©*The Pakistan Development Review*
46 : 4 Part II (Winter 2007) pp. 1119–1135

Environment-Friendly Cotton Production through Implementing Integrated Pest Management Approach

MUHAMMAD AZEEM KHAN, M. IQBAL, and IFTIKHAR AHMAD

BACKGROUND

Tremendous increases in pesticide use in cotton growing areas have severely affected the health of peoples and degraded environment [Poswal and Williamson (1998); Ahmad and Poswal (2000); Orphal 2001 and Khan (2000)]. Farmer Field School (FFS) based IPM implemented in the world to reduce dependence on pesticides and promote environmentally safe plant protection practices. An FFS-led Integrated Pest Management (IMP) model implemented in Pakistan during 1996—popularly known as "Vehari Model", clearly demonstrated that IPM could be implemented on a large scale at the farm level. UNDP-FAO Policy Reform Project provided required policy level support to scale up the Farmer-led IPM in the country.

Implementation of pesticide policy project in Pakistan highlighted that pesticide consumption increased from 665 metric tons in 1980 to 78,132 metric tons in 2003-4. The role of private sector in promoting the production and use of pesticides was found tremendously high. The private sector also took full advantage of government's pesticide import liberalisation policies. One of the key components of dramatic increase in pesticide use in Pakistan is related to very soft import and registration at that time, which allowed the generic compounds registered elsewhere, to be imported without field-testing.

The policy project estimated environmental and social cost to the nation amounted US$ 206 million per year [UNDP (2001) and Azeem, *et al.* (2003)]. Analysis proved that such a tremendous cost of pesticide use not only drains the exchequer, but also presents a growing threat to national health and environment of the country. It was concluded that chemical based control program in crops has actually increased the pest problems, disturbed the agro-ecosystem and has killed the non-targeted and environment friendly organisms such as parasitoids, predators and birds. Disturbance in an agro-ecosystem led the new pest problems through resurgence and resistance processes in the naturally occurring pest populations. It was understood that over and misuse of pesticides has led to tremendous ecological disasters [Feenstra, *et al.* (2000); Orphal (2001) and Ahmad, *et al*. (2000)]. The results of pesticide policy analysis project not only paved the way to

Muhammad Azeem Khan <mazmkhan@isb.paknet.com.pk> is Chief Scientific Officer, Social Sciences Division, Pakistan Agricultural Research Council, Islamabad. M. Iqbal <miqbalpide@yahoo.com> is Senior Research Economist, Pakistan Institute of Development Economics, Islamabad. Iftikhar Ahmad is Director-General, National Agricultural Research Centre, Islamabad.

establish National IPM Programme in Pakistan but also to scale-up the implementation of Farmer Field School (FFS) based IMP approach in different agro-ecological zones of the country.

During year 2001, Training of Facilitators (TOF) and Farmers Field School (FFS) activities were implemented in Sindh, Punjab and Balochistan provinces. FFS approach builds capacity of the farmers, through participatory learning processes, to develop and adopt best agriculture practices. This helps in attaining better quality production, higher incomes and reduces dependence on chemical pesticide. The programme is supposed to enable the farmers to grow healthy crops, make regular and critical field observations of their crops and become experts. Empowerment of farmers to practically understand the interactions of pests and predators helps them to make rational plant protection decisions. Pesticide alternatives are also experimented during FFS training sessions. Farmers take observations from the field, analyse data and draw conclusions to take informed crop management decisions. The season long FFS training sufficiently empowers farmers to scan the real motives of the commercial sector advice on chemical based plant protection measures.

This study was specifically conducted to make assessment of change in knowledge and practices of farmers on plant protection measures, number and doses of chemicals used, toxicity of pesticide use, environmental quotients estimation and attitude towards environment. Additionally, improvement in biodiversity, preservation of soil health and water quality, human and animal health gains, empowerment of farmers in decision-making on plant protection measures was also assessed during post-FFS impact assessment study.

METHODOLOGY

Sample Area and Size

IPM impact assessment area included the cotton growing areas of Sindh province. At a first stage Khairpur district was purposively selected for implementing baseline survey. Khairpur was preferred over Nawabshah district where TOF was implemented simultaneously during Kharif 2001. Selection of sample districts was decided by considering the presence of large number of small and tenant farming communities and increasing pesticide use scenarios [Pakistan (2000)]. The low income and high poverty profile of the selected district was another factor behind this selection.

At a second stage 4 FFS villages planned for the 2002 cotton crop and finally 4 villages in 20 km radius were selected in the Sukkur district, which were nearly 60 kilometers away from FFS project areas of the Khairpur district. FFS were selected from four different clusters of FFS situated in 4 adjoining Tehsils. 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.

About 100 FFS-participating farmers (all 25 farmers per FFS), 60 Non-FFS (15 from each of four FFS villages) 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 and information was collected for the Kharif 2001 cotton crop (the year during which Training of Facilitators was held hereafter referred as ToF year). The post-FFS impact survey was conducted through multiple visits in three rounds during 2003 cotton season. Information was collected through formal survey on crop stages, doses, chemical mixes, active ingredients, and toxicity color bands of pesticide used by farmers. Information on chemical and trade name was noted from the packing of pesticides used by the farmers.

On human and animal health accounts, the information was collected on safety precautions observed during spray, cotton picking, and disposal of empty containers. Pesticide-associated sickness incidences; workdays lost and treatment cost data were also collected during pre and post-FFS surveys. Data was also collected on 15 beliefs or attitude statements related to environment, biodiversity, biosafety and pesticide usage intensions. Observed biodiversity was estimated through cross-questioning on behavioural aspects of farmers' dependence on pesticide use as only effective plant protection measure. Farmers' knowledge on non-chemical-based organic soil fertility management practices was also explored.

Analytical Methods

Mean, Standard Deviation and paired T-test statistics were used to highlight the differences in number and doses of pesticides, toxicity class and number of pesticide applied at different crop growth stages. Change in human and animal health indicators was also assessed through these analyses.

Measurement of impact on environmental stability was accomplished by assigning different score to specific questions asked on the subject. The scoring on soil improvement was assigned to responses on FYM (50) and compost (25) use and green manuring (25) knowledge and behaviour questions. The observed biodiversity scoring was estimated through collecting responses on questions asked to provide assessment on crop losses if pesticides were not used as crop protection measure. The responses gathered were subtracted from 100 to have quantitative assessment on crop biodiversity from the respondents.

Attitude towards environmental scoring was done on six statements used to collect responses on degree of agreement from individual respondents. These statements include belief statement on cultural and biological methods of crop protection (20), consideration of pesticide use as sole crop protection solution (10), perceptions on biodiversity losses (20), understanding on pesticide threat to natural environment (20), know-how on pesticide hazards to all living organisms (10), beliefs on health risk to pesticide applicators only (10), understanding on relationship between health problems and pesticide use (10).

The Environmental Impact Quotient (EIQ) methods used in this study was adopted from the models calibrated at New York State Integrated Pest Management Programme, pesticide use and risk calculations on vegetables in Hanoi province Vietnam and FAO-EU IPM Programme for Cotton in Asia [Phuong Ngoc Thi Tran (2001)]. The common or trade names of pesticide were entered along with active ingredients; doses and number of times each chemical used per season per ha. Using this model EIQ for consumer, farmer, ecology and field were estimated for each farm individually. A data base of 250 chemicals was used to estimate the total field EIQ of the farmer, ecology and consumer categories. The mean and T-test analysis was also performed to estimate changes in EIQ on sample farms.

Data on pest and predator population was collected during 19 season long sessions of CESA held in the study area of Sindh. Wide variety of diverse cropping systems is represented through these districts. Data collected for large number of pests and predators was divided into 3 categories of pests like sucking, chewing, and bollworms and a predator category. Bollworms were estimated in terms of percent damage to total bolls per plant and other pests data was accumulated on per leaf basis. Adding all predators and dividing by total pests estimated the ratio of predators and pests.

RESULTS

Pesticide Use

The number of pesticide sprays and doses used, varied significantly on project and non-project area farms (Table 1). The total doses of pesticide chemicals were largely reduced (41 percent) on FFS farms but quite oppositely its use had increased (33 percent) on control farms. The Non-FFS farmers followed FFS farmers by reducing pesticide doses to the tune of 18 percent. As last year (2003) was wet year and pest flare up had happened at boll formation stages, pesticide use had increased on all types of sample farms. However, this increase was significantly less on FFS farms (39 percent) than non-FFS (93 percent) and control farms (107 percent) even at boll formation stage. Difference in the number and doses of pesticide application on FFS farms was observed as a result of improved understanding of FFS farmers on beneficial and harmful insect interactions. More time spent on crop observations and experimentation contributed significantly towards using environment friendly pesticide alternatives at FFS farms.

Impacts of Toxicity on Environmental Impact Quotient

The most visible reduction is estimated for Red class of highly hazardous pesticides on FFS farms (54 percent), whereas a significant increase (25 percent) in the use of the same class of pesticide was observed at control farms (Tables 3 and 4). Previously, the use of this red class of pesticide was identical on all three types of farms. This reduction in the use of red class pesticides is caused by a significant reduction in the use of pesticides at vegetative (85 percent) and flowering (32 percent) stages (Tables 1 and 2). Field EIQ indexation shows 49 percent improvement on FFS farms as compared to 72 percent severity caused at control farms. These results show that FFS graduate farmers did not succumb to use lethal chemicals under panicking pest flare up situation and non-FFS also benefited from this behaviour. Similarly FFS-plots managed under the facilitators' supervision shows zero use of class 1 pesticides. In the same way on FFS plots field EIQ (on IPM-plots where pesticide was used) was more than 100 points lower than Non-FFS farmers' practices. This show the potentiality of environmental gains as a result of the use of full knowledge learnt in FFS on plant protection components of the crop management.

Table 1

Pesticide Use in Terms of Number and Doses at Different Crop Growth Stages

Year	Types	N	Pesticide Applications (No/Season)		Total Pesticide Doses (ml/ha)		Vegetative Stage Applications (No/Season)		Flowering Stage Applications (No/Season)		Boll Stage Applications (No/Season)	
			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	
2003	IPM-plot	5	1		28		0		0		1	

Table 2

Change in Pesticide Use at Different Crop Growth Stages (2001 vs. 2003)

Types	Pesticide Applications		Total Pesticide Doses		Vegetative Stage Applications		Flowering Stage Applications		Boll Stage Applications	
	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change
FFS	0.010	–13	0.000	–41	0.000	–85	0.003	–32	0.002	39
Non-FFS	0.107	10	0.021	–18	0.000	–77	0.020	–29	0.000	93
Control	0.000	21	0.000	33	0.000	–66	0.266	12	0.000	107
Overall	0.233	4	0.000	–15	0.000	–76	0.005	–18	0.000	75

Table 3

Toxicity of Pesticide Use and Impacts on Environment and Human Health

			Highly Hazardous Class-1 (ml/ha)		Total Field EIQ*		Farmers EI		Ecology EI		Consumer EI	
Year	Types	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	2828	1802	194	168	176	182	365	298	41	39
	Non-FFS	59	2757	1994	162	158	133	125	322	360	31	28
	Control	53	2790	1631	196	147	178	175	370	247	39	37
	Overall	190	2795	1810	185	159	164	165	354	304	38	36
	Sig.		0.904		0.437		0.241		0.651		0.306	
2003	FFS	78	1292	1225	98	94	83	82	191	197	20	19
	Non-FFS	59	1831	1640	157	237	135	227	303	442	32	51
	Control	53	3488	2666	337	378	267	389	682	706	62	84
	Overall	190	2072	2055	183	264	150	257	363	505	35	57
	Sig.		0.000		0.000		0.000		0.000		0.000	
2003	IPM-plot	185	0	0	40	50	23	18	97	122	21	2

*Total field EIQ is equal to sum total of farmers EI, Ecology EI and Consumer EI divided by 3.

Table 4

Impact of Change in the Pesticide Use Toxicity on Environment and Human Health (2001 vs. 2003)

Types	Highly Hazardous Class-I		Field EIQ		Farmers EI		Ecology EI		Consumer EI	
	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change
FFS	0.000	–54	0.000	–49	0.000	–53	0.000	–49	0.000	–51
Non-FFS	0.009	–34	0.985	–3	0.847	2	0.898	–6	0.893	3
Control	0.121	25	0.014	72	0.139	50	0.003	84	0.079	59
Overall	0.000	–26	0.990	–1	0.599	–9	0.764	3	0.727	–8

Community Health

Reduction in the use of highly toxic pesticides at FFS farms had significantly reduced the number of poisoning incidences at household level (50 percent), total workdays lost (83 percent) and expenditure for poisoning treatment (74 percent). These reductions on non-FFS and control farms were also observed but with non-significant difference over the previous years (Tables 5 and 6). The differences in the use of precautionary measures were non-significant on all types of sample farms categories. Health gains were mainly the result of less hazardous chemicals used on FFS farms, as health risk reduction curriculum is mainly pilot tested with women folk of the project area. Integration of health risk reduction components in the ToF and FFS curriculums is required for further health conscious pesticide usage. There is significant reduction in animal health problem on all types farms reported, due to differences in the span over which these losses were estimated during baseline and impact surveys.

Environment Stability

The cumulative score on soil improvement, observed biodiversity and attitude towards environment had significantly (at 1 percent level of significance) improved on FFS farms (Tables 7 and 8). FFS farmers' beliefs and attitudes on biodiversity and environment had changed significantly which caused drastic cuts in pesticide applications and reduction in the use of highly toxic pesticide which provides solid empirical evidence on changes in these attitudes, knowledge and practices.

Although, understanding on soil improvement practices in terms of substituting chemical based manuring with organic manuring has increased but it is still a long way ahead to materialise the actual switchovers. Higher use of fertilisers by all sample farm categories indicates the potentiality of providing technical backup support to graduate farmers during post-FFS seasons. The principles of judging water deficiency symptoms in relation to fertilisation and appropriate plant protection measures were not equally adhered. Such variation in the farmers' behaviour is reflected from the higher SD of highly toxic chemicals and estimated EIQ (Table 3).

Association between Environmental and Socio-economic Attributes

The socio-economic attributes show strong association with the pesticide use doses, toxicity of pesticide use and decision-making scores of trained farmers. FFS-farmers attendance score and their age and education were found significantly associated with pesticide applications, observed biodiversity and field EIQ. Old age decision makers' understanding on biodiversity and attitude towards environment were associated negatively. They use more pesticide resulting in negative effects on environment and human health. Educated farmers have been better in perceiving biodiversity roles. However, more attendance score significantly contributes towards decision-making capacities, observed biodiversity, positive attitude towards environment and reduction in pesticide use.

Decision-makers' education without proper FFS attendance however, did not empower farmers to have better attitude towards environment and pesticide use reduction. Improvement in environmental impact quotient is an outcome of improvement in decision making power of farmers, pesticide use reduction, positive attitude towards environment and strong belief on role of biodiversity in plant protection.

Table 5

Impacts on Human and Animal Health

Year	Types	N	Household Poisoning (No/Season)		Work Loss Due to Poisoning (Days/Season)		Treatment Cost ($/Season)		Precaution Knowledge Score (%)		Livestock Poisoning /House Hold (No/Season)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	0.6	0.6	13.4	49.2	12.8	30.3	58.1	19.6	1.2	2.5
	Non-FFS	59	0.5	0.7	4.2	6.6	7.5	14.9	52.3	23.0	1.4	4.6
	Control	53	0.6	0.7	5.4	8.4	22.0	51.1	43.2	16.9	1.9	3.9
	Overall	190	0.6	0.7	8.3	32.2	13.7	34.5	52.1	20.9	1.5	3.7
	Sig.		0.333		0.185		0.081		0.000		0.515	
2003	FFS	78	0.3	0.6	2.3	5.7	3.3	7.6	59.4	14.9	0.3	0.9
	Non-FFS	59	0.4	0.7	2.7	6.7	3.8	9.0	49.2	17.8	0.2	0.7
	Control	53	0.4	0.6	1.7	4.5	7.5	25.0	38.3	13.5	0.7	2.0
	Overall	190	0.4	0.6	2.3	5.7	4.6	15.0	50.3	17.7	0.4	1.3
	Sig.		0.833		0.650		0.247		0.000		0.047	

Table 6

Change in Human and Animal Health Hazards (2001 vs. 2003)

Types	Household Poisoning Cases		Workdays Loss		Treatment Cost		Precaution Knowledge		Livestock Poisoning	
	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change
FFS	0.002	–50	0.049	–83	0.006	–74	0.619	2	0.002	–75
Non-FFS	0.604	–20	0.264	–36	0.102	–49	0.416	–6	0.043	–86
Control	0.151	–33	0.004	–69	0.036	–66	0.113	–11	0.055	–63
Overall	0.004	–33	0.011	–72	0.000	–66	0.304	–3	0.000	–73

Table 7

Impacts on Environmental Stability Indicators

Year	Type	N	Soil Improvement Practices Score (%)		Observed Biodiversity Score (%)		Attitude Towards Environment Score (%)	
			Mean	SD	Mean	SD	Mean	SD
2001	FFS	78	20.19	24.19	52.44	16.69	37.95	21.82
	Non-FFS	59	23.73	26.43	51.19	19.48	36.10	22.82
	Control	53	2.83	10.58	45.66	12.25	33.77	18.83
	Overall	190	16.45	23.62	50.16	16.71	36.21	21.32
	Sig.		0.000		0.063		0.548	
2003	FFS	78	52.56	28.66	72.05	14.80	75.90	32.85
	Non-FFS	59	11.86	20.42	54.75	17.87	39.15	33.44
	Control	53	5.66	15.99	46.32	18.06	29.81	19.46
	Overall	190	26.84	31.65	59.50	19.94	51.63	36.22
	Sig.		0.000		0.000		0.000	

Table 8

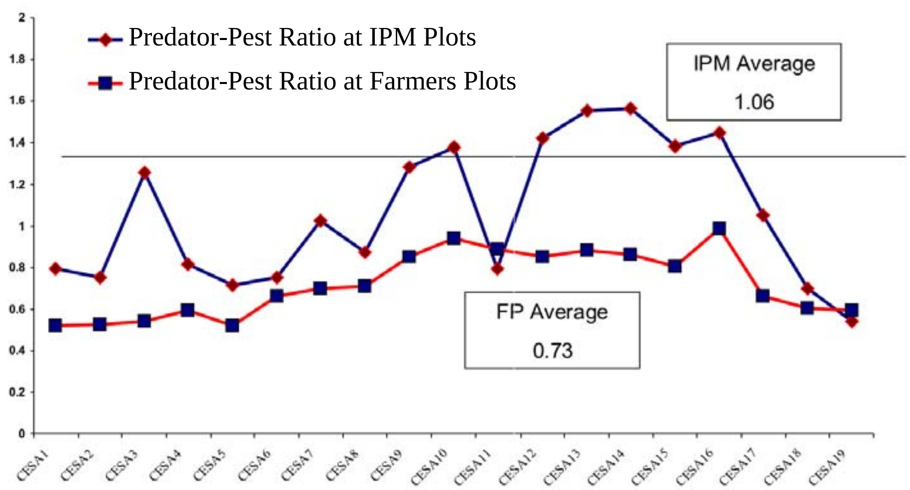
Change in the Environmental Stability Indicators (2001 vs. 2003)

Categories	Soil improvement Practices		Observed Biodiversity		Attitude Towards Environment	
	T-Test Sig.	% Change	T-Test Sig.	% Change	T-Test Sig.	% Change
FFS	0.000	160	0.000	37	0.000	100
Non-FFS	0.008	–50	0.292	7	0.468	8
Control	0.308	100	0.823	1	0.208	–12
Overall	0.000	63	0.000	19	0.000	43

Biodiversity Situation

Sucking pests' complex which starts from early crop stages is the main driving force to initiate early sprays. The bollworms and chewing complex started taking over at mid season and reached threatening level at fruit formation and crop maturity stages. The graphic presentation of 19 CESA results provides interesting relationships in pest-predator dynamics. On IPM-plots wider fluctuations in both pest and predator populations show how these counter each other when there is less intervention in terms of pesticide use. Results further show that at various points, predator population was above pests and vice versa at IPM-plot. However, when farmers start using pesticides in farmer practice plots (FP), the curves are smoothened to show how predators' fluctuation is suppressed and how pests' population persists for inflicting damages on crop. The noticeable feature of this figure is that predators curve never rises above sucking complex on FP plots. The ratio of predators and pests presented in Figure 1 further highlights that less chemical use gives free hand to predators to fluctuate and counter pest pressure, whereas on FP plots the pesticide aid reduces natural pest control processes which enhances pesticide use dependencies.

Fig. 1. FFS Impact on Predator-Pest Ratio (Pakistan, 92 IPM and FP Plots)



The biodiversity interaction findings at IPM plot are in the backdrop of 0.05 sprays (1 spray at 5 plots and Zero at other 85 IPM plots with no class 1 pesticide used and hence Zero EIQ) and 28ml/ha doses of pesticide used (average of 90 plots as only 5 plots were sprayed). At FFS plots on an average 2.27 sprays were used with 2799ml/ha of pesticide dose that consists of 1085ml/ha class 1 (highly hazardous) pesticide. The dose on FFS plot is still half of what farmers use under control situation, as estimated in the impact survey. This shows that to a certain extent the IPM-plot practices are followed at the adjoining farmer plots. The lower use of inputs with proper knowledge of optimal timing, yield gains were 11 percent higher and gross margin was 48 percent higher on IPM plots than farmer plots (Table 10).

Table 9

Correlation Matrixes of Socio-economic and Environment Attributes at FFS Farms

Attributes	Attendance (%)	Decision Maker Age (Years)	Decision Maker Education (Years)	Observed Biodiversity Score (%)	Attitude Towards Environment Score (%)	Total Pesticide Dose (ml/ha)	Field EIQ Index	Decision Making Score (5)
Attendance (%)	1.000	–0.132	0.145	0.126	0.246*	–0.240*	–0.253*	0.245*
Decision-maker's Age (Years)		1.000	–0.507**	–0.355**	–0.087	0.332**	0.142	–0.085
Decision-maker's Education (Years)			1.000	0.348**	0.136	–0.214	–0.102	0.270*
Observed Biodiversity Score (%)				1.000	0.366**	–0.451**	–0.379**	0.287*
Attitude Towards Environment Score (%)					1.000	–0.241*	–0.305**	0.378**
Total Pesticide Dose (ml/ha)						1.000	0.733**	–0.273*
Field EIQ Index							1.000	–0.382**
Decision-making Score (5)								1.000

* Correlation is significant at the 0.05 levels.
** Correlation is significant at the 0.01 levels.

Table 10

Average Pesticide Use, Yield and Gross Margins at IPM versus Farmer Plots (FP)

Category	Spray (no)	Pesticide dose (ml/ha)	Class1 pesticide (ml/ha)	EIQ	Yield (Kgs/ha)	Gross Margin ($US/ha)
IPM-plot	.05	28	0	0	1768	506
Farmer-plot	2.27	2801	1087	55	1582	342
Total Number	216	216	216	216	210	216

CONCLUDING OBSERVATIONS

Total pesticide and especially highly toxic pesticides use reduction at FFS-farms have left positive impacts on bio-safety and biodiversity phenomenon. FFS-farmers through using field observation skills considerably reduced pesticide use at vegetative and flowering stages. The armyworm (*Spodoptera litura*) flare-up during crop maturity stages had affected FFS-farmers' decisions to use more pesticides but to a quite lesser degree in relative terms. This shows how informed decision-making strength of FFS-approach helps farmers to restrict themselves to use pesticide more rationally under tempting abnormal crop situations.

Decrease in the use of highly toxic pesticides and improvement in the consumer, ecology and farmer environment quotients is the plausible outcome of the FFS training. Human and animal health hazards and treatment cost was reduced as a result of use of less toxic chemicals. The health precaution score for pesticide spraying workers and cotton pickers improved slightly and needs special consideration during FFS-follow up activities and ToF trainings. Health risk reduction components of Women Open Schools suggested for simultaneous implementation with FFS and integration in the ToF curricula. The mix male and female FFS establishment while blending crop management and health risk reduction focuses will bring further improvement in community health and natural environment.

Attitude towards environment, soil fertility management and biodiversity has improved considerably. These changes in farmers' perception directly benefited the communities through cost reduction and health and environmental improvements. Green manuring and compost making practices if adopted at community level would help in improving village level sanitation through recycling agricultural waste and its utilisation to manage fertility for sustainable production. The Women Health Risk Reduction component as well as FFS-based community organisations should be mobilised to achieve sanitation as well as low cost land fertility management goals.

Information generated through CESA on pest and predator dynamics provides immense opportunity to understand the natural plant protection processes. This helps farmers to understand pest-predator interaction to allow nature to work its way and opt for most appropriate interventions if so required. More involvement of plant protection experts during both FFS-trainings and post-FFS follow-ups is suggested for improved understanding among farmers, extension agents and researchers. The data collection methods, analysis, interpretation and hypothesis building is recommended to be pursued further for developing appropriate innovations in the approach and devising certain specific technological packages compatible to local conditions.

REFERENCES

Ahmad, I. and A. Poswal (2000) Cotton Integrated Pest Management in Pakistan: Current Status. Country Report Presented in Cotton IPM Planning and Curriculum Workshop organised by FAO, Bangkok, Thailand. February 28-March 2.

Azeem, M. K., M. Iqbal, M. H. Soomro, and I. Ahmad (2002) Economic Evaluation of Pesticide Use Externalities In the Cotton Zone of Punjab, Pakistan. *The Pakistan Development Review* 41:4, 683–698.

Feenstra S., A. Jabbar, R. Masih, and W. A. Jehangir (2000) *Health Hazards of Pesticides in Pakistan*. Islamabad: IWMI and PARC.

Khan, M. A. (2000) Economics Evaluation of Pesticide Externalities in Cotton Zones of Punjab Pakistan. Report for the UNDP study, FAO, Rome, Italy.

Orphal, J. (2001) Economics of Pesticide Use in Cotton Production in Pakistan. Diploma Thesis, University of Hannover, Germany.

Pakistan, Government of (2000) *1998 District Census Report of Khairpur*. Islamabad: Population census organisation Statistics Div. Government of Pakistan.

Poswal, M. A. and S. Williamson (1998) Stepping off the cotton pesticide treadmill: Preliminary findings from a farmer’s participatory cotton IPM training project in Pakistan. CABI Bioscience Centre, Rawalpindi.

Rikke, Peterson and Gerd Walter-Echols (n.d.) FAO-EU IPM Programme for Cotton in Asia: Own Calculations.

Tran, Phuong Ngoc Thi (2001): Pesticide Use and Risk Calculations (Environmental Impact Quotient) on Vegetables in Hanoi Province, Vietnam.

UNDP (2001) Policy and Strategy for the Rational use of Pesticides in Pakistan, Building Consensus for Action, UNDP/FAO Paper Rome, Italy.