenty-six types of chemicals (Table 6-2) were used.

Table 6-2: List of Pesticides Used by the Reporting Farmers

Pesticide	WHO hazard class*	Chemical Family	% of all pesticides
Parathion	1a	Organophosphate	0.3
Monocrotophos 36% SL	1b	Organophosphate	12.0
Phorate 10% G	1b	Organophosphate	3.6
Triazophos 40% EC	1b	Organophosphate	0.6
Chlorpyriphos 20% EC	2	Organophosphate	10.0
Cypermethrin 25% EC	2	Pyrethroid	8.0
Dimethoate 30% EC	2	Organophosphate	0.6
Endosulfan 35 EC	2	Organochlorine	13.0
Fipronil	2		0.6
Lambda cyhalothrin 5% EC	2	Pyrethroid	0.6
Phosalone 35 EC	2	Organophosphate	1.3
Profenophos 50% EC	2	Organophosphate	4.0
Quinalphos 25% EC	2	Organophosphate	13.6
Acephate 75% SP	3	Organophosphate	4.3
Acetamiprid 70% WP	3	Chloronycotil	4.6
Copper oxychloride 50% WP	3	Inorganic	1.3
Dicofol 18.5%	3	Organochlorine	0.6
Fenvalerate 20% EC	3	Pyrethroid	0.3
Imidachloprid 17.8% SL	3		4.6
Malathion 50% EC	3	Organophosphate	0.3
Carbendazin	U	Azole	0.6
Indoxacarb 14.5% SC	U		4.7
Mancozeb 75% WP	U	Carbamate	0.3
Spinosad 45% SC	U	Microbial	2.0
Sulfur 80% WP	U	Inorganic	0.6
Wafarin 0.025%	U	Coumarin	0.6
Others (botanical, inorganic, unidentified ingredient)			7.0

*The WHO hazard classification refers to the formulated chemical products. The values were calculated on the basis of the LD50 dermal toxicity using WHO conversion tables. 1a = extremely hazardous, 1b = highly hazardous, 2 = moderately hazardous, 3 = slightly hazardous, U = unlikely to present acute serious hazard in normal use

6.3.3 Reported Symptoms and Signs

Out of the 317 reported exposure events, 16% were asymptomatic, 39% led to mild poisoning, 38% to moderate and 7% to severe poisoning. The *severity score* (the value assigned to each form as a result of the scoring procedure) was positively correlated with the total number of signs and symptoms reported in each form (Pearson Correlation coefficient 0.779, correlation significant at the 0.01 level). Mild attacks were associated with an average signs and symptoms score of 1.9 moderate attacks with 4.0 and severe attacks with 8.4.

The occurrence of pesticide poisoning events was found to be significantly correlated with landholding status (chi square significant at P<0.0001). For example, the incidence of severe poisoning was 10 times higher among marginal and small farmers than larger landholders (Figure 6-2); precisely, 10.2% of the marginal and small farmers suffered from severe poisoning effects.

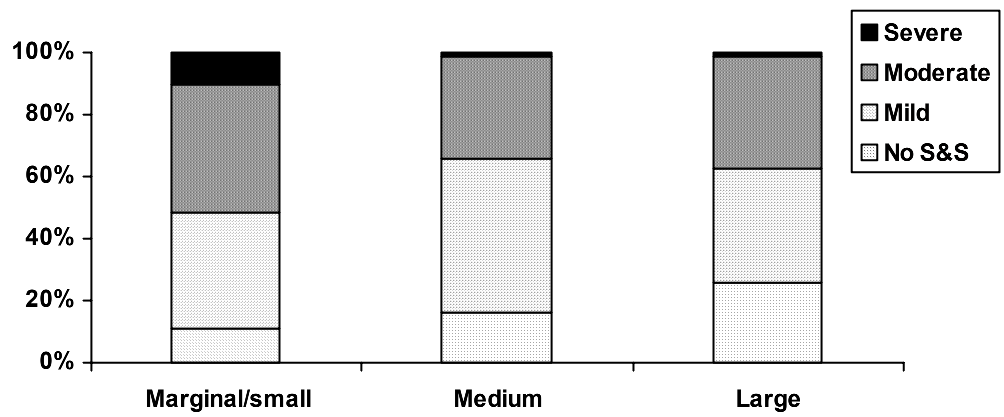

Figure 6-2: Distribution of S*everity Score* by Landholding Size

The distribution of the signs and symptoms showed that marginal and small landholding farmers experienced more effects than medium and large landholders.

The gender segregated analysis showed no significant differences in the distribution of signs and symptoms between men and women. Also, the *severity score* was not significantly correlated with the gender of the respondents. The health effects experienced by the women were comparable to the ones experienced by men. These results confirm the hypothesis that women are seriously exposed to pesticide contamination.

6.3.4 Severity Score Versus Exposure Variables (Exposure Time, Pesticide Toxicity, Spray Volume, Operation)

Exposure was described by four variables:

Pesticide toxicity: toxicity of the formulated chemical product classified according to the WHO Hazard classes. Pesticides belonging to the WHO class 1a (extremely hazardous) scored 1 point, class 1b (highly hazardous) 2 points, class II (moderately hazardous) 3 points and class III (slightly hazardous) 4 points. Pesticides unlikely to present acute hazards under normal use (class U) were assigned with a score of 5 points.

Exposure time: the duration in hours of the working session

Volume: the final volume of the spray solution expressed in litre

Operation: the type activity performed during the working session

The *severity score* was positively correlated with the *toxicity* and the *exposure time*, but no significant correlation was found with the *volume* (Table 6-3).

Table 6-3: Correlation Between S*everity Score* and *ExposureVariables*

		Pesticide toxicity	Exposure Time
Severity score	Pearson Correlation	.420**	.337**
	Sig. (2-tailed)	.000	.000

* Correlation is significant at the 0.01 level (2-tailed).

The *severity score* distributed by the type of operation performed showed . that “spraying” and “mixing” were key-exposure activities with a similar incidence of severe poisoning (Table 6-4). During the operation “mixing”, the respondents prepared chemical solutions in rapid succession. In between, the respondents were present in the field. The same activities (mixing), when associated with fieldwork afterwards, led to a slight shift of the distribution towards higher degree of severity. “Mixing” and “spraying” tasks had an average duration of 3.5 and 3.8 hours, respectively. The same operations combined with fieldwork lasted 6.7 hours (mixing and field work) and 7 hours (spraying and field work). This prolonged exposure more often led to the development of severe illness. “Field work” alone did not cause any severe or moderate poisoning. This may be explained by the absence of direct contact with the concentrated chemical.

Table 6-4: Distribution of the S*everity Score* Among Operations in Percentage and Total Number of Working Sessions

% (No. of sessions)	Mixing	Mixing +Field work	Field work	Spraying	Spraying + field work	Total
No S&S	10 (9)	0 (0)	57(16)	20 (27)	3 (1)	16 (53)
Mild	52 (45)	10 (4)	43 (12)	44 (59)	19 (7)	39 (127)
Moderate	33(28)	80 (31)	0 (0)	31 (42)	64 (23)	38 (124)
Severe	5 (4)	10 (4)	0 (0)	5 (6)	14 (5)	6 (19)
Total	100 (86)	100 (39)	100 (28)	100 (134)	100 (36)	100 (323)

6.3.5 Medical Assistance

Regardless of the seriousness of the illness, farmers sought medical advice only in 8% of the cases. Homemade treatments were taken in 70% of the cases while no action was taken in the remaining cases. Occasionally, a few hours of extra rest (1.41 for women and 1.38 for men) were taken before resuming work. In 7% of the cases, a full day of rest was recorded - a total of 23 sick days for the all participants during the 4-month reporting period. This percentage is similar to the total number of severe cases reported (5.9%). This suggests that using sick days as an indicator might lead to an underestimation of the extent of pesticide poisoning.

6.4 Discussion

The study documented the serious consequences from the indiscriminate use of pesticides on the health of farmers and specifically women field helpers in India. The health surveys reviewed by Kishi (2002b) pointed out that the existing world data on poisoning refer mainly to male workers directly involved in pesticide application applying pesticides. Only few studies investigated the exposure of women carrying out pesticide applications (Murphy, 1999; Kimani, 1995; Trivelato, 1992). However, women in developing countries are often exposed in other ways performing supportive tasks during the chemical application process (London, 2002). Few studies have mentioned this aspect and none have estimated the health effects of pesticides on women quantitatively (Rother, 2000; London 2002; Atkin, 2002). The current survey addressed this information gap by focusing on the adverse effects observed among two target groups, women and marginal farmers, after they performed operations with the risk of pesticide exposure.

The presented study showed no differences between the degree of illness related to pesticide experienced by women and men. Is not entirely clear whether this is related to the fact that women reported both on themselves and their husbands. Nevertheless, women reported significant health effects. They performed typically female tasks, such as mixing concentrated chemical products and refilling spraying tanks, which are key exposure activities and potentially are as hazardous as pesticide applications itself.

Although 6% of the spray sessions were associated to serious neurotoxic effects, none of the respondents sought medical care or were hospitalized. On the contrary, farmers rarely stopped working for more than a day. This finding confirms the serious underestimation of pesticide poidoning based on official medical records (Keifer, 1996; Murray, 1994).

Low-income marginal farmers were more often subject to severe poisoning than landlords. Small-holders and landless people often apply pesticides throughout the season as hired labourers and therefore are exposed more frequently and for longer time. Pesticide toxicity and exposure time were positively correlated for the symptoms observed in this survey, while education and land holding were negatively correlated to this measure of illness. Factors that could re-enforce poisoning symptoms and thus leave the more marginal farmers and workers more vulnerable to illness are malnutrition and other diseases, (WHO, 1990; Repetto, 1997).

The methods applied in this study are a relatively inexpensive way to achieve an overview about pesticide exposure and health risks for female and male farmers in cotton production. However, there are some limitations (Murphy, 2002). Since signs and symptoms of acute poisoning are non-specific, the health data generated can be taken only as estimates. Whether the women over- or underreported the true extent of the problem cannot be determined without medical data. Self-reporting of symptoms would need to be backed-up by clinical tests and blood sample analyses, such as cholinesterase depressions. Another issue is that respondents belonging to the same village had close interactions. This may have introduced a systematic bias yielding homogeneity of reporting. Finally, the methodology cannot assess the chronic consequences of prolonged exposure to pesticides. A study conducted with female cotton workers in India has shown long-term consequences of exposure to pesticides (Rupa, 1991) Relevant in the case of women are especially the long term effects on the reproductive system that can lead to abortions, still births, neonatal deaths and congenial defects (Restrepo, 1990; Taha, 1993; Zhang, 1992; Rojas, 2002).

The extent of pesticide poisoning among farmers and workers in developing countries is worrying (Kishi, 2002). In the extremely hot weather of the tropics, protective gear does not seem to be a viable solution to eliminate occupational risks. Farmer education on the pesticide hazards alone has not achieved significant results (Atkin, 2000). The solution seems to be in the replacement of toxic pesticides with non- or less toxic alternatives or more ecological pest management strategies. One such alternative can be found in the Integrated Pest Management approach.

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7 Impact of the FAO-EU IPM Programme for Cotton in Asia on the Environment

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7.1 Introduction

Agriculture intentionally disturbs natural ecosystems which leads to multiple direct and indirect environmental consequences. To assess the impacts of agricultural practices and pest management decisions on the environment, many different approaches have been proposed. These range from monitoring single indicator species to elaborate fate models or indexing the impacts of pest control products and methods. Many challenges to environmental impact assessment are still unresolved as to methodologies, sampling and monitoring. (Levitan *et al.,* 1995; Levitan, 1997 and 2000). Over the past decade, many risk indicators have been developed and OECD, EU and USDA are currently evaluating different models to find the best suitable pesticide risk indicator to help governments assess the impact of IPM and pesticide policies (AFT, 2003; CEC, 1994; OECD, 1997, 2001 and 2002; Reus *et al.,* 1999; Vercruysse and Steurbaut, 2002). IPM practitioners are being challenged to think more deeply about the potentials, limitation and complexities of environmental impact assessment and to integrate these aspects into IPM implementation.

Over many years, IPM has been assessed primarily in terms of cost and efficiency of practices. To the extent that environmental impact was considered, it was measured by the reduction of pesticide use or by indicators relating to the impacts on beneficial arthropods. Pesticide reduction was mostly measured in terms of cost, dose rate of formulated products, active ingredient or number of applications. However, the number

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of pesticide sprays contains little information about the hazards of the application, particularly when different pesticides are used in a single spray mixture. Measuring the amount of active ingredients is likely to underestimate the effects of modern pesticides that are highly active in very small quantities. This limitation is somewhat compensated by monitoring the dose rate of formulated products which are sold at more or less similar unit efficacies. Since there is no single ideal pesticide parameter with which to assess pesticide usage, different measurements would have to be used. Therefore, specific pesticide risk reduction indicators may be more suitable to capture the environmental impact of IPM than pesticide reduction figures.

The FAO-EU IPM Programme for Cotton in Asia (Cotton IPM Programme) monitored pesticide use and also decided to test the Environmental Impact Quotient (EIQ; Kovach *et al.,* 1992) as a means to assess the environmental risk of different pest management strategies. This method was already used by a Norwegian IPM project in Vietnam (Eklo, 2002) and it was easy to apply with the help of a computer application developed by the Cotton IPM Programme. The EIQ relies on a ranking methodology to assess the environmental and health risks of particular pesticide application schemes. The model uses toxicology data and chemical parameter information to calculate the risk to farm workers, consumers and environmental organisms.

This paper summarises the direct or indirect evidence obtained by the Cotton IPM Programme for IPM-FFS impacts on the environment and assesses the suitability of different evaluation parameters for IPM-FFS impact evaluation.

7.2 Methodology

Pesticide use data were collected as part of the Cotton IPM impact assessment studies for both the year before FFS and the year after. Parameters included the number of pesticide applications and the dose rate of the formulated products in kilogram per hectare. Most studies recorded segregated data for insecticides, fungicides and herbicides. The India and Pakistan, studies also included information on the WHO hazard classes of the chemicals used and on the timing of pesticide applications. The results were generally expressed by means and standard deviation for the different respondent groups, and the statistical significance of differences between the groups was determined by paired t-tests of the mean differences between the FFS or exposed farmers and the control village farmers.

Calculation of the EIQ followed the method described by Kovach *et al.* (1992) and used the list of updated EIQ values posted in 2003 (Kovach *et al.,* 2003). Values for pesticides missing from this list were calculated using pesticide datasheets available from EcoToxNet, USEPA, WHO/FAO or PAN. The aggregated field EIQ for season-long pest control schemes as well as separate impact (EI) values for farmers, consumers and the environment were calculated using an Excel spreadsheet programme that automatically looked up the list values and multiplied them with the percent of active ingredient, dose rate and total number of sprays over the cotton season. In Pakistan, the EIQ values were calculated for both the pre- and post-FFS pest management practices by the different respondent groups. In India, only post-FFS data were available for comparison. In all other countries, EIQ values were only calculated for IPM and farmer-practice plots managed during farmer field schools.

The effects of IPM management decisions on the population levels of pests and natural enemies were mostly determined from weekly ecosystem analyses conducted by farmers as part of the farmer field schools. The list of natural enemies observed during FFS was often limited to ladybird beetles, spiders and lacewings. In China, cotton fields of farmers who graduated in the previous year were monitored season-long to assess the post-FFS impact on insect population. Only one study determined the overall species diversity in IPM and non-IPM farmer fields: the participants of two special courses on insect identification in India and Bangladesh reported the total number of plant feeder, predator species and parasites species found in IPM, organic and farmer fields (Watson, 2003).

7.3 Results

Impact on Pesticide Reduction

Overall results from the impact studies showed that after the attending FFS, farmers reduced the number of pesticide applications from an average of 13.1 sprays per season before FFS to only 6.8 afterwards (p=0.064). Over the same period, control village farmers reduced their applications by only 0.5 sprays. This amounted to a reduction of 55% relative to control values. Most of these applications were for insecticides. In the baseline of both FFS and control villages, only 1.4 applications were for fungicides and herbicides. The average number of non-insecticide applications remained unchanged in the FFS villages (increase of only 0.06 applications) and increased slightly in control villages (by 0.5 applications) between the pre- and post-FFS survey years. Thus insecticide sprays accounted for 11.7 applications before FFS and 5.5 applications afterwards (p=0.046), which represent a 54% decline relative to the control (p=0.052).

In terms of formulated product, FFS farmers reduced their insecticide consumption by 8.5 kg from an average of 13.9 kg per ha to only 5.4 kg afterwards (p=0.053). Over the same period, control village farmers showed a reduction of 2.5 kg (p=0.246). Thus, relative to control village farmers, FFS farmers used 6.0 kg insecticide per hectare or 43% less (p=0.052) as the result of FFS education (Figure 7-1).

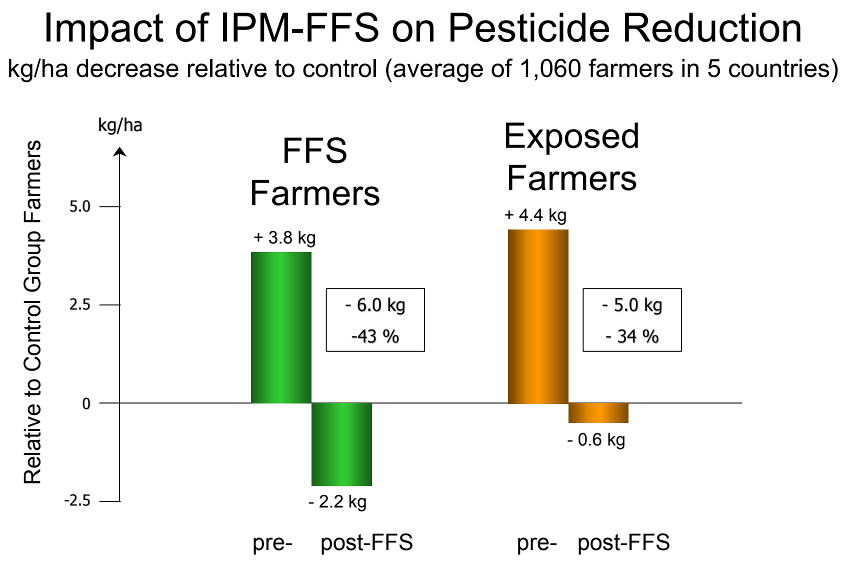

Figure 7-1: Impact of IPM-FFS on Pesticide Reduction

In addition to the strong pesticide reduction effects on the FFS participants, farmer field schools also had a considerable effect on the neighbouring cotton farmers in the same villages. The sample of exposed farmers reduced their insecticide usage by an average of 5.0 kg or 34% (p=0.028) relative to the control. Thus diffusion to non-FFS farmers amounted to 83% of the pesticide reduction achieved among FFS participants.

It must be noted that the FFS and control villages were not equal in terms of pesticide usage and FFS villages had a distinct but statistically not significant (p=0.232) higher pesticide consumption before FFS implementation, as depicted in Fig. 8 in the pre-FFS columns. Baseline values for the control villages were 10.8 pesticide applications or 10.1 kg of insecticides while the correspondent values in the FFS villages (FFS and non-FFS farmers combined) were 12.7 applications or 14.2 kg insecticide per hectare. Since it is the goal of IPM to reduce the use of pesticides, villages with higher pesticide consumption were selected for FFS training. Due to fluctuating pest pressures and changing environmental conditions between the pre- and post-FFS years, pesticide consumption in control villages increased in two study sites while it remained constant or slightly declined in four other sites.

Based on these pesticide reduction figures for FFS and exposed farmers, it is estimated that almost 1,900 tons worth $ 17 million less pesticides were used in the FFS villages during the first year after FFS alone (Table 7-1). Thus about 250,000 ha of cotton were treated with substantially fewer toxic chemicals as a result of IPM training. These figures do not include the almost 40,000 farmers that attended FFS financed by governments in India, Pakistan and China in 2003 and 2004. With these farmers included, the total estimated annual pesticide reduction would double to about 4,700 tons worth US$ 43 million.

Since these farmers are likely to continue their practices in the coming years, the accumulated reduction of toxic chemicals over large areas of cotton is expected to have noticeable positive impacts on the environment and biodiversity.

Table 7-1: Estimated Total Pesticide Reduction as a Result of Cotton IPM-FFS Education (without Philippines)

Country	Cotton [ha/HH][1]	FFS			NFFS			Total tons
		Farmers	Reduction [kg/ha]	Subtotal tons	Farmers[2]	Reduction [kg/ha]	Subtotal tons	
Bangladesh	0.35	3,700	-0.90	-1.2	11,100	-0.70	-2.7	-3.9
China	0.22	18,336	-4.6	-18.6	55,008	-5.2	-62.9	-79.9
India	1.9	12,043	-20.0	-457.6	36,129	-14.0	-961.0	-1,338.8
Pakistan	2.7	10,471	-5.8	-164.0	31,413	-3.8	-322.3	-431.6
Vietnam	0.78	10,615	-0.86	-7.1	31,845	-0.68	-16.9	-24.0
Total		55,165		-648	165,495		-1,366	-1,878

[1] average cotton plot size per household;
[2] assuming 3 exposed farmers per 1 FFS participant or 100 households per FFS village.

Impact on Pesticide Risk

Figures on pesticide reduction do not indicate the degree of environmental risk reduction because some products are more hazardous than others. A more differentiated analysis that takes into account environmental toxicity figures and exposure to ecosystems is needed to assess environmental risks. Since there is not yet a widely adopted pesticide risk assessment methodology, the Cotton IPM Programme chose the Environmental Impact Quotient (EIQ) as an estimate of environmental risk, being aware of the limitations of this approach (Dushoff *et al.,* 1994). A comparison of the EIQ values and pesticide reduction parameters in Pakistan showed an EIQ reduction of 71% relative to control figures, while the number of sprays was only reduced by 39% and the dose rate by 47%. Data from India showed similar trends with reduction figures of 47% for EIQ, while only 14% for sprays and 31% for dose rates. This indicates that FFS farmers selectively reduced more hazardous products because they understood their effects on natural enemies in the field. The EIQ values reflect this important change better than the number of spray application or pesticide dose rates.

The overall field EIQ value can be segregated into sub-indices that selectively estimate the pesticide risks to farm workers/farmers, consumers and the environment. A comparison of these values from India and Pakistan shows that each dataset displays different characteristics that cannot be generalized (Table 7-2). While in Pakistan all three indices were within a narrow range and showed similar reduction patterns, these were quite different for the India data. There, the reduction of the EI Environment was far greater than that for farmers and consumers. This was due to the continued use of a highly toxic pesticide in the IPM treatment. A comparison of the percent of total dose and percent of total EIQ values for individual pesticides used in a pest management strategy can help identify those products that contribute disproportional to their dose to the environmental risk. Typical cotton pesticides like monocrotophos or methamidophos clearly showed up as the biggest contributors to high EIQ values while neem or other biopesticide products contribute proportionally less.

Table 7-2: Comparison of EI Values and Field EIQ from Pakistan and India

	EI Farmer	EI Consumer	EI Environment	Field EIQ
Pakistan (87 FFS participants)				
Pre-FFS	89	21	199	105
Post-FFS	30	7.1	72	36
Average % reduction	***-67%***	***-66%***	***-64%***	***-66%***
India (post-FFS values for 37 FFS participants and 30 control farmers)				
Control Farmers	98	22	244	121
FFS graduates	71	21	102	65
Average % reduction	***-18%***	***-5%***	***-58%***	***-46%***

The term "pesticide" often only refers to synthetic chemical products and excludes non-synthetic pest control measures such as bio-pesticides, sulphur, soaps or oils. Even though these products may be relatively safe for humans, their environmental impacts can be substantial, particularly when used at very high dose rates as it is often the case for soaps and oils. If these products can kill pests, they can also kill predators and parasites. Therefore they must be included in an environmental risk evaluation of different pest management schemes. Table 7-3 shows the EIQ values for an IPM practices with and without soaps. The results show clearly the potential negative environmental impact of pest management that rely too heavily on pesticide substitution instead of ecological measures. This aspect would be easily missed when looking only on chemical pesticide reduction figures.

Table 7-3: EI and Field EIQ Values With and Without Soap Treatments.

	EI Farmer	EI Consumer	EI Environment	Field EIQ
Bangladesh (52 FFS and Farmer Practice Plots, 2003)				
Farmer Practice	149	49	229	143
IPM (chemicals only)	37	12	57	35
Average % reduction	***-75%***	***-76%***	***-75%***	***-76%***
IPM (incl. soap)	122	49	371	181
Average % reduction	***-18%***	***0%***	***+62%***	***+27%***

Impact on Species Diversity

While the EIQ may be an useful and easy-to-use indicator to assess environmental risks of different pest management schemes, the ultimate impacts of IPM on biodiversity and bio-safety needs to be shown through positive effects on species populations and compositions. Because such investigations could not be part of farm-household surveys, the Cotton IPM Programme relied on evidence from special case studies which monitored insect populations and species diversity in the field.

The weekly ecosystem analyses during FFS consistently showed more natural enemies in the IPM plots as compared to conventional farmer's practices. For example, data collected from cotton fields in Hubei Province, China, showed 2-3 fold higher late-season predator populations (spiders, ladybird beetles and lacewings) in IPM fields as compared to farmer fields. (Figure 7-2; Yang *et al.,* 2003) In Pakistan, the average predator-pest ratio was increased from 0.73 in farmer fields to 1.06 in IPM plots (Figure 7-3; Khan *et al.,* 2004). In conventional farmer fields, the ratio never exceeded the value 1:1, while there were clearly more natural enemies than pests in IPM plots. Since these studies monitored only relatively few natural enemy species, the overall impact on natural enemy populations may be much larger.

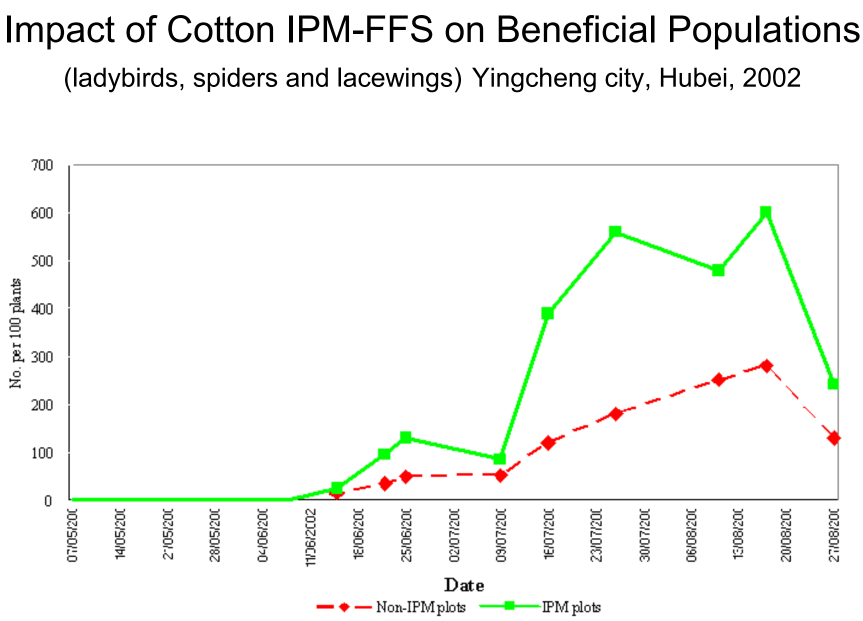

Figure 7-2: Impact of Cotton IPM-FFS on Beneficial Populations

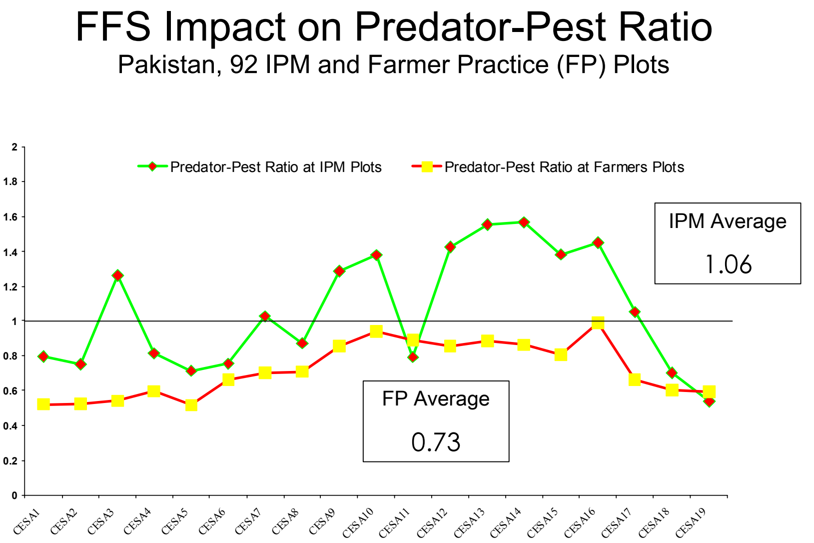

Figure 7-3: FFS Impact on Predator-Pest Ratio

A study that measured the total number of arthropod species found in cotton fields was conducted in Bangladesh and India (Watson, 2003). Results showed that the total number of insect species found in cotton fields was increased by 45% in IPM fields. This increase was mainly due to natural enemies. A noticeable increase in parasitoids was observed in IPM plots while this group of insects was largely absent from conventional farmer fields (Table 7-4).

Table 7-4: Species Diversity in IPM and Conventional Cotton Fields

Trophism Level	India (near Hyderabad)		Bangladesh (near Jessore)	
	IPM Plot	Farmer Plot	IPM Plot	Farmer Plot
Herbivores	21	16	13	14
Predators	19	15	31	19
Parasitoids	8	0	5	3
Total	48	31	49	36

7.4 Conclusions and Recommendations

The FAO-EU IPM Programme for Cotton in Asia has shown that environmental risks from agriculture can be substantially reduced through an ecology-based crop production approach and that this in turn can lead to an improved biodiversity in rural areas. The Programme was successful in reducing pesticide consumption not only among FFS participants, but also among exposed farmers in the same villages. After having heard about the bad effects of pesticides, these farmers followed their FFS neighbours, but without having gained their deeper understanding or improved decision-making skills. The removal of substantial amounts of toxic chemicals from a large area of cotton fields can be taken as an indirect indicator for positive impacts on the environment. Since cotton receives the biggest share of pesticides in Asia, a widespread implementation of IPM would greatly reduce overall pesticide-related environmental risks and particularly in the major cotton production areas.

Other positive environmental effects from IPM may come from a reduction of nitrogen fertilizer. Even though this was not a major objective of FFS, there appears to be a noticeable trend of reduced urea fertilizer and an increase in potassium and phosphorus after FFS; however, more analyses are needed to substantiate these preliminary observations. FFS data from Pakistan also showed a reduction in use of irrigation water (a very precious commodity in the country) in IPM plots as compared to FP plots (IPM 6.4 irrigations, FP 7.8 irrigations). Furthermore, a rational "intercropping" with weeds as a source of fodder for the animals or as herbs for human consumption could also have positive environmental effects. Though minor, the increase in plant biomass in IPM fields positively contributes to the absorption of carbon from the atmosphere.

The selected case studies showed that EIQ reduction figures exceeded those of sprays, dose and cost, indicating that the EIQ may be able to capture IPM benefits better than pesticide reduction indicators. However, the dose at which products are applied is probably the single most important factor that affects environmental risk. Since solvents are a major component of pesticide formulations, their effect on the environment would also need to be included. While considered less toxic to humans, the effect of these "inert" ingredients on the environment may equal those of alternative pest control measures such as oils or soaps.

The overall single field EIQ index number may not be the best indicator for environmental impact since it also includes farm worker and consumer risk estimates. Therefore, the separately calculated index for environmental risks (EI Environment) may be a more useful indicator for assessing potential environmental impacts from different pest management practices.

Field ecology study results showed considerable increases in natural enemy populations and predator-pest ratios in IPM plots, as well as an increase in the total number of species, substantiating the positive impacts of IPM on the environments. However, showing the correlation between risk reduction and increased populations and species diversity requires further studies.

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8 IPM-FFS Training Is Crucial for Sustaining Bt Cotton – A Case Study from Hubei Province, P. R. China

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8.1 Methodology

Sampling

Two townships, Huangtan and Nanyuan were selected in Yingcheng County for conducting farmer household surveys. In Huangtan township farmer field school (FFS) training for Integrated Pest Management (IPM) in cotton was conducted in 2001, while Nanyuan township is the control township where no cotton IPM-FFS activities were carried out. The distance between these two townships is about **35 kilometers**, Three villages, namely Yujia, Longwan and Sanba in Huangtan township which held cotton IPM-FFS in 2001 were selected as the IPM villages, three control villages, namely Yifenchang, Erfenchang and Maihang village in Nanyuan township were selected as the control villages.

Three treatments were established: (i) **IPM farmers**, who participated in cotton IPM-FFS in 2001, (ii) **exposed farmers (non-IPM farmers),** who did not participated in a cotton IPM-FFS but live in the same community (village) with IPM farmers, and (iii) **control farmers,** who are sampled from the three villages of the control townships, and are assumed to have no exposure to cotton IPM-FFS.

Three groups of 20 IPM farmers each were randomly selected from 28 cotton IPM-FFS graduates in Sanba village, 27 graduates in Yujia village and 28 graduates in Longwan village. Hence a total of 60 IPM farmers is included in the study. Also, three groups of 20 exposed farmers (who did not participate in the 2001 cotton IPM-FFS) were randomly selected from

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the three IPM villages selected in each IPM village, and three groups of 20 control farmers <u>each</u> who were not exposed to cotton IPM-FFS were randomly selected from the three control villages of the non IPM townships. The total sample for this study hence comprises 180 farmers, 60 IPM, exposed and control farmers, respectively.

Pilot Test

The pilot test for the farmer household surveys was done in late April 2001 before the baseline survey was conducted. A sample of 6 randomly selected farmers were surveyed to test the consistency and comprehensibility of the questionnaires (both baseline and post-training survey questionnaires). The questionnaires were revised and improved based on the results of pilots test. Subsequently, the enumerators shared their experiences gathered during the survey and were further trained to ensure the quality of farmer household surveys.

Baseline Survey

The baseline survey was carried out in May 2001, the questionnaire was used to collect recall information of farmers' agricultural performance in the 2000 season. For the survey the enumerators were organized in groups of 2-3 persons to interview the sample farmers in one village. All the 60 FFS participants and 60 sample exposed farmers from the three IPM villages, and 60 control farmers from the non IPM villages were interviewed individually using the same questionnaire.

Post-Training Surveys

Post training surveys were carried out monthly (8 times) throughout the whole cotton season (May to December) in 2002 with all 180 sample farmers (IPM farmers, exposed farmers and control farmers). Farmers were asked to keep individual daily records (recording forms were distributed to the sample farmers before the cotton season) of agronomic activities in cotton plots. For example, the date of preparing fields, seed treatments, sowing, fertilizing, transplanting, irrigation, spraying, weeding and harvest, the size of plots, amount of precipitation and the names of varieties etc. Input costs, including pest control and labor inputs, were also recorded. The use of pesticides was recorded in detail including the type, name and amount of pesticide sprayed. The enumerators visited each of the 180 farm households once a month to crosscheck the recorded information prior to computer entry and analysis and assist the farmers if necessary.

Information on local market prices of agro-chemicals including pesticides, fertilizers and plant growth regulators was collected regularly to determine the costs of inputs. The actual amounts of cotton hand-picked by farmers were recorded during the harvest season and used as the basis for estimating total cotton production. Gross revenues for the plots were then calculated using these estimates and the prevailing local prices for cotton output. The costs of labor, pesticide, fertilizers and plant growth regulators needed to compute the net revenue were also based on local market prices.

Data Processing and Analysis

The survey data were encoded, entered into *Excel* sheets and verified prior to analysis. Variation analysis was done by using *Excel 2000*, and *SAS (Version 8.0)*.

8.2 Results

The Adoption Rates of Bt Cotton

Bt cotton was initially released into the fields for trials in very small scales in Hubei province in 1999. The Bt cotton varieties were independently developed by the cotton research institute, biotechnology research center of Chinese Academy of Agricultural Sciences (CAAS) and the US based company Monsanto. There were over 20 Bt cotton varieties available in the market in 2001. The most varieties 33B and 32B (Monsanto) occupied the biggest proportion. Other major varieties are Zhongmian-29, 38 and 39 from cotton research institutes of CAAS, and SGK-321 from the biotechnology research center of CAAS.

The adoption of Bt cotton has increased from 2000 to 2002. Results of the farmer household survey showed that the Bt cotton adoption increased by 89%, 50% and 20% in the IPM, exposed and the control farmer group, respectively (Table 8-1).

Table 8-1: Adoption of Bt Cotton in the Sample by Category

Numbers of farmer households adopted Bt cotton	2000	2002	Change between 2000 and 2002	Change
Control farmers (n=60)	20	24	4	20%
IPM farmers (n=60)	19	36	17	89%
Exposed farmers (n=60)	18	27	9	50%

Gross Margin Analysis of Cotton Productions by Farmer Categories

The results showed that the gross margins of cotton production for the farmers in the control group who planted Bt cotton did not show a significant change between 2000 and 2002. However their gross margins decreased rather than increased (-6.7%) while cotton yields increased by 5.4% over the three years. For those control farmers who planted conventional cotton, gross margins decreased significantly (-21.6%). Over the same period, the cotton gross margins of IPM farmers who planted Bt cotton increased significantly (29.7%), and the IPM farmers who planted conventional cotton also realized 27.1% higher gross margins. For the group of exposed farmers, gross margins increased significantly by 16.8% and 17.6%, for those planting Bt cotton and conventional cotton, respectively (Table 8-2).

Table 8-2: Impacts of IPM-FFS and Bt Cotton on Gross Margins by Farmer Category

Categories	Gross margins (US$/ha) 2000	Gross margins (US$/ha) 2002	Change between 2000 and 2002	Change [%]
	SAS Anova (F=0.77, p=0.57) Duncan's test	**SAS Anova (F=52.3, p<0.0001) Duncan's test**	**T test**	
Control farmers with Bt cotton (n=20 in 2000, 24 in 2002)	1174.0*a*	1095.1*d*	-78.9	-6.7%
Control farmers with the conventional cotton (n=40 in 2000, 36 in 2002)	1138.4*a*	910.7*c*	-228.4*	-21.6%
IPM farmers with Bt cotton (n=19 in 2000, 36 in 2002)	1166.8*a*	1513.1*a*	346.3**	29.7%
IPM farmers with the conventional cotton (n=41 in 2000, 24 in 2002)	1201.9*a*	1551.6*a*	349,7**	29.1%
Exposed farmers with Bt cotton (n=18 in 2000, 27 in 2002)	1038.2*a*	1212.9*b*	174.7*	16.8%
Exposed farmers with the conventional cotton (n=42 in 2000, 33 in 2002)	1085.4*a*	1276.4*b*	191*	17.6%

Note: * Significant at 0.05, ** Significant at 0.001; Gross margin = yield x cotton price – total variable inputs (including seeds, pesticides, fertilizers etc.).

In the year 2000, there was no significant difference among the gross margin for the three different goups (IPM, control and exposed farmers), and there was also no significant difference between those farmers who planted Bt cotton and those using conventional varieties (Table 8-2).

In the year 2002, the IPM farmers got the highest economic returns. This holds true for all trained farmers, no matter whether they are adopters of Bt cotton or not. The exposed farmers got significant higher economic returns than the control farmers, though lower returns than the FFS participants. The control farmers had significantly lower gross margins than IPM and exposed farmers and those control farmers who planted conventional cotton varieties performed worst (Table 8-2).

8.3 Conclusions

Based on the findings of this study, it can be concluded that farmers' education in IPM is crucial not only for the cultivation of conventional cotton varieties, but also for the production of Bt cotton. The results indicate that IPM farmers obtained higher net incomes irrespective of the variety they were using (both conventional and Bt cotton).

In most previous academic studies of Bt cotton impact on the field level, economic analysis was based on a comparison between Bt and non-Bt cotton production leading to a parochial and outdated top-down delivery mechanism (Wugang *et al*., 1999, Jingyuan *et al*., 1999, Rong and Puyun, 2001). The issue on the sustainability of Bt cotton is raised as the number of farmers who adopted Bt cotton increased dramatically without the appropriate ecological knowledge. Many ecological repercussions were experienced in the past in the applications of new technologies developed during the "green revolution" when no efforts were taken to enhance farmers' knowledge (Qingnian *et al.,* 2000, Yingqian, 1999).

The introduction of Bt cotton into the Chinese cotton ecosystem offers both challenges and opportunities. The technology aims at a reduction of pesticide applications without compromising economic and ecological returns. In large scale farming systems, the so-called "high dose/refuge strategy" is recommended as a countermeasures to overcome or slow-down the development of pest resistance; but it is considered that the high dose/refuge strategy is unsuitable for the diverse smallholder farming systems prevalent in China (Jingyuan *et al.,* 1999; Yingqian, 1999). The study demonstrates that farmer training following the IPM-FFS approach is crucial for the sustainability of Bt cotton. Enhanced knowledge of farmers is required in order to better understand the ecological impacts of Bt cotton in smallholder farming systems and develop an ecological approach to use Bt cotton in an effective and sustainable way

The study shows that the economic returns of Bt cotton production depend on various factors, such as the state of the agro-ecosystem, infestation levels of the target pests, and location of the cotton region (Wugang *et al*., 1999; Jingyuan *et al.,* 1999; Qingnian *et al*., 2000). Based on our findings and previous academic research in the Yangtze River valley zone, Bt cotton does not have a significantly higher economic return as compared to the local conventional cotton. As such, it is envisaged that the future adoption of Bt cotton in this zone may not reach the high level that was originally expected. Moreover, there are a number of uncertainties, such as the severance of bollworm infestation, changes in the cropping systems, uncertain weather conditions, and unpredictable strong fluctuations in cotton prices.

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9 Impact of FFS-based IPM Knowledge and Practices on Rural Poverty Reduction: Evidence from Pakistan

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9.1 Background

In Pakistan, agriculture is the driving force of the national economy. Sixty-seven percent of the total population lives in rural areas and is directly or indirectly dependent on agriculture for sustenance. Agriculture contributes 26% to GDP, absorbs 47% of the labor force and meets food requirements of the growing population. With virtually all available cultivable land and water resources now being used, pressure on the country's natural resources is growing and environmental problems have already reached critical levels. The pressure to increase production is enormous on low income and resource poor small farms.

Poverty in Pakistan has historically been higher in rural communities than in cities. However, due to a fast agricultural growth in the 1970s and the first half of 1980s, poverty had declined. A slow-down in agricultural growth in the 1990s has had an adverse impact on poverty reduction (Pasha and Palnivel, 2003). Poverty rose sharply in the rural areas in the 1990s, and by 1999 the incidence of rural poverty (36%) was significantly higher than urban poverty (23%). Some rural areas are more affected by poverty than others. Poverty is particularly manifested in many remote rural areas with landless labor depending on agriculture. The poor are also characterized by their vulnerability to environmental degradation and deterioration of the natural resource base, given that they tend to be strongly dependent on the exploitation of such resources.

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Farmer Field School (FFS) based Integrated Pest Management (IPM) was initiated in cotton growing areas of Pakistan to address the persistent rural poverty among small-scale farmers characterized by inadequate incomes, lack of food security and cumulative damage to the productive land. Among the large numbers of resource-poor smallholders in the country, a substantial proportion is trying to cope with unprofitable and ecologically degraded land. The FFS approach has been designed not only to enhance farmer skills and knowledge but also to create new institutions for farmers-to-farmers knowledge transfer, to reform existing extension institutions for participatory skills transfer and improve linkages among development agencies, research institutions, extension departments and organised farming communities. It is now well recognised that institutions matter in the development process and can lead to higher investment levels, better policies, increase in social capital stock of community, and better management of ethnic diversity and conflicts (see for example North, 1990, 1994; Jutting, 2003; Rodrik, *et al*., 2002; Dollar and Kray, 2002; World Bank, 2002; Aron, 2000; Chu, 2001; and Frischtak, 1995).

The overall objective of this study was to conduct a first assessment of the poverty implications of FFS. The specific objectives of the study included: (i) to assess the impact of FFS-based IPM approach on income derived from cotton; (ii) to develop data bases to measure transition in poverty profiles and (iii) to measure the programme impacts on changes in poverty.

9.2 Methodology

Sample Area and Size

IPM impact assessment was conducted in the cotton growing areas of Sindh province. Khairpur District in northern Sindh was purposively selected because of the presence of a large number of small and tenant farming communities and increasing pesticide use scenarios (Government of Pakistan 2001 and 2003). The low income and high poverty profile was another factor behind this selection (Development Statistics of Sindh, 1998).

At a second stage, 4 FFS villages were selected from four different clusters of FFS situated in 4 adjoining Tehsils. Finally 4 control villages within a 20 km radius were selected in the adjoining Sukkur District, which were nearly 60 kilometer away from the nearest FFS project areas of Khairpur district. About 100 FFS-participating farmers (all 25 farmers per FFS), 60 non-FFS (15 from each FFS village) from 4 IPM villages and 60 control farmers from 4 non-IPM villages (15 farmers per village) were interviewed.

Data Collection

The baseline survey was conducted during July 2002 immediately after the formation of the FFS training groups, and information was collected about the 2001 cotton crop. The post FFS-impact survey was conducted during the 2003 cotton season through multiple visits in three rounds. Information was collected through a formal survey on quantities and cost of traction power, fertilizer, seed and irrigation inputs used. Family and hired labor use with gender distribution was also gathered to compute opportunity and cash costs paid for seed sowing, weeding, fertilizer and pesticide applications and cotton picking. Information on area allocation to Rabi and Kharif crops was collected along with total production and estimated values of total outputs. Data on livestock and poultry enterprises numbers and outputs was also collected in the sample survey. Off-farm employments and sources of income were gathered from all sample households. Resource persons were interviewed in all 8 villages to gather information on inputs use and prices for all other crop and livestock enterprises for constructing individual enterprise budgets.

Analytical Methods

Mean, standard deviation and paired T-test statistics was used to highlight the differences in the household incomes, production costs and input and structural variables at farms. The gross margin of cotton was estimated to compare the differential among different sample categories with before and after scenarios. Enterprise budgets were prepared and net incomes were calculated for all crops and livestock enterprises for measuring net household incomes.

Poverty lines were based on Ahmed (1993) who estimated these for rural and urban areas based on an explicit listing of cost of meeting basic needs. While it is recognized that there are other poverty dimensions (e.g. Havinga *et al.,* 1989; Anwar 1996; Bhatti *et al.,* 1999) in this study we consider income as a measure of poverty unlike studies by some other researchers like Ali and Tahir (1999), Malik (1988) used income as a measure of living standard. Malik (1988), Qureshi and Arif (2001) estimated the basic need poverty line for Pakistan.

Hence, in this study, per capita income of the households was used as the criterion to assess the poverty status of the households.

Estimation of Total Income, Total Cost and Net Income

To calculate the net income, as a first step, budgets were prepared for the individual enterprises in different sample situations. The total income was computed from the incomes received from the final sale of the products, i.e. total value of the product or revenue from the main product as well as from by-products. The revenue earned by production activities is the type and quantity of outputs, and their market prices. The types of output per production activity were categorized into main product and by-product. Given the prices received for each output, the total revenue earned from each activity x_j was measured as:

$$r_j = \sum_{n=1}^{N} \sum_{t=1}^{T} p_{njt} y_{njt}$$

Where p_{njt} is the unit price of the n^{th} output of activity j in time period t; y_{njt} is the yield of the n^{th} output produced from one unit of activity j (ha) in time period t; and $n = 1,\ldots,N$ denotes the outputs.

The total variable cost of the inputs used to produce one unit (ha) of each enterprise consists of cash costs and in-kind costs which were normally opportunity costs. The opportunity costs were estimated for the operations performed by owned farm machines, family labour and farm inputs (farm yard manure and seed). The cash costs were paid for inputs like fertilizer, herbicide, insecticide, fuel, improved seed, casual hired labour, picking and transportation. The total variable costs to produce an activity x_j were specified as:

$$c_j = \sum_{i=1}^{k} \sum_{t=1}^{T} p_{ijt} a_{ijt}$$

Where p_{ijt} is the unit price of the i^{th} variable input applied to activity x_j in time period t; a_{ijt} is the amount of i^{th} input used by activity x_j in time period t; the subscript $t=1,\ldots,T$ identifies the time intervals within the activity's production period. The land rent for each crop according to the duration of crop and interest at 12 percent per annum was also calculated and included in the cost. Total cost was calculated as the sum of variable and fixed cost.

The net income from each production activity, that is the difference between an activity's per unit revenue and total costs per unit, was computed as:

$$g_j = r_j - c_j$$

Where r_j is an activity's per unit revenue and c_j is an activity's per unit total cost.

As the farm size at the study sites was very small, only family labor was found applied. Particularly in vegetable farming, all the practices from land preparation to marketing was done by the farmers. Therefore total cost (fixed + variable) and net income was calculated both with and with out rental cost. The opportunity cost of family labor was calculated at market price in the study area.

Net Household Income

Net income at average farm level was calculated multiplying the different area allocations of the production activities with the net income per unit area. The net income and the respective area allocations were estimated for all food, cash, vegetable, orchard and livestock enterprises. Total net household income was calculated by adding net farm and off-farm incomes. The poverty indices were developed by finally estimating the per capita income of the individual members of each household on a per month basis. The poverty line per capita was US$ 12.79 for baseline year and US$ 13.26 for the impact survey year (Table 9-1).

Table 9-1: **Poverty Line for Different Years**

Years	Sensitive Price Index (SPI)	Poverty Line [Rs & US$/ Capita/Month]	
		Pak Rupees	US $
1998-99	-	672.50	11.59
1999-00	1.8	684.61	11.80
2000-01	4.8	717.47	12.37
2001-02	3.4	741.86	12.79
2002-03	3.7	769.31	13.26

Source: Qureshi and Arif (2001) and Pakistan (2001-02)

Poverty Estimation Techniques

The following methods were used to determine poverty profile at sample farms.

- **Gini Coefficient**

Gini (1912) devised the so-called Gini coefficient that can be used to estimate income inequalities:

$G = 1 – [Psi (CYSi + CYSi\text{-}1)]$

Where,

G = Gini coefficient

Psi = Population share of ith household.

CYSi = Cumulative income share of ith household.

CYSi-1 = Cumulative income share of i-1th household.

- **Redistribution Index**

The redistribution index (R) indicates whether the poor part of the population can be compensated through a shift in income from the rich part of the population to the poor. With the index smaller than 1, the rich population is able to provide the compensation:

$$R = \sum_{i=1}^{q} (Z-Yi) / \sum_{i=j}^{N-q} (Yi-Z)$$

Where,

R = Redistribution index.

Z = Poverty line

Yi = Income of the *ith* household

N = Total number of households

q = Number of households below the poverty line (poor households).

- **Foster Greer Thorbecke index**

Foster *et al*. (1984) introduced a flexible poverty index known as FGT index. FGT index has an advantage that it incorporates the factor of poverty aversion. The measure in its general form is given below:

$$P_\alpha = 1/n \sum_{i=1}^{q} \{(Z - Yi)/Z\}^\alpha$$

Where,

P_α = FGT poverty measure, α is the measure of poverty aversion,

n = Total number of individuals

q = Number of individuals having monthly income below poverty line

Z = Poverty line (level of income at which poverty begins)

Yi = Income of i^{th} individual

The salient feature of FGT index is the measure of poverty aversion "α".

For α = 0, the FGT poverty measure becomes the head-count ratio, the proportion of individuals below the poverty line.

For α = 1, the FGT poverty measure becomes poverty gap index. It takes into account the income of the poor below the poverty line and its distance from the poverty line. The index is sensitive to the number of poor and the extent of poverty.

For α = 2, the FGT measure is sensitive to the distribution of income among the poor, i.e. households with income far below the poverty line receive a stronger weight.

9.3 Results

Cotton Share in Household Income

Cotton was the central point of learning and practicing IPM-based knowledge for farm level production activities hence cotton income changes are crucial for changes in poverty. Table 9-2 shows that before training, the share of cotton in gross household income was higher on control farms whereas, net income share was higher by 8% on FFS farms. After training in 2003 cotton gross income share was still higher on control farms (59%) than FFS farms. However, share of net cotton income for FFS farms increased to 46% which was much higher than the change in non-FFS and control farms (12%). The results highlight that net income estimates truly reflect the contribution of cotton as a cash crop towards total net gains of the farming households.

Table 9-2: Cotton Share in Total Household Income

Year	Categories	N	Gross Income [US$/year]		Net Income [US $/year]		Cotton Share in Gross Income	Cotton Share in Net Income
			Mean	SD	Mean	SD	(%)	(%)
2001	FFS	78	3617	3389	1463	1439	39	20
	Non-FFS	59	3452	2986	1402	1742	39	12
	Control	53	3257	2226	706	1067	60	12
	Overall	190	3465	2967	1233	1482	45	16
	Sig.		.794		.009			
2003	FFS	78	5170	6350	2548	3057	43	46
	Non-FFS	59	3484	3121	1479	1830	36	18
	Control	53	3616	3327	715	1425	59	12
	Overall	190	4213	4807	1705	2445	45	34
	Sig.		.071		.000			

Table 9-3 shows the T-test significance and percentage change in the total gross and net household income. Comparison between baseline and impact years shows that both gross and net income were significantly different at 1% levels on FFS farms but were not significant for the other two categories.

Table 9-3: Change in the Household Gross and Net Incomes

Categories	Gross Income (2001 vs. 2003)		Net Income (2001 vs. 2003)	
	T-Test Sig.	Change (%)	T-Test Sig.	Change (%)
FFS	0.006	(+) 43	0.000	(+) 74
Non-FFS	0.924	(+) 1	0.641	(+) 5
Control	0.367	(+) 11	0.952	(+) 1
Overall	0.007	(+) 22	0.001	(+) 38

Tables 9-4 and 9-5 show actual levels of land holding, cotton area and cropping intensity. There was no significant difference in land holding before the training among the three groups. This was opposite for the area planted to cotton and the cropping intensity. The latter was highest for FFS farmers and the former highest for control farmers. In 2003 the general pattern largely remained the same but the significance levels were lower. Hence testing for changes within the groups reveals that these were highest for FFS farmers for all the three criteria. Furthermore the increase in cotton area was clearly significant. This could be a result of higher cotton productivity as experienced by trained farmers. The increase in land holding is not necessarily attributakble to the training but may have been the result of an increase in rent-in areas and the pooling land resources among relatives. Further studies are needed to explore to what extent the collective action which is promoted by the FFS can lead to other institutional changes that may have positive income and poverty reduction effects.

Table 9-4: Operational Land holdings, Area Allocation to Cotton and Cropping Intensities

Year	Categories	N	Operational holding [ha]		Cotton area [ha]		Cropping intensity [%]	
			Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	2.71	3.15	1.95	2.23	183	27
	Non-FFS	59	2.77	2.25	1.91	1.72	182	29
	Control	53	3.24	1.94	2.82	1.68	165	37
	Overall	190	2.88	2.58	2.18	1.97	178	32
	Sig.		0.490		0.020		.002	
2003	FFS	78	3.37	4.15	2.80	3.55	204	107
	Non-FFS	59	2.69	3.14	2.00	2.37	185	28
	Control	53	3.50	2.70	3.25	2.57	164	37
	Overall	190	3.19	3.49	2.68	2.99	187	74
	Sig.		0.390		0.079		.010	

Table 9-5: Change in Land Holdings, Cotton Area and Cropping Intensity (2001 vs. 2003)

Categories	**Operational holding**		**Cotton area**		**Cropping intensity**	
	T-Test Sig.	Change [%]	T-Test Sig.	Change [%]	T-Test Sig.	Change [%]
FFS	0.052	(+) 24	0.007	43	0.085	(+) 21.28
Non-FFS	0.779	(-) 3	0.707	5	0.476	(+) 3.29
Control	0.502	(+) 8	0.237	15	0.936	(-) 0.63
Overall	0.118	(+) 11	0.006	23	0.092	(+) 9.58

Poverty Profile

Table 9-6 shows that during 2001, nearly 71% of the FFS farms were below poverty line. This proportion decreased to 55% during 2003. Among non-FFS and control farmers poverty headcounts were 75% and 89% respectively during baseline period. Among these two groups poverty also reduced slightly to 69% and 85% respectively. Among households of the non-FFS and control farms, only 4-6% farmers could were able to get out of poverty while FFS farmers these were 16%.

In addition to the headcount ratio poverty gap was also reduced for FFS relative to non-FFS farmers. For control farmers the poverty gap even had increased.. Overall the results show that if income from cotton can be increased this can have positive implications for poverty reduction. The Gini-income coefficients indicate that income inequalities had increased in all three groups while the change was less pronounced in the FFS group. Also the income redistribution index for FFS farmers declined from 1.03 (i.e. full compensation not possible) to 0.34, i.e. a level where the income of the rich within the group would be theoretically sufficient to compensate the poor.

Table 9-6: Poverty During Pre- and Post FFS Scenario

Year	Farm Type	FGT Index			Gini Income	Redistribution Index
		Headcount Measure	Poverty Gap Measure	Foster-Greer-Thorbecke		
		α = 0	α = 1	α = 2		
Baseline 2001	FFS	0.71	0.38	0.24	0.43	1.03
	Non-FFS	0.75	0.47	0.37	0.54	1.38
	Control	0.89	0.47	0.60	0.80	7.90
	Overall	0.77	0.48	0.38	0.55	1.72
Impact 2003	FFS	0.55	0.25	0.15	0.47	0.34
	Non-FFS	0.69	0.39	0.27	0.52	0.88
	Control	0.85	0.70	0.80	0.95	7.49
	Overall	0.68	0.42	0.37	0.58	0.90

It could be concluded from these results that the FFS-participating farmers augmented their income through increasing operational capacities, increasing areas allocation to cotton (as a major cash crop) and through adopting better crop management practices.

9.4 Conclusions and Recommendations

The analysis on poverty and income distribution underlines the need to further investigate the participation process of FFS farmers. While in order to conduct a more comprehensive poverty analysis these data may give some first indication a larger sample of FFS should be drawn among the more than 10,000 farmers trained in FFS in Pakistan so far. Nevertheless this first analysis using the three impact areas are believed to be a good start to address this important question. It is also concluded that follow-ups of the FFS activities will be necessary in order to better understand the need for re-training on the one hand but also to better recognize the potential for further institutional innovations that can increase the impact of the FFS approach in terms of environmental improvement and pro-poor growth in rural areas.

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