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Socio-economic Parameters of Eggplant Pest Control in Jessore District of Bangladesh

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Executive Summary

One hundred eggplant growers from two townships of Jessore District of Bangladesh were interviewed during July 2000 to February 2001 to generate baseline data on socio-economic parameters of pest control in eggplant production. Growers were interviewed again during June to December 2002 to study the possible impact of adoption of an IPM strategy for the control of a major pest, the eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis*. Questionnaires were used to understand pest problems, management practices, patterns of input use, and economic returns associated with eggplant cultivation.

EFSB was identified as the key insect pest in the region. Ninety-eight percent of farmers relied solely on pesticide use to control this pest and 88% indicated that such pesticide use boosts yields. More than 60% of the farmers sprayed their eggplant crop 140 times or more in a season of 6–7 months. During the rainy season most farmers sprayed every day or on alternative days while in the winter the spraying frequency was reduced to once a week. Pesticide cost was the single highest cost of production, constituting 32% of the total cost.

Pesticide dealers were the major source of information to farmers on the selection of chemicals and application procedures. The farmers who were most likely to misuse pesticides were those who valued information from pesticide dealers, were members of a farmers' association, or visited with agricultural technicians. On the other hand, the farmers who were least likely to misuse pesticides were those who were more experienced in farming, better educated, or attended training in IPM. Ninety-eight percent of farmers felt sickness and more than 3% were hospitalized due to various complexities related to pesticide use.

This study reflects the irrational use of pesticide use in eggplant cultivation that has serious consequences to human health and the environment. After two years of research, an integrated pest management (IPM) strategy consisting of weekly excising of EFSB-damaged shoots, installation of pheromone lures to trap male EFSB moths, and withholding of chemical pesticides to allow local natural enemies to control EFSB, was developed. This strategy was implemented in two pilot project studies, one each in winter (January to June) and summer (June to December) on farmers' fields.

Farmers who adopted this IPM strategy used 22% and 13% less labor in winter and summer seasons, respectively, compared to non-IPM farmers, defined as farmers who relied solely on pesticides for insect pest control. Furthermore, the IPM strategies led to lower production costs and higher net incomes. Production costs per hectare for IPM farmers were only Tk 67,025 compared to Tk 97,783 for non-IPM farmers in winter crops, and Tk 85,053 for IPM farmers compared to Tk 128,274 for non-IPM farmers in summer crops (58.39 Tk = 1 USD). Net income per hectare was Tk 91,020 for IPM farmers compared to Tk 57,257 for non-IPM farmers in winter crops, and Tk 214,002 for IPM farmers compared to Tk 36,786 for non-IPM farmers in summer crops. Successful nationwide adoption of IPM in eggplant cultivation will increase profits, protect the environment, and improve public health.

Introduction

Eggplant, *Solanum melongena*, commonly called *brinjal* in South Asia, is the most popular and economically important vegetable in Bangladesh. It is cultivated on small, family-owned farms where sale of its produce serves as a ready source of cash income throughout the year to improve the livelihood of the farmers. This versatile vegetable is especially important during the hot, humid monsoon season, when other vegetables are in short supply.

Although eggplant is cultivated all over the country, the greater Jessore region in the southwest is the major production area and is traditionally considered as the “vegetable basket” of the country. This area is less prone to summer monsoon flooding, hence it is preferred for vegetable production. Intensive cultivation of eggplant in this area provides 30.2% of the summer and 21.5% of the winter supply of this vegetable for the country (Bangladesh Bureau of Statistics, 1998).

Nationwide, production area for eggplant has increased from 29,132 ha in 1994–95 to 66,789 ha in 1998–99 and the production has gone up from 187,705 tons to 403,730 tons during this period (Bangladesh Bureau of Statistics, 1999). Although this represents an increase of 2.29 times in area under cultivation and 2.15 times increase in production volume nationwide, the production area and volume in the greater Jessore region increased by only 1.17 and 1.15 times, respectively (Bangladesh Bureau of Statistics, 1996; 1999). Several factors may have contributed to slower growth of eggplant production in Jessore. One of the most visible is the increasing damage by pest insects and farmers’ increased reliance on the use of toxic chemical pesticides to combat them.

Among the many pest species, the eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis* Guenée, is the most destructive. The pest larvae bore inside tender shoots and stunt plant growth. More severe economic damage comes from larvae feeding inside fruits, making even slightly damaged fruit unfit for human consumption. This results in direct economic yield loss. The yield loss varies but can exceed 65% in Bangladesh (Bangladesh Agricultural Research Institute, 1999).

Despite the importance of eggplant and severity of EFSB problem, the management practices to combat EFSB are still limited to frequent sprays of toxic chemical pesticides (Kabir et al., 1996). For vegetables in general, Sabur and Mollah (2000) observed an increase in use of pesticides by farmers in combating pests throughout Bangladesh. According to Pesticides Association of Bangladesh (1999), pesticide use for growing eggplant was 1.41 kg/ha whereas for vegetables overall it was 1.12 kg, while it was only 0.20 kg in rice. Meanwhile, inappropriate pesticides, incorrect timing of application, and improper dosages all have resulted in high pesticide costs with little or no appreciable reduction in target pest populations.

Non-optimal and non-judicious use of pesticides may result in a series of problems related to both loss of their effectiveness in the long run and certain externalities such as pollution and health hazards. It has been argued that the profits gained by using pesticides in rice production are negated when associated health costs are counted (Rola and Pingali, 1993). Since pesticides impart undesirable effects on the environment and human health, several countries including Bangladesh are introducing integrated pest management (IPM) approaches that are based on the natural balance between pests and predators in ecological systems. Efforts to adopt IPM in Bangladesh are currently confined only to rice, the country's staple food.

In the present study, which was a part of a larger Department for International Development (DFID)-funded project on development and implementation of IPM to combat EFSB in South Asia, an attempt was undertaken to document pest problems, farmers' pest management practices, patterns of input use, and economic returns associated with eggplant cultivation. A baseline understanding of the socio-economic parameters that influence pest management practices of eggplant in Bangladesh was achieved. Toward the end of the three-year project, we studied the potential impact of adoption of IPM on farmers' income and profitability of eggplant production. The results of these studies are reported herein.

Methodology

Two intensive eggplant cultivated areas, Barinagar and Chowgachha townships, were selected in the Jessore District (Figure 1). These two towns have a long history of growing vegetables, especially eggplant. A total of 100 farmers were interviewed during July 2000 to February 2001. We selected five locations from each township and 10 farmers from each location. To determine the recent insecticide use pattern, farmers who did not grow eggplant over the last three years were not selected.

Objective-oriented, structured questionnaires were used to identify different pest problems, pest management practices, patterns of input use, and economic returns associated with eggplant cultivation (see Appendix). Pre-tested survey instruments were used for the collection of data. The collected data were code edited for processing and analysis. Descriptive statistical methods were used to analyze the survey data.

Several factors were hypothesized to affect pesticide misuses during the cropping seasons, including producer characteristics, farm structure and management, source of pesticide information, and pesticide and pest management perceptions (Table 1). Most of these hypothesized factors were included in previous adoption studies referenced above. However, being a member of a cooperative or other association, credit source, and specific pesticide information sources were identified as potentially important factors by the surveys. Among producer characteristics, the specific variables included in the model are: age (AGE), farming experience (FEY), education (EDUCN), access to IPM training (TRAINING), exposure to pest management information from pesticide dealers (PESTDEAL), tenure status (TENSTAT), and membership in a farming organization (MEMBER).

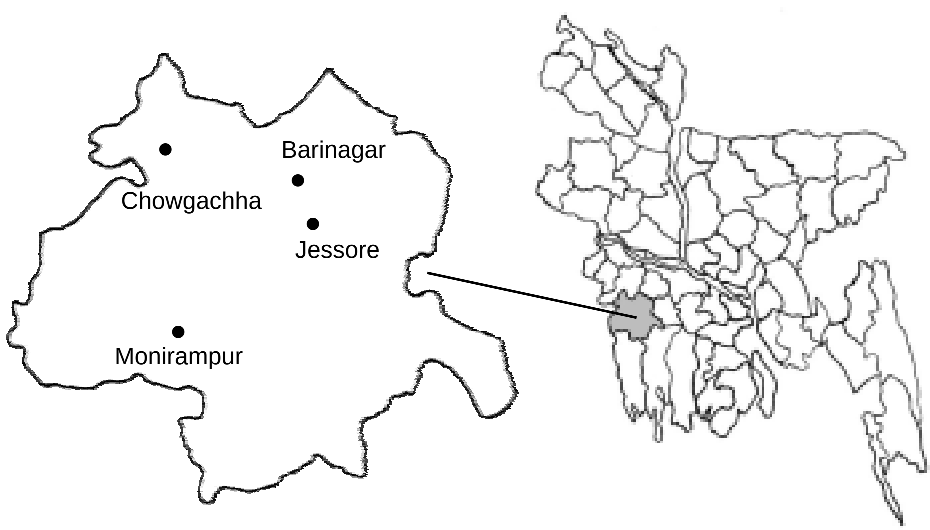

Figure 1. Location of socio-economic survey and impact assessment sites in Jessore District, Bangladesh

It is anticipated that the likelihood of misuse increases with age, as older farmers may be slower to change practices and be less concerned about health effects of pesticides, which may not occur for several years. Increased education is expected to reduce pesticide misuse because farmers are more likely to read pesticide labels and seek additional sources of information. If the farmer has access to IPM training, this is expected to reduce pesticide misuse. Membership in a cooperative or farmers' association is expected to decrease pesticide misuse as these organizations provide a forum for discussion on production practices including IPM. Also, some credit sources used by cooperatives require farm plans that encourage excessive pesticide use.

Pesticide misuse is expected to decrease as the number of working family members besides the farmer (LABOR) increases. As the number of farm laborers increases, the use of alternative pest management practices becomes more probable as the alternatives are often more labor intensive than pesticides. The effect of receiving credit (BORROW) should increase pesticide misuse as farmers may be pressured by creditors to use pesticides. If the source of the credit is a cooperative, the probability that a farmer will misuse pesticides may increase due to the requirement of a farm plan.

Farmers were asked to rank on a scale from one (extremely important) to four (not important), the influence of price and of four sources of information in deciding which pesticide to use. These information sources include agricultural technicians (AGTECH), pesticide dealers (PESTDEAL), chemical company representatives (CHEMCO), and neighbors (NBOR). Increased importance of pesticide price and advice from a pesticide dealer or chemical company representative is expected to increase pesticide misuse. Information from an agricultural technician is expected to reduce it.

The perceptions that killing natural enemies will hasten pest infestation (NENEMY) or harm water quality (WAQUAL) are expected to reduce pesticide misuse. Finally, farmers who have been personally harmed by pesticides either by their farm's water quality being poisoned or by someone in their family having become acutely ill from pesticides (IMPACT) will be less likely to misuse pesticides.

For the second survey, which was to study the impact of adoption of IPM on income and profitability, the data were collected from 20 farmers of Monirampur village. This included farmers who hosted the IPM on-farm research studies as well as neighboring farmers who used pesticides routinely. *IPM farmers* were defined as those who used recommended practices developed by this project (weekly clipping of infested shoots, using pheromone traps, and withholding of insecticide sprays), *non-IPM farmers* followed the traditional practice of regularly spraying to control pests, and *IPM + spray* farmers followed the project's recommended IPM practices and sprayed pesticides on their crops. The sample size of this second survey was rather small; however, the plot size among the interviewed farmers was considerably large (not less than 1.5 ha). The information was collected from the crops traditionally planted in January (winter crop) and June (summer crop).

Table 1. Factors affecting use and misuse of pesticides

Variable	Definition
Producer characteristics	
AGE	age of farmer
FEY	farming experience in years
EDUCN	educational attainment of farmer: 1 for no schooling; 2 for some primary school (1–6 years); 3 for some high school (7–10 years); and 4 for some college (9–11 years or more)
TRAINING	1 if farmer attended IPM training; 0 otherwise
VISAGT	1 if visited by an agricultural technician to discuss IPM; 0 otherwise
TENSTAT	1 if farmer is owner/operator; 0 otherwise
MEMBER	1 if member of a cooperative or farmers association; 0 otherwise
Farm structure and management	
LABOR	number of non-wage labor person in family besides the farmer
IRRIG	1 if the eggplant land is irrigated; 0 otherwise
AREA	total eggplant area on farm
BORROW	1 if farmer received credit for eggplant production; 0 otherwise
COOP	1 if source of eggplant production credit is cooperative; 0 otherwise
Pesticide cost and information sources	
COST	importance of cost when deciding which pesticide to use: 1 if extremely important; 2 if very important; 3 if somewhat important; and 4 if not important
AGTECH, PESTDEAL, CHEMCO, NBOR	importance of information source when deciding which pesticide to use: 1 if extremely important; 2 if very important; 3 if somewhat important; and 4 if not important
Pesticide and pest management perception	
NENEMY	1 if farmers believes that killing the natural enemies in the field by applying pesticides can hasten pest infestation; 0 otherwise
WAQUAL	1 if farmer believes pesticides can be harmful to water quality; 0 otherwise
IMPACT	1 if farmer believes pesticides have harmed the water on his farm or attributes the health problems of a family member to pesticides; 0 otherwise

Statistical Procedures

This analysis uses a logit model in which a dependent variable takes a value of 1 if there is insecticide misuse and 0 otherwise. Misuse of insecticides means application of insecticides in a higher or lower than recommended dose and frequency, spraying mixture of two or more insecticides per application, or using unregistered, banned, or highly toxic chemicals. Logit is used when the dependent variable involves an "either or" situation or when the variable falls into groups or categories.

The general bivariate logit model, and the probability of insecticide misuse by the ith farmer is given by:

$$P_i = F(\beta' X) = 1/[1 + \exp(-\beta' X)],$$

where F is cumulative distribution function (Maddala, 1988). The log likelihood function of the general multinomial logit model is:

$$\text{Log } L = \sum_{i=1}^{n} \sum_{i=1}^{m} Y_{ij} \log P_{ij},$$

where Y_{ij} is a dummy variable equal to 1 if individual i falls into the jth category and 0 otherwise. It is estimated that each producer's objective function contains a nonstochastic portion that equals $\beta' X$, where β is a row vector of parameters and X is a column vector of the exogenous variables. The model is estimated using maximum likelihood. The parameter estimates provided by the logit model does not provide the change in probability associated with the change in an explanatory variable. Instead, the marginal effects were computed using the following equation:

$$\delta P_i / \delta x_{ij} = \beta_j P_i (1 - P_i),$$

where β_j is the initial parameter estimate for independent variable j. These probabilities are provided for each variable. The overall significance of the model is measured in two ways. Goodness of fit is evaluated using the McFadden R^2, which is defined as:

$$\text{McFadden } R^2 = 1 – [\text{Log } L (\beta_{ml}) / \text{Log } L_0],$$

where Log L (β_{ml}) and Log L_0 are the Log-likelihood values of the restricted model and unrestricted model, respectively. The McFadden R^2 equals zero when the likelihood function with all parameters is no greater than the likelihood function with the constraint that all parameters equal zero except the constant. The predictive ability of the model is judged by the number of correct predictions divided by the total number of observations. A variation of this measure is reported for each outcome by dividing the number of correctly predicated misusers or proper users by the number observed. Significance levels of variables are reported as well. AGE, EDUCN, and LABOR were included as continuous variables, information sources were included as a ranking from 1 to 4, and all other independent variables were included as intercept dummies.

Socio-economic Characteristics of Eggplant Farmers

The socio-economic characteristics of the eggplant farmers in two Jessore area townships are presented in Table 2. Farming is the occupation for the vast majority (93%) of the inhabitants in the study area. Among farmers, most (62%) rely on farming as their only source of income.

The selected farmers were grouped into six categories according to their level of education. Most farmers were educated and only 27% farmers had not attended school. A high proportion (39%) of the farmers had received five years of formal primary education, whereas about 21% of the farmers received secondary education from class VI to X. About 7% and 4% had passed Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) examinations, respectively. Only 2% had university level education.

Half of the farmers (50%) were relatively young, falling in the age group of 30 to 40 years. The average farm size per household was 1.12 ha. Farm size in Chowgachha was much larger (1.60 ha) than in Barinagar (0.64 ha). About 38% of the cultivated land was allocated to vegetable cultivation, of which eggplant occupied 12% and other vegetables, 26%. The average family size had 7.35 members. The adult male, adult female, and children constituted 2.99, 2.33, and 2.02 individuals of total family size, respectively. Only 3% of the selected farmers were members of any farmers' associations and only 6% farmers had received training in pest management.

In Jessore, the major cropping patterns among eggplant growers were based on the production of eggplant (Table 3). Cropping patterns included rotations with rice, potato, mustard, onion, or gourd folowed by two consecutive eggplant crops.

Table 2. Socio-economic characteristics of eggplant farmers in Barinagar and Chowgachha townships

Traits	Barinagar	Chowgachha	Average
Major occupation (% of farmers)			
Farming	94	92	93
Business	4	6	5
Service	2	2	2
Education level (% of farmers)			
None	26	28	27
Up to class V	40	38	39
Class VI to X	18	24	21
Secondary School Certificate	8	6	7
Higher Secondary Certificate	6	2	4
University graduate	2	2	2
Age (% of farmers)			
Below 30 years	16	10	13
30 to 40 years	50	50	50
41 to 50 years	24	30	27
Above 50 years	10	10	10
Average farm size (ha)			
Owner cultivated land	0.64	1.60	1.12
Family size (number)			
Adult male	3	3	3
Adult female	3	2	3
Child (below 13 yrs.)	2	2	2
Total	8	7	8
Other			
Member of farmers' associations (%)	4	2	3
IPM training received (%)	10	2	6

Table 3. Cropping patterns in two survey towns in Jessore District

	(% farmers responding)		
Cropping pattern	Barinagar	Chowgachha	Average
Rice – eggplant – eggplant	49	46	48
Potato – eggplant – eggplant	23	22	23
Gourd – eggplant – eggplant	9	19	14
Mustard – eggplant – eggplant	19	0	10
Onion – eggplant – eggplant	0	13	7

Insect Pests and Their Management

Every farmer considered EFSB as the most common pest insect (Table 4). This pest damaged 31% and 33% eggplant crop in 1999 and 2000 seasons, respectively. This is despite repeated spraying of pesticides in the survey areas. Other notable pests were red spider mites (*Tetranychus* sp.), whitefly (*Bemisia tabaci*), and epilachna beetle (*Epilachna* spp.), reported by 73%, 43%, and 10% of farmers, respectively. The inter-site difference in the incidence of pests was non-significant. Despite the fact that many farmers report presence of non-EFSB pests, no specific control measures were directed at controlling them, because the current pesticide use for EFSB also controlled these pests. Proliferation of red spider mites and whiteflies are likely to be induced by heavy use of chemicals in combating EFSB.

Table 4. Common arthropod pests of eggplant in Barinagar and Chowgachha

	(% farmers responding)		
Pest	Barinagar	Chowgachha	Average
Fruit and shoot borer	100	100	100
Red spider mite	75	70	73
Whitefly	40	45	43
Epilachna beetle	10	10	10

Nearly all farmers (98%) relied solely on spraying of pesticides for the control of EFSB; the remaining 2% used a combination of sanitation, which consists of prompt removal of damaged shoots, coupled with pesticide sprays. The vast majority of the farmers (82%) sprayed their eggplant crop from the initial indication of pest infestation and thereafter on a routine basis (Figure 2).

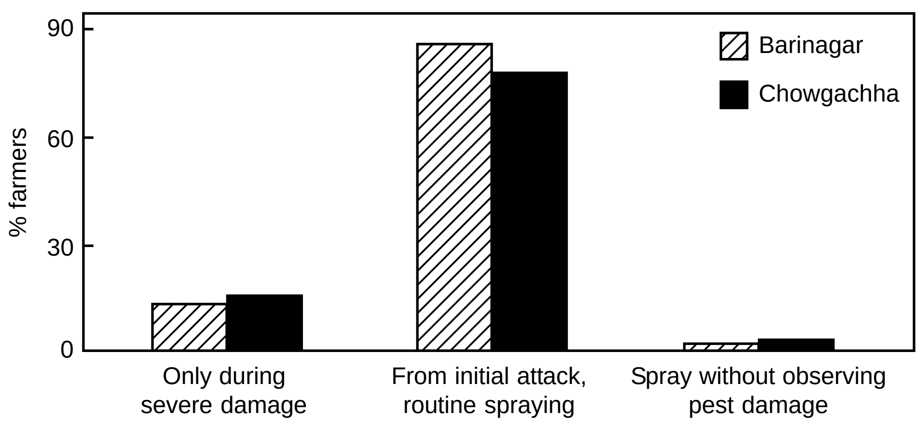

Figure 2. Farmers' practice of application of pesticide for the control of EFSB in two townships in Jessore District

Jessore farmers use a variety of pesticides belonging to different chemical groups in numerous formulations, such as emulsifiable concentrate (EC), soluble powder (SP), granular (G), flowable (FL), and water-soluble concentrate (WSC). Quinalphos (Corolux) 20EC, cartap (Suntuf) 50SP, and carbosulfan (Marshall) 20EC were the most popular chemicals, being used by 54%, 52%, and 50%, of the eggplant growers, respectively (Table 5). Other insecticides used in lesser amounts were: malathion (Fyfanon) 57EC, monocrotophos (Azodrin) 40WSC, quinalphos (Ekalux formulation), and esfenvalerate (Fenfen) 20EC. Theovit was the only fungicide used by the farmers.

The interval between applications mostly depended upon the season. During the rainy season (June–September) farmers sprayed their eggplant crop nearly every day while in winter the interval is more than five days (Figure 3). As a result 35% of the total application was done as daily sprays.

About 60% of growers applied insecticides more than 141 times a season (Figure 4). During the rainy season most farmers harvest and market their eggplant on the same day insecticides are applied. During winter, three to four days lapse between insecticide application and the harvest of the fruits. For many of the insecticides that farmers use in Jessore area, the re-entry period is 10 to 15 days (Table 5).

Table 5. Types of insecticides used against EFSB in Jessore District, July 2000 to February 2001

Chemical	Trade name[1]	Farmers using (%)	Quantity a.i. used per spray[2] (g or ml/ha)	Recomm. dose of a.i. per spray[2] (g or ml/ha)	Re-entry period (days)
Carbamate					
Carbosulfan	Marshall 20 EC	50	254	200	15
Cartap	Suntuf 50 SP	52	225	400	15
Organophosphate					
Malathion	Fyfanon 57 EC	28	512	684	10
Monocrotophos	Azodrin 40 WSC	14	419	400	15
Quinalphos	Corolux 25 EC	54	300	375	15
Quinalphos	Ekalux 25 EC	48	300	375	15
Pyrethroid					
Cypermethrin	Basuthrin 10 EC	24	124	100	10
Cypermethrin	Ostad 10 EC	40	136	100	10
Esfenvalerate	Fenfen 20 EC	14	240	100	10

[a]EC = emulsifiable concentrate, SP = soluble powder, WSC = water-soluble concentrate

[2]a.i. = active ingredient

Note: Among the chemicals, only cypermethrin formulations Ostad 10 EC and Basuthrin 10 EC have been registered against EFSB. Other registered insecticides against EFSB are cypermethrin (Fanom 10 EC), cyfluthrin (Baythroid 50 EC), deltamethrin (Decis 2.5 EC), diazinon (Diazinon 60 EC), fenitrothion (Sumithion 50 EC, Agrothion 50 EC, Folithion 50 EC), esfenvalerate (Sumialfa 5 FL), pirimicarb (Pirimor 50 DF) (Source: Plant Protection Wing, 1999).

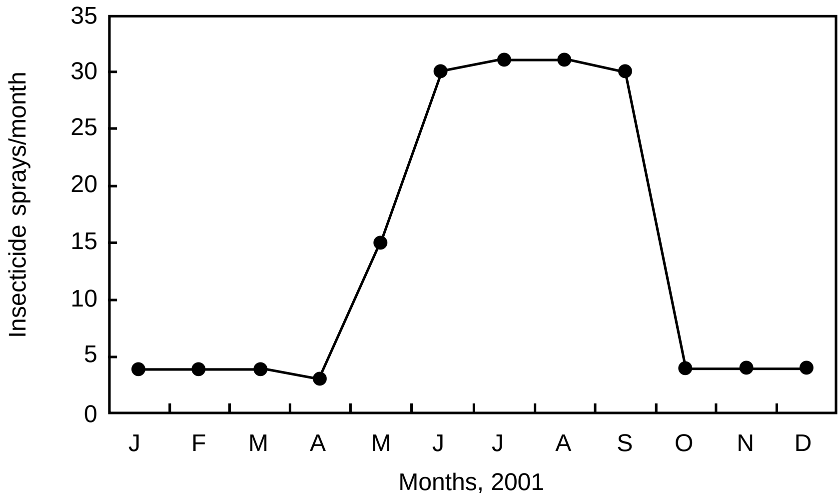

Figure 3. Frequency of pesticide sprays per month for the control of EFSB in Jessore District

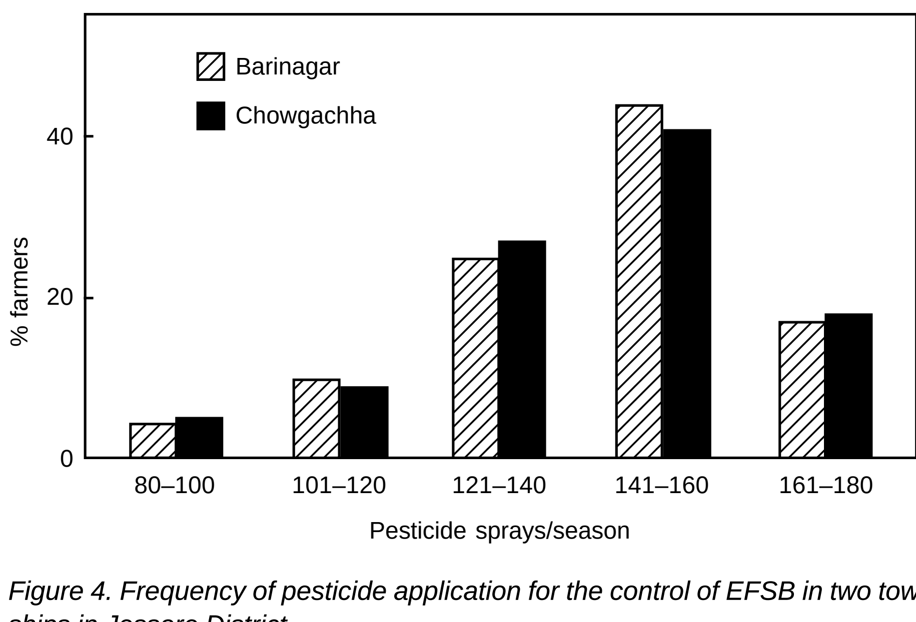

Figure 4. Frequency of pesticide application for the control of EFSB in two town-ships in Jessore District

About 61% farmers reported they received advice on the selection of chemical and their dosages from pesticide dealers (Table 6). This indicates that the retailers of pesticides are an important factor of pesticide use in Bangladesh. On the other hand, the widespread misuse of pesticides also indicates that pesticide dealers do not have the expertise to guide farmers on effectively controlling EFSB. Even if they have the necessary expertise, they are obviously motivated by profits from their own business of pesticide sale. Results of this survey also imply that either the extension workers in the area do not have proper technical expertise or their communication with farmers is not convincing enough.

Table 6. Sources of eggplant pest control advice for farmers in Barinagar and Chowgachha

	(% farmers responding)		
Pest	Barinagar	Chowgachha	Average
Pesticide dealers	59	63	61
Neighbor	18	22	20
Extension worker	8	11	10
Relatives	8	9	9

Health Hazards

Very few farmers used protective clothing or other safety measures during pesticide application; 74% did not observe any safety measures at all. Only 11% covered their body to reduce exposure to the toxic chemicals and only 6% covered their faces with cloth to minimize breathing the pesticides (Table 7). Only 3% used gloves or socks to cover their hands and legs. No farmer used glasses or other form of protective devices to protect their eyes during pesticide application. Almost all farmers experienced sickness related to pesticides application, for example, eye infection, dizziness, vomiting tendency, respiratory related problems, and/or skin irritation; and 3% were hospitalized due to different complications related to pesticide use (Table 8).

Table 7. Types of protective measures during pesticide application

	% of farmers' responding		
Protective measures	Barinagar	Chowgachha	Average
Cover body	10	12	11
Cover face	5	6	6
Cover head	5	5	5
Cover hands and legs	2	3	3
Protect eyes	0	0	0

Table 8. Health problems faced by eggplant farmers in Barinagar and Chowgaccha townships after applying pesticides, July 2000–February 2001

	% of farmers' responding		
Health problems	Barinagar	Chowgachha	Average
Physical weakness	96	98	97
Feel dizzy	76	78	77
Vomiting tendency	76	60	68
Eye pain	64	58	61
Breathing problem	22	26	24
Body itching	24	20	22

Farmers’ Awareness on Pesticide Use Issues

Most farmers believed that spraying pesticides is the single most dangerous practice in their farming operations. An average of 74% of farmers believed that pesticide applications are harmful to farm labor and 71% opined that pesticide applications are harmful to other persons living nearby (Table 9). An average of 72% and 43% of farmers expressed the view that pesticide applications pollute the water and air, respectively. In contrast, only 21% and 11% of farmers believed that pesticide applications pollute crops or cause harm to natural enemies of pests, respectively.

Table 9. Farmer awareness of environmental pollution due to pesticides, Barinagar and Chowagachha townships, July 2000–February 2001

	% farmers’s responding		
Particulars	Barinagar	Chowgachha	Average
Harmful to farm laborer	70	78	74
Harmful to other person	60	82	71
Water pollution	72	72	72
Air pollution	46	40	43
Harmful to animals	24	22	23
Crop pollution	18	24	21
Harmful to natural enemies	12	10	11

Nearly two-thirds of farmers believed that all insects are harmful to crops (Table 10). This is due to the farmers’ lack of training in recognizing harmful and useful insects and other arthropods. This lack of knowledge leads to destruction of these useful fauna by indiscriminate pesticide use. An average of 88% of farmers opined that pesticide use will boost eggplant yields. Only 13% respondents were aware of the natural enemies of insect pests and role of these arthropods in pest control.

Table 10. Farmers’ attitude about insects and pesticides

	% farmers’s responding		
Particulars	Barinagar	Chowgachha	Average
All insects are harmful	59	64	62
Pesticide use boosts yields	89	86	88
Knowledge about natural enemies	15	11	13

Findings from Pesticide Use Model

Results of the logit analysis are presented in Table 11. The initial model has a log-likelihood value of -75.59 and McFadden R^2 of 0.234. A McFadden R^2 value of between 0.2 and 0.4 is typical for logit models (Sonka et al., 1989). The model's chi-squared value is 49.15, which is significant at $P = 0.019$. Of the 100 total observations, 80% were predicted correctly, with 92% misuses and 44% proper users being predicted correctly.

Significant at the 10% level are variables AGE, FEY, EDUCN, TRAINING, VISAGT, and COOP. As farming experience and level of education increases, the probability that the farmer misuses pesticides decreases. IPM training (TRAINING) has the effect of reducing the probability of misuse by 15%. Contrary to expectations, a visit by an agricultural technician to discuss pest management increases the probability that a farmer will misuse pesticides by 12%, while receiving credit from a cooperative reduces the probability of pesticide misuse by 29%.

The only variable significant at the 1% level is PESTDEAL. As farmers reduce the importance of information from a pesticide dealer when deciding which pesticide to use, the probability of misusing pesticides decreases by 26%. The variable MEMBER is significant at the 5% level, as membership in a farmer's association increases the probability of pesticide misuse by 23%. The effect of TV and radio upon farmers was negligible and is therefore not shown in the analysis.

Table 11. Socio-economics determinants of pesticide misuse in Jessore District

Variable	Description	Coefficient	Std dev.	Level of signif.	Probability effect
Constant		3.159			
AGE	Age of farmer	-0.004	12.350	0.089	0.000
FEY	Farming experience	-0.895	0.391	0.056	-0.140
EDUCN	Level of education[1]	-0.781	0.654	0.066	-0.108
TRAINING	Attended IPM training[2]	-0.965	0.471	0.059	-0.150
VISAGT	Visited with ag technician[2]	0.723	0.374	0.077	0.117
TENSTAT	Land tenure status[3]	-0.111	0.392	0.590	-0.002
MEMBER	Member of farm association[2]	1.591	0.701	0.018	0.233
LABOR	Number of family labor	0.112	1.210	0.221	0.003
IRRIG	Irrigated land[2]	0.312	0.392	0.315	0.002
AREA	Total eggplant area	-0.263	0.690	0.716	-0.006
BORROW	Received credit[2]	1.223	0.310	0.191	0.215
COOP	Member of cooperative[2]	-1.801	0.322	0.058	-0.293
COST	Importance of cost when selecting pesticides[4]	-0.329	0.612	0.211	-0.050
AGTECH	Importance of ag techs when selecting pesticides[4]	0.351	0.591	0.312	0.008
PESTDEAL	Importance of pesticide dealers when selecting pesticides[4]	-1.805	0.432	0.004	-0.264
CHEMCO	Importance of chemical co. reps when selecting pesticides[4]	0.337	0.662	0.477	0.005
NBOR	Importance of neighbor when selecting pesticides[4]	0.120	0.893	0.525	0.003
NENEMY	Understand natural enemies[2]	-0.792	0.254	0.253	-0.131
WAQUAL	Pesticides may harm water[2]	-0.182	0.418	0.810	-0.005
IMPACT	Pesticides harmed water or family on farm[2]	0.785	0.392	0.291	0.119

McFadden R^2 = 0.234
Log likelihood = -75.59
Chi-squared = 49.15, P-value = 0.0197
Correct prediction (%) = total: 79.89, misusers: 91.88, non-misusers: 43.89

[1] Rated as 1 = no schooling; 2 = primary schooling (1–6 years); 3 = high school (7–10 years); 4 = college (11 or more years)
[2] Rated as 1 = yes; 0 = no
[3] Rated as 1 = owner/operator; 0 = otherwise
[4] Rated as 1 = extremely important; 2 = very important; 3 = somewhat important; and 4 = not important

Marketing Analysis

The place where farmers sell their produce is an important determinant of price received by the farmers. In Barinagar and Chowgachha townships, about 91% of eggplant harvest is sold in the local market while the remainder is sold at the farmgate. Eggplant sold in local markets receives higher prices than eggplant sold at the farmgate.

The maximum amount of eggplant found in the market is from January to June with peak availability being from March to April (Figure 5). Much lower volume is found in markets during July to December with the peak of scarcity being in August to September. The prices received by farmers follow typical supply and demand trends with low prices during January to May when volume is high, and peak prices during June to September when volume is lowest (Figure 5). During the rainy season from June to September, even pest-damaged fruits receive attention from the consumers. An additional factor is the availability of competing vegetable commodities, which tend to plentiful during cooler winter months and thereby put downward pressure on eggplant prices in that season.

Ninety-five percent of farmers sell eggplant to *beparis*, who purchase 85% of

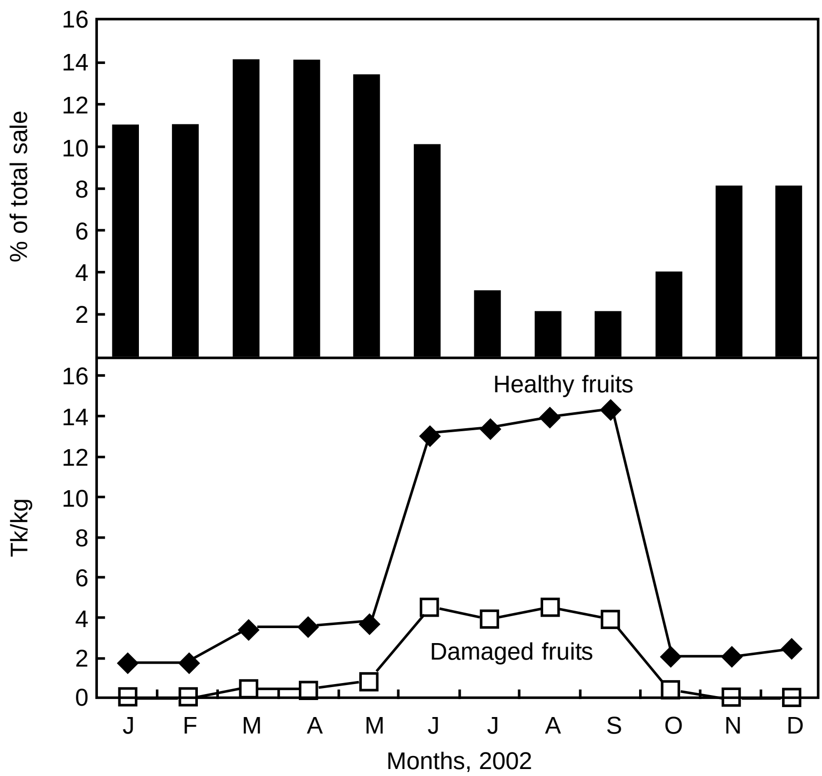

Figure 5. Monthly sale volume expressed as percentage of annual sale of egg-plant (top) and eggplant prices in two markets (bottom) in Jessore District

the farmers' harvest (Table 12). Beparis are professional traders who purchase vegetables from growers at the local market, bring their consignment to the urban wholesale market, and sell them to retailers through commission agents, called *arthdars*. Beparis also sell a small amount of eggplant through *paikers*, who bypass arthdars and sell directly to retailers and consumers. Occasionally beparis go to the village to purchase their produce and some beparis buy vegetables from *farias* in the local market. Farias are petty traders who purchase eggplant from growers in the village or in local markets and sell their produce to beparis. About 23% of farmers sell to farias. Lastly, 5% of farmers sell directly to retailers and 1% of farmers sell

Table 12. Types of intermediaries to whom the farmers sell their eggplant

	% of farmers' responding		
Intermediary	Barinagar	Chowgachha	Average
Bepari[1]	98	94	96
Faria[2]	24	22	23
Retailer	4	6	5
Consumer	1	1	1

[1]Professional traders who purchase produce from growers at the local market and sell to retailers through commission agents

[2]Petty traders who purchase produce from growers in the village or in local market and sell to beparis

directly to consumers.

The movement of eggplant through market channels involves three main stages: 1) from farmgate to the local primary market; 2) from primary market to the urban arth center; and 3) from the arth center to the retail market. These stages are not always followed strictly and some eggplant may go the local retailer directly from the growers. The largest amount of eggplant, however, passes from bepari via arthdar through retailer to the consumer (Figure 6).

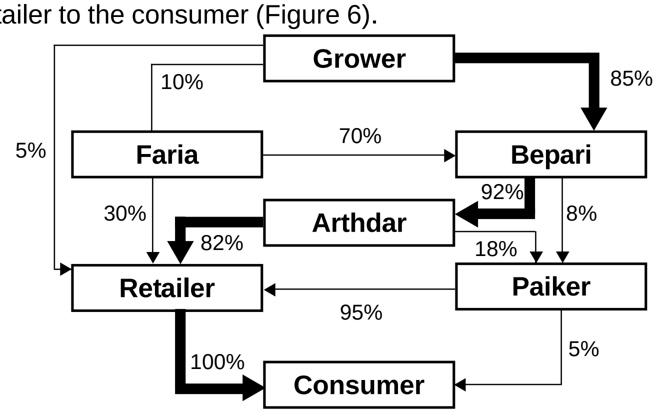

Figure 6. Marketing channels and proportion of eggplant produce passing through their business activities in Jessore District

Production Costs and Returns

Average production cost per hectare of eggplant is calculated at Tk 177,513 (Table 13). Pesticide cost, the single highest cost item, constitutes 32% of total cost of production followed by triple superphosphate fertilizer, 20%, and human labor 20%. Total cost included 24% material cost and 76% non-material cost.

On average, farmers obtained gross income of Tk 310,297/ha from eggplant cultivation. Average net income was Tk 132,784/ha and benefit to cost ratio was 1.75, indicating farmers earned substantial profits from eggplant cultivation.

Table 13. Costs and returns for eggplant production in Barinagar and Chowgachha townships

Items	Barinagar (Tk/ha)	Chowgachha (Tk/ha)	Average (Tk/ha)	Total costs (%)
Service costs				
Human labor	34 000	35 000	34 500	19.4
Animal labor	5 900	4 400	5 150	2.9
Power tiller	1 482	1 902	1 692	1.0
Sprayer machine	553	500	527	0.3
Subtotal	41 935	41 802	41 869	23.6
Material costs				
Seed cost	5 187	6 669	5 928	3.3
Inorganic fertilizer	52 503	49 398	50 951	28.7
Urea	7 110	6 222	6 666	3.8
Triple superphosphate	35 916	34 284	35 100	19.8
Muriate of potash	9 477	8 892	9 185	5.2
Pesticide	59 725	52 982	56 354	31.8
Manure	2 371	2 223	2 297	1.3
Irrigation	1 482	2 078	1 780	1.0
Rental value of the land	14 820	14 820	14 820	8.4
Interest on capital	3 594	3 436	3 515	2.0
Subtotal	139 682	131 606	135 644	76.4
Total production costs	181 617	173 408	177 513	100.0
Gross income	305 666	314 927	310 297	-
Net income	124 049	141 519	132 784	-
Benefit to cost ratio	1.70	1.80	1.75	-

1 USD = 58.39 Tk

IPM Strategy and Impact Assessment

Farmers who practiced IPM required less labor for eggplant production compared to non-IPM farmers, defined as farmers who controlled pests only by spraying pesticides. In the winter crop, 337 man-days of human labor were required for IPM farmers compared to 432 man-days for non-IPM farmers. In the summer crop, 453 man-days were required for IPM farmers compared to 515 man-days for non-IPM farmers. In the summer crop, a group of modified IPM adopters was added; these persons used sanitation practices, installed sex pheromones as well as sprayed regularly. These farmers used 600 man-days of human labor (Table 14). IPM farmers used the least labor since their needs for spraying were nil.

Costs of production were calculated on full cost and cash cost bases. Cash costs were calculated for hired or purchased items. Full costs were calculated for both the family-supplied, hired, or purchased-inputs such as family labor and the opportunity cost of land. Rental value of land covering the crop season was included in full cost analysis.

Farmer groups varied substantially in their input costs. Non-IPM growers spent much more on pesticides and inorganic fertilizers (urea, triple superphosphate, and muriate of potash) compared to IPM growers. For the winter crop, IPM growers spent an average of Tk 67,025/ha while non-IPM growers spent Tk 97,783 (Tables 14, 15). For the summer crop, IPM growers spent an average of Tk 85,053/ha while non-IPM growers spent Tk 128,274 and the growers using both spraying and IPM technologies spent Tk 107,276.

IPM growers earned higher gross returns than non-IPM growers. In the winter crop, IPM growers earned Tk 158,045 while non-IPM growers earned slightly less, Tk 155,040 (Table 15). Differences were more pronounced in the summer crop: on average, IPM farmers obtained gross returns of Tk 299,055 compared to Tk 165,060 for non-IPM growers and Tk 301,658 for the modified adopters of IPM.

IPM growers earned more profits than non-IPM growers. In the winter crop, IPM growers earned a profit of Tk 91,020/ha compared to only Tk 57,257 earned by non-IPM growers. In the summer crop, IPM growers earned a profit of Tk 214,002/ha compared to only Tk 36,786 for non-IPM growers and Tk 194,382 for the modified adopters. The low profits of non-IPM farmers during the summer season can be attributed to the significant amount of expenses on pesticides, which on many farms were applied daily. Despite this incredible amount of spraying, these growers did not effectively control EFSB and their marketable yields did not surpass those of growers utilizing IPM practices. The benefit to cost ratio of growers using IPM was higher than for non-IPM growers during both seasons; this is another indication that IPM practices are more profitable.

Table 14. Input use and costs for eggplant cultivation under different EFSB management regimes in Jessore District[1]

	Winter trial				Summer trial					
	IPM		Non-IPM		IPM		Non-IPM		IPM + spray	
Input use	Qty.	Tk	Qty	Tk	Qty.	Tk	Qty.	Tk	Qty.	Tk
Human labor (man-days):										
Family	105	5 250	134	6 700	223	11 150	295	14 750	315	15 750
Hired	232	11 600	298	14 900	230	11 500	220	11 000	285	14 250
Total	337	16 850	432	21 600	453	22 650	515	25 750	600	30 000
Animal labor (pair-days):										
Family	4	400	5	500	8	800	9	900	7	700
Hired	5	500	6	600	6	600	6	600	8	800
Total	9	900	11	1 100	14	1 400	15	1 500	15	1 00
Tractor/power tiller	-	2 978	-	3 179	-	3 127	-	3 232	-	3 091
Seed cost	-	2 558	-	2 568	-	2 495	-	2 512	-	2 537
Manure (kg)	2 003	436	2 088	445	-	1 514	-	1 012	-	918
Urea (kg)	518	3 367	756	4 914	600	300	746	4 476	952	5 712
Triple superphosphate (kg)	552	7 176	763	9 919	1 447	17 364	1 501	18 012	1 690	20 280
Muriate of potash (kg)	182	1 638	201	1 809	255	2 805	331	3 641	214	2 354
Sulfur (kg)	12	108	18	162	-	-	-	-	-	-
Gypsum (kg)	175	612	286	1 001	-	-	-	-	-	-
Pesticide	-	-	-	27 740	-	-	-	42 076	-	10 200
Sex pheromone lures	-	7 675	-	-	-	7 675	-	-	-	7675
Irrigation	-	8 307	-	8 342	-	5 723	-	8 462	-	5 905
Rental value for the land	-	13 461	-	13 461	-	15 384	-	15 384	-	15 384
Interest on operating capital	-	959	-	1 543	-	1 316	-	2 217	-	1 720
Total costs:										
Full cost basis	-	67 025	-	97 783	-	85 053	-	128 274	-	107 276
Cash cost basis	-	46 955	-	75 579	-	56 403	-	95 023	-	73 722

[1]All data are on a per hectare basis; 1 USD = 58.39 Tk. *IPM farmers* were those who used recommended practices developed by this project (weekly clipping of infested shoots, using pheromone traps, and withholding of insecticide sprays), *non-IPM farmers* followed the traditional practice of regularly spraying to control pests, and *IPM + spray* farmers followed the project's recommended IPM practices and sprayed pesticides on their crops.

Table 15. Costs and returns of EFSB management practices for eggplant cultivation in Jessore District[1]

	Winter trial		Summer trial		
Parameters	IPM	Non-IPM	IPM	Non-IPM	IPM + spray
Full cost basis	67 025	97 783	85 053	128 274	107 276
Cash cost basis	46 955	75 579	56 403	95 023	73 722
Variable cost	53 564	84 322	69 669	112 890	91 892
Yield (kg/ha)	31 609	31 008	39 874	22 008	40 221
Gross return	158 045	155 040	299 055	165 060	301 658
Gross margin	104 481	70 718	229 386	52 170	209 766
Net return	91 020	57 257	214 002	36 786	194 382
Benefit to cost ratio					
Full cost basis	2.4	1.6	3.5	1.3	2.8
Cash cost basis	3.4	2.1	5.3	1.7	4.1

[1]All costs and returns in Tk on a per hectare basis; 1 USD = 58.39 Tk. *IPM farmers* were those who used recommended practices developed by this project (weekly clipping of infested shoots, using pheromone traps, and withholding of insecticide sprays), *non-IPM farmers* followed the traditional practice of regularly spraying to control pests, and *IPM + spray* farmers followed the project's recommended IPM practices and sprayed pesticides on their crops.

Conclusions and Recommendations

The present investigation demonstrates the indiscriminate and irrational use of pesticides to protect eggplant from EFSB in Jessore District of Bangladesh. The existing pattern of pesticide usage, if continued, will result in further loss of efficacy due to the development of resistance by EFSB to pesticides. Other undesirable effects include resource degradation, resurgence of pest populations, environmental pollution, and threat to human health.

Very few farmers use simple sanitation methods, such as cutting off of pest-damaged shoots, that have potential in reducing pest damage. Although farmers are interested in planting pest-resistant eggplant varieties, such varieties are not likely to be developed in the immediate future. The IPM strategy that has been developed through this project provides an opportunity to reduce farmers' pesticide use drastically.

Wherever pesticide use is restricted in Bangladesh, local predators and parasitoids proliferate and help in reducing pest damage. For this purpose the use of sex pheromone is essential to trap substantial numbers of EFSB male adults as well as to give confidence to farmers not to use pesticides. The sex pheromone, which is now commercialized in neighboring India, needs to be made commercially available in Bangladesh at a competitive price.

Farmers need to be trained by means of field days or demonstrations on the proper use of sex pheromone chemicals. The trained farmers should be motivated to adopt all methods, including sanitation, conservation of natural enemies by withholding pesticide use for as long as possible, along with the use of sex pheromone. In the meantime, intensified research is needed to develop component technologies such as EFSB-resistant eggplant cultivars, economical use of sex pheromone, introduction of effective biological pesticides, and introduction of additional exotic parasitoids.

Rural development authorities need to hire well-trained staff that are willing to assist farmers. The farmers should be encouraged to consult such trained extension workers instead of pesticide dealers and chemical company representatives to get proper information about pest management. Research-extension ties need to be improved for the quick dissemination of the improved IPM approach. NGOs should also be involved in the diffusion process. Information dissemination through mass media should be undertaken on the use of IPM as well as the detrimental effect of pesticide use in vegetable cultivation.

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Appendix

Questionnaire for Field Survey

Date of interview ______________________

Respondent __________________ District ____________ Thana ____________

Union ____________ Village ____________

Respondent information

1. Gender: Male ______ Female ______
2. What is your age? ______ years
3. What is highest grade/year in school you have completed? ____________
4. Agricultural farming experience: ______ years
5. Total cultivated land: ______ ha
   Total cultivable vegetable land: ______ ha
   Total cultivated vegetable land: ______ ha
   Total eggplant cultivated land (1998): ______ ha
   (1999): ______ ha
   (2000): ______ ha
6. Land tenure status (ha)
   Owner-operated: ______ ha
   Rented in: ______ ha
   Mortgage in: ______ ha
   Rented out: ______ ha
   Mortgage out: ______ ha
   Other (specify) ______ ha _________________________________
7. Are you a member of any farmers' organization? Yes / No
   If yes, which farmers' organizations are you a member of?

8. Have you attended any training on pest management conducted in your area?
   Yes / No
   If yes, what was the training about? Who organized the training?

9. What cropping pattern(s) do you follow?

Pest management practices

10. What pests of eggplant did you have in the last cropping season?
    a) ____________________________ b) ____________________________
    c) ____________________________ d) ____________________________

11. Do you know about the eggplant fruit and shoot borer (EFSB)? Yes / No
    If yes, how can you identify the pest?
    What is the local name of the pest?

12. What percentage of your total eggplant production was damaged by EFSB during:
    1999: ______ %
    2000: ______ %

13. How did you control this pest? (✔)
    ______ Apply pesticide
    ______ Hand picking
    ______ Other method(s), please specify: ________________________________

14. When did you decide to apply pesticides? (✔)
    ______ After severe attack
    ______ After initial attack
    ______ Without observing any insect

15. List the number of times you applied pesticides at particular stage(s) of the crop. What chemicals did you apply during those stages?

Time of application(s)	No. of application(s)	Pesticide name(s)	Qty. of application(s)	Rationale
a)				
b)				
c)				
d)				

16. How many days apart were insecticide applications?

January	______	February	______	March	______
April	______	May	______	June	______
July	______	August	______	September	______
October	______	November	______	December	______

17. How many days after spraying did you wait before harvesting eggplant?

January	______	February	______	March	______
April	______	May	______	June	______
July	______	August	______	September	______
October	______	November	______	December	______

18. In general, estimate the percentage of EFSB pests killed by the insecticides that you used? (✔)

______ 100% of EFSB ______ 50–74% of EFSB
______ 75–99% of EFSB ______ < 50% of EFSB

19. Do you have any idea about natural enemies of pests? Yes / No

If yes, describe some of them:

____

20. What is your opinion about the deleterious effect of pesticides (✔)

______ Natural enemies mortality

______ Water pollution

______ Air pollution

______ Harmful to farm labor

______ Injurious to health of man and animal

______ Harmful to crops

______ Reduces profits

21. Was there any pesticide(s) which was not effective at all after spraying? Yes / No

If yes, name the pesticide(s):

____

22. How do you spray pesticide(s)? (✔)

______ With sprayer machine

______ Other means (please specify):

____

23. If you use a sprayer machine, from where do you get it? (✔)
_______ Personally owned
_______ Rented from other source (please specify):
____

24. What protective measures do you adopt during pesticide spraying? (✔)
_______ Cover face with cloths
_______ Cover body and face with cloths
_______ Other means

25. From where do you get pest control advice? (✔)
_______ Neighbor
_______ Extension technician/block supervisors
_______ Relatives
_______ Pesticide dealers
_______ Radio
_______ TV
_______ Other sources (please specify):
____

26. Where do you purchase/collect pesticide(s)?
____

27. Do you agree that applying pesticides to eggplant will boost up the yield? (✔)
_______ Agree
_______ Disagree
_______ No other option available

28. In the last cropping season did you borrow money for eggplant production?
Yes / No
If yes, from which of these sources did you borrow money?
_______ Bank (government/private) at an interest rate of _______%
_______ Private source at an interest rate of _______ %

29. What was your eggplant yield and market price for last season?
_______ kg per ha, and sold at a price of _______ Tk/kg

30. How much money did you spend last season to cultivate eggplant? (Tk/ha)

_______ Human labor	_______ Animal labor
_______ Machine power	_______ Sprayer machine
_______ Seed	_______ Cowdung /oil cake
_______ Urea	_______ Triple superphosphate
_______ Muriate of potash	_______ Pesticides/insecticides
_______ Irrigation	_______ Rental value of land for season

_______ Others (please specify) ____

31. What was the net return from eggplant cultivation last year? _____________ Tk/ha

Marketing

32. Where do you sell your eggplant? (✔)

_______ Farm sale

_______ Local market sale

_______ Other (please specify):

____

33. Types of intermediaries to whom you sell their eggplant (%):

_______ Bepari

_______ Faria

_______ Retailer

_______ Consumer

34. Monthwise sale of eggplant (kg):

January _______	February _______	March _______
April _______	May _______	June _______
July _______	August _______	September _______
October _______	November _______	December _______

35. Monthwise price received from eggplant (Tk/kg):

January _______	February _______	March _______
April _______	May _______	June _______
July _______	August _______	September _______
October _______	November _______	December _______