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Contents

Chapters

Tables

Figures

Executive Summary

Vegetable cultivation has become an important means for reducing poverty in rural areas. Eggplant, *Solanum melongena* L., is a typical vegetable crop in that its cultivation helps to generate valuable income for farmers and laborers. At the same time, like other vegetables, its cultivation also degrades the environment, and poses a threat to human health due to misuse of pesticides. Among the plethora of pest species that feed on eggplant, the eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis* Guenée, is the most destructive, especially in South Asia. As a result of its feeding inside fruit, the fruits become unmarketable and yield losses of up to 90% have been reported. Nearly all farmers rely exclusively on application of chemical insecticides to combat EFSB. This practice has resulted in tremendous misuse of pesticides, causing a multitude of side effects that includes increased cost of production as well as exposure of farmers and consumers to pesticide residues. The excessive use of chemical pesticides has destroyed natural enemies of EFSB, resulting in a resurgence of the pest's population.

In order to overcome the situation, a simple and economical IPM strategy was implemented and promoted in Birbhum district of West Bengal State of India. Simultaneously, a socio-economic study was undertaken to understand farmers' pest management practices, patterns of input use, and economic returns in production. This study also evaluated the extent of adoption of IPM practices and the initial economic and social impacts of such adoption.

A personal interview survey, based on a pre-tested structured questionnaire, was conducted in eggplant growing areas of Bolpur, Illambazar and Sainthia blocks in Birbhum District. A total of 100 farmers from 10 villages from the three blocks were interviewed at the initiation of the project and then again two years later in October–November 2005, just before the project's conclusion. During the second installment of interviews, 37 farmers from the same villages who refused to follow IPM were also interviewed in order to understand their reasons for not adopting the strategy. These farmers also served as a check for judging the impact of IPM.

The vast majority of farmers (86%) operated farms of 2 ha or less. Most (55%) were experienced eggplant producers having cultivated this crop for at least 5 years. Over 90% of farmers were 50 years old or younger. Although 95% of farmers were literate, only 13% of the laborers they hired had attended school.

Paddy rice followed by eggplant was the most common cropping sequence. Most farmers used their own eggplant seeds saved from the previous planting, although 34% farmers sowed hybrid varieties that were purchased in the market.

All farmers considered EFSB as the most serious pest of eggplant followed by Epilachna beetle and mites. Ninety-seven percent of farmers used pesticides to combat EFSB and 58% felt that the use of pesticides was profitable, but 36% of farmers felt that pesticides were not effective in reducing EFSB damage. They

sprayed pesticides an average of 54 times during the winter season. Farmers used all major classes of chemical insecticides, including organochlorines, organophosphates, carbamates, and synthetic pyrethroids to combat EFSB. There was widespread misuse, especially overuse of chemicals. Pesticide misuse decreased as farming experience and level of education increased. Greater awareness about IPM technologies as well as awareness of failures of pesticide use also reduced pesticide misuse.

Nearly half of the farmers were aware of beneficial insects in eggplant fields, but only 26% were aware of the harmful effect of pesticides on these natural enemies of EFSB. At the same time, 54% of them were aware of the adverse effect of pesticides on eggplant consumers. Birbhum farmers were able to get advice on pesticide use in combating EFSB from various sources, but 79% of farmers depended on the local pesticide sales agent on what chemicals to use. This practice is similar elsewhere in India and neighboring Bangladesh. Ninety-two percent of farmers covered their face and/or body with cloth while applying pesticides.

The average cost of production of eggplant was Rs.94,000 (US$2,140), while gross returns were Rs.165,000 and net returns were Rs.71,000 per hectare per season. The benefit-cost ratio was 1.76. The average yield was 28 t/ha, which is almost twice the national average of 16.1 t/ha.

On-farm grading is a common practice of eggplant farmers in Birbhum District and most of the produce (89%) was sold in local markets. Insect-damaged eggplant fruits were fed to cattle by 86% of the farmers. After the final harvest, only 8% of farmers disposed of plant residues promptly, while 88% of farmers stored the plant stalks around the field for use as fuel. Since these plants may harbor EFSB, this will be an impediment to adoption of IPM unless a suitable compromise is found that will entice farmers to dispose of crop residue quickly.

The significant factors promoting adoption of IPM are the farmers' awareness about IPM, availability of IPM inputs, perceived economic and health benefits, and degree of crop damage. Significant factors hindering adoption of IPM include size of landholding, age of decision maker, and easy access to pesticides.

The impact of the project is significant both in terms of reducing the cost of growing eggplant as well as in increasing returns. Growers who adopted IPM practices experienced increases in yield, a higher proportion of pest-free fruit, and higher profits compared to non-practitioners. IPM adopters reduced their labor requirements by 5.9%, while the labor requirements of non-adopters rose by 1.2%. Adopters of IPM increased their eggplant production area by 21.6% while non-adopters reduced their production area by 8.7%. Farmers adopting IPM sprayed pesticides 52.6% less often than before while non-adopters sprayed 14.1% more often. Nearly all (99%) of adopters will continue to use IPM and 73% of non-adopters plan on switching to IPM next year. The economic surplus model revealed an internal rate of return of 38% and a benefit-cost ratio of 2.78.

1 Introduction

Vegetable cultivation is one the most economically important and dynamic branches of agriculture. It has become an important source of income for both farmers and field laborers, serving as a vehicle for reducing poverty in rural areas. At the same time, vegetable cultivation is becoming more costly due to the increased use of purchased inputs, such as pesticides and fertilizers, to sustain production levels. If used improperly, many of these purchased inputs have deleterious effects on human health and the environment.

Eggplant, *Solanum melongena* L., is a typical vegetable crop in that its cultivation helps to generate income for farmers, yet it also degrades the environment largely due to heavy use of pesticides, especially in Asia. This crop is especially important in South Asia, where it is one of the three most widely grown vegetable species. This region accounts for almost 50% of the world's eggplant production. Eggplant is cultivated largely on small landholdings where sale of its produce from frequent pickings through the prolonged harvest season generates valuable cash income to farmers. In the hot-wet monsoon season, when other vegetables are in short supply, eggplant is practically the only vegetable that is available at an affordable price for rural and urban poor.

In India, 8.2 million tons of eggplant on 510,000 ha is produced annually, second only to China in production. Yields in India increased from 6.6 t/ha in 1961 to 16.1 t/ha in 1998 (FAOSTAT data, 2006), largely due to an increased use of inputs such as fertilizers and pesticides. However, yields have stopped rising since 1998, despite continued increase in the use of these inputs. We surmise this to be largely due to increasing damage by insect pests and failure of pesticides to combat these pests.

Among the plethora of pest species that feed on eggplant, the eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis* Guenée, is the most destructive. Insect larvae bore inside tender shoots, which results in withering of that plant part. 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. Yield losses of up to 90% have been reported in India (Kalloo, 1988) and similar losses are also common in neighboring Bangladesh (Ali et al., 1980).

In the absence of effective alternative control measures, farmers rely exclusively on application of chemical insecticides to combat EFSB. This practice has resulted in tremendous misuse of pesticides, causing a multitude of side effects that includes a loss of biodiversity. This, in turn, has resulted in the resurgence of EFSB and other pest populations due to the killing of their natural enemies.

The abuse of pesticides, including the use of excessive rates and non-registered chemicals, as well as a disregard for re-entry and harvest-delay intervals, have resulted in both loss of pesticide effectiveness as well as damage to the environment and human health. In other crops, namely rice, it has been argued that the profits gained by using pesticides in 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 India, have introduced integrated pest management (IPM) approaches that are based on restoring the natural balance between pests and their predators in ecological systems. Most of such IPM approaches are pest specific and influenced by host-plant relationships and the crop ecosystem.

A simple IPM approach was developed during a three-year (2000–2003) project funded by the Department for International Development (DFID) of the UK (Alam et al., 2003). In brief, the IPM strategy involved (a) removal of previous crop residue before planting; (b) installation of pheromone-baited traps throughout the field once flowering starts; (c) prompt cutting and disposal of EFSB-damaged shoots; and (d) withholding of pesticide use for as long as possible. The project was extended for an additional two years to implement and promote this IPM strategy in Bangladesh and India.

The present study, undertaken in West Bengal State of India, documented eggplant pest problems, farmers' pest management practices, patterns of input use, and economic returns in order to develop a baseline understanding of socio-economic parameters that influence farmers' pest management practices in eggplant. West Bengal State is especially suitable for such a study because it is leading producer of eggplant, accounting for 28% of the country's production (IASRI, 2005).

This study also evaluated the extent of the adoption of IPM practices to combat EFSB and documented the underlying factors that led to adoption or non-adoption of the IPM strategy. The initial economic and social impacts of the project are also presented herein.

2 Socio-economic Characteristics of Eggplant Farmers

2.1 Methodology

Three intensive eggplant growing areas of Birbhum District: Bolpur, Illambazar and Sainthia blocks, were selected (Fig. 1). These blocks, each with several villages, have a long history of cultivating vegetables, especially eggplant—the most important vegetable in West Bengal. A total of 100 farmers (35 from six villages in Bolpur, 32 from one village in Illambazar, and 33 from four villages in Sainthia blocks) were interviewed at the initiation of the project and then again two years later in October–November 2005, just before the conclusion of the project.

Objective-oriented, structured questionnaires were used to identify 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 collection of data. The collected data were code edited for processing and analysis to determine factors responsible for farmers' misuse of pesticides and factors that lead to their adoption or rejection of IPM strategy.

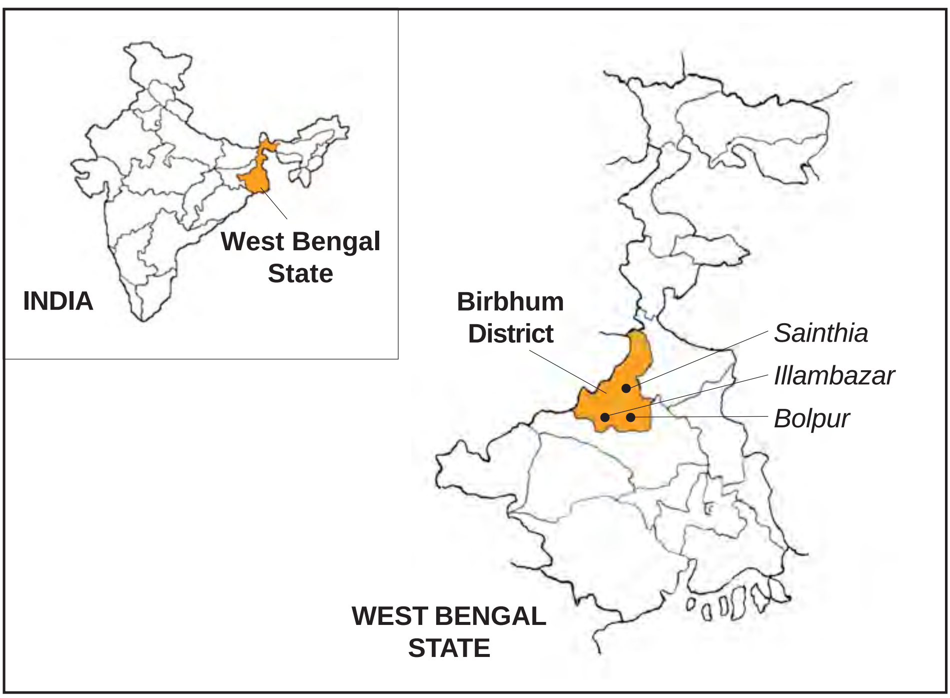

Fig. 1. *Location of Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal State of India, where project implementation and socio-economic studies were carried out*

2.2 Results

The socio-economic characteristics of the eggplant farmers in Bolpur, Illambazar, and Sainthia blocks in Birbhum District of West Bengal are presented in Table 1. All of the respondents were males. Among the farmers interviewed, 45% operated small farms of 1 to 2 ha in size, and 41% operated even smaller farms. Only 1% operated farms 4 ha or larger, and no farmers operated as much as 10 ha. The average size of holding was highest in Ilambazar (1.45 ha) followed by Bolpur (1.30 ha) and Sainthia (1.17 ha).

Thirty-eight percent of farmland was sown in crops, and half of this, 19%, was sown in vegetables (5% in eggplant). Sainthia block had the largest percentage of cropland devoted to eggplant production, approximately 7%.

Farmers were experienced but fairly young in age. Among the respondents, 82% of farmers had at least 10 years of farming experience and 66% had at least 5 years of experience growing eggplant. Farmers in Bolpur were generally more experienced compared to farmers of the other two blocks.

Forty-two percent of farmers were in the age group of 30 to 40 years, an age of high labor productivity. Half of the farmers in Bolpur block were within this age group. Overall, only 9% of farmers were over 50 years of age.

Ninety-three percent of hired farm laborers were between the age group of 14 to 60 years; only 2% were younger and 5% were older.

The farmers and hired farm laborers were grouped into four categories based on their educational attainment: illiterate, primary school, secondary school, and higher secondary school level education. Only 5% of farmers were illiterate and 83% had received education at least up to the secondary school level. In contrast, 87% of hired farm laborers were illiterate and only 1% had received education in a secondary school.

2.2.1 Cropping patterns in survey area

Eggplant was a common vegetable in all of the cropping sequences practiced by the growers in the surveyed area (Table 2). Paddy rice followed by eggplant was a common cropping sequence at all locations.

Locally improved varieties of eggplant were grown by 46% of farmers (Table 3) while F_1 hybrids were grown by 34% of the growers. Most farmers saved their own seeds to grow eggplant in West Bengal, a situation similar to other parts of India.

Table 1. *Socio-economic characteristics of eggplant farmers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Traits	Bolpur	Illambazar	Sainthia	Mean
Farm size (% of farmers)				
Marginal (less than 1 ha)	35	39	49	41
Small (1 to less than 2 ha)	53	43	39	45
Medium (2 to less than 4 ha)	9	18	12	13
Semi-medium (4 to 10 ha)	3	0	0	1
Large (more than 10 ha)	0	0	0	0
Average size of holdings (ha)	1.30	1.45	1.17	1.31
Cropping pattern (% of total cropped area)				
Potential area under vegetables	40	44	30	38
Actual area under vegetables	21	17	19	19
Area under eggplant in 2001	4	4	6	4
Area under eggplant in 2002	4	4	7	5
Area under eggplant in 2003	5	4	9	6
Area under eggplant in 2001–2003	4	4	7	5
Farming Experience (% of farmers)				
Raising crops				
Less than 10 years	9	18	27	18
10 to less than 20 years	59	40	52	50
20 to 30 years	29	36	18	28
More than 30 years	3	6	3	4
Growing eggplant				
Less than 1 year	3	9	0	4
1 to less than 5 years	21	33	36	30
5 to 10 years	62	46	58	55
More than 10 years	14	12	6	11
Age of farmers (% responding)				
Under 30 years	15	27	46	29
30 to 39 years	50	40	36	42
40 to 50 years	23	21	15	20
Over 50 years	12	12	3	9
Age of farm labor (% responding)				
Child labor (below 14 years)	0	4	1	2
Adult (14 to 60 years)	97	91	93	93
Senior citizen (above 60 years)	3	5	6	5
Education level of land owners (% responding)				
Illiterate	9	6	0	5
Primary school level	15	15	6	12
Secondary school level	67	61	85	71
Higher secondary school level	9	18	9	12
Education of farm labor (% responding)				
Illiterate	88	82	90	87
Primary level	12	17	10	12
Secondary level	0	1	0	1

Table 2. *Cropping patterns in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Cropping pattern	Bolpur	Illambazar	Sainthia	Mean
Eggplant–eggplant	24	3	9	12
Paddy–eggplant	68	76	61	68
Potato–eggplant	38	18	21	26
Wheat–eggplant	15	9	3	9
Other vegetables–eggplant	91	42	33	56
Other crops–eggplant	21	6	12	13

Note: Some farmers were following more than one cropping sequence

Table 3. *Variety types used by eggplant farmers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Variety type	Bolpur	Illambazar	Sainthia	Mean
Locally improved	27	64	49	46
Hybrid	38	30	33	34
Local	35	6	18	20

2.2.2 Insect pests and their management

All farmers considered EFSB as a serious pest; Epilachna beetles and mites were next in importance (Table 4). Infestation by mites in Sainthia was quite serious at times and two-thirds of its farmers considered this arthropod to be a damaging pest of eggplant.

Table 4. *Common pests of eggplant crops in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Pest	Bolpur	Illambazar	Sainthia	Mean
Eggplant fruit and shoot borer (*Leucinodes orbinalis*)	100	100	100	100
Epilachna beetle (*Epilachna* spp.)	85	42	45	58
Mites (*Tetranychus* spp.)	35	42	67	48
Jassid (*Amrasca* spp.)	29	27	21	26
Whitefly (*Bemisia* spp.)	3	6	49	19
Armyworm (*Spodoptera* spp.)	0	9	21	10
Aphid (*Aphis* spp.)	0	21	6	9
Termite (Order Isoptera)	0	3	0	1

Note: Some farmers named more than one species as serious pest of eggplant

Ninety-seven percent of farmers used pesticides to control EFSB (Table 5) and most (59%) pesticide applications were conducted during times of severe attack. Ninety-two percent of farmers initiated spraying after observing initial pest infestation. Bolpur farmers had a tendency of spraying only during severe infestations of the crop. Only 28% farmers supplemented pesticide use with others practices in controlling this pest.

Table 5. *Management of EFSB through pesticide application and other practices in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Practice	Bolpur	Illambazar	Sainthia	Mean
Use pesticides:	100	97	94	97
During severe attack	85	49	42	59
During initial attack	21	30	15	22
Before attack	9	9	6	8
Other practices	44	21	18	28

Note: Some farmers gave more than one answer as to when they begin spraying pesticides

Most farmers (58%) felt that pesticide use was profitable; Bolpur farmers were most optimistic about pesticide use (Table 6). Among all blocks, 36% of farmers felt pesticides were not effective in reducing EFSB damage and only 3% of farmers asserted that pesticide use can reduce damage by more than 75%. Only 50% of farmers felt that the use of pesticides led to higher yields.

Table 6. *Effectiveness of pesticide application in controlling EFSB in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Item	Bolpur	Illambazar	Sainthia	Mean
Profitability of pesticide use				
Profitable	74	67	33	58
Incurred loss	6	15	12	11
Cannot say	20	18	55	31
Damage reduction by pesticide use (%)				
Ineffective	32	21	55	36
Less than 25	23	36	12	24
25 to less than 50	32	19	18	23
50 to 75	9	21	12	14
More than 75	3	3	3	3
Yield increase due to pesticide use				
Increased	62	45	43	50
Unchanged	18	15	30	21
Cannot say	20	40	27	29

2.2.3 Pattern of pesticide use

In Birbhum District, eggplant is grown mostly during winter or “rabi” season. Nearly 89% farmers preferred to grow this crop during winter, 10% during summer, and only 1% farmers grew it during both seasons. The frequency of application of pesticide was higher in the winter season (54 sprays) compared to the summer (21 sprays) (Table 7).

Table 7. *Frequency of pesticide use in controlling EFSB in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	No. of pesticide applications			
Season	Bolpur	Illambazar	Sainthia	Mean
Winter	45	71	44	54
Summer	35	NA	30	32

NA = Not applicable since eggplant was not grown in summer

The farmers of Illambazar block applied pesticides most often, 71 sprays during the winter season (Table 7) and 16 times during November alone (Fig. 2). In Bolpur block, where eggplant is also grown in summer, farmers applied 13.4 sprays per month in July (Fig. 2).

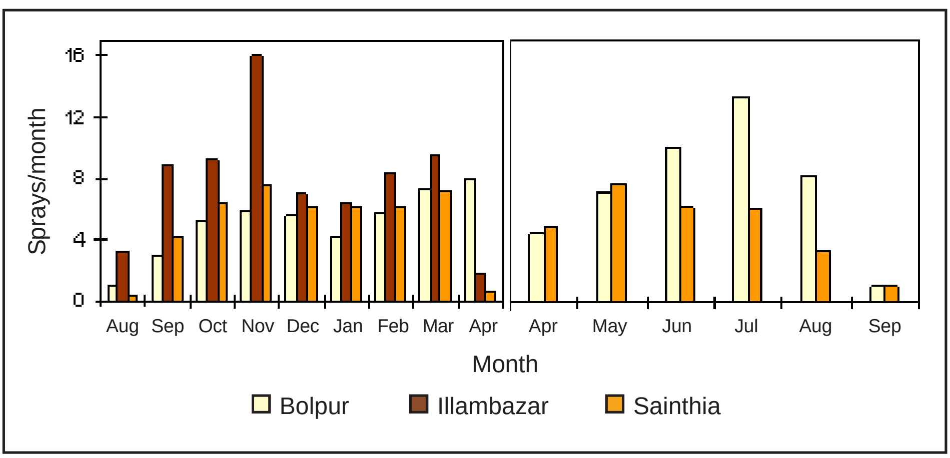

Fig. 2. *Pattern of pesticide use on winter and summer eggplant crops in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

The growers used various pesticides of different chemical groups in different formulations (Table 8). Among them, Triazophos 40 EC was very popular, used by 33% of farmers, closely followed by Cartap 50 SP by 31% of farmers. Among granular insecticides, Carbofuran 3G was used by 25% of farmers followed by Phorate 10G by 13% of farmers. Synthetic pyrethroids were used by 19 to 21% of farmers. Neem insecticide was used by only 1% of farmers. Insecticides like Cartap 50, Carbaryl 50WP, Phorate 10 G, Acephate 75% SP were applied at higher than recommended doses, while some others were used at below recommended doses.

Table 8. *Types of insecticide used to control EFSB in Birbhum District, West Bengal, India*

Chemical	Farmers using (%)	Active ingredient (g/L or ml/L)	
		Applied	Recommended
Carbamate			
Cartap 50 SP	31	1.26	1.00
Carbofuran 3 G	25	10.32[1]	30.00[1]
Carbosulfan 25 EC	3	1.83	2.00
Carbaryl 50 WP	1	2.50	2.00
Organochlorine			
Endosulfan 35 EC	23	1.02	2.00
Organophosphate			
Triazophos 40 EC	33	1.08	1.00
Dimethorate 30 EC	15	1.73	2.00
Phorate 10 G	13	15.08[1]	10.00[1]
Prophenophos 50 EC	11	1.00	1.50
Quinalphos 25 EC	10	1.42	2.00
Monocrotophos 36 SL	6	2.08	1.50
Phosphamedon 40 SL	5	1.10	1.50
Acephate 75 SP	4	1.00	0.75
Methyl parathion 50 EC	3	1.00	1.00
Synthetic pyrethroids			
Alpha-cypermethrin 10EC	21	1.02	1.00
Cypermethrin 10 EC	19	1.13	1.00
Neem (Tritarphenoid)			
Azadirachtin 1500 PPM	1	2.00	4.00

[1] Dose in kg/ha

2.2.4 Farmers' awareness on pesticide use and related issues

Nearly 50% of farmers were aware of beneficial insects in their eggplant fields (Table 9). More than half (54%) of the farmers were aware of the harmful effects of pesticides on eggplant consumers and 41% were mindful of the danger it posed to laborers working in the field. Approximately 40% of farmers were aware of possible contamination of air and water by pesticides, and 26% were mindful of the adverse effect of these chemicals on beneficial insects.

Table 9. *Farmers' awareness about beneficial insects and harmful effects of pesticide use in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Issue	Percentage of farmers			
	Bolpur	Illambazar	Sainthia	Mean
Beneficial insects	50	33	64	49
Harmful effect of pesticide on:				
Beneficial insects	32	15	30	26
Eggplant consumers	59	39	64	54
Eggplant crop laborers	32	27	65	41
Water pollution	29	52	49	43
Air pollution	29	45	42	39

Although farmers were able to get information from various sources, pesticide sales agents were the main source of information regarding the use of chemicals to control EFSB (Table 10). Nearly 80% of the farmers relied on them. Neighbors and relatives were valued sources of information, but extension agents and radio broadcasts were not. This situation is identical to what is happening in neighboring Bangladesh (Rashid et al., 2003) and in other states of India (Alam et al., 2006).

Table 10. *Sources of technical information for the control of EFSB in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Source	Percentage of farmers			
	Bolpur	Illambazar	Sainthia	Mean
Pesticide sales agents	82	73	82	79
Neighbor	76	85	45	69
Relatives	32	12	24	23
Extension workers	44	15	3	21
Radio broadcast	0	6	9	5

Note: Some farmers were using more than one source of information to decide upon pest control practices

2.2.5 Health hazards

Most farmers (59%) covered their faces with a piece of cloth as a protective measure while applying pesticides and slightly fewer (52%) covered their body with clothing (Table 11). Nineteen percent covered both their body and face, while 8% farmers did not adopt any protection measures.

Table 11. *Protective measures adopted during pesticide application by farmers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Protective measure	Bolpur	Illambazar	Sainthia	Mean
Only face covered with cloth	32	45	42	40
Only body covered with cloth	41	36	21	33
Both body and face covered with cloth	24	15	18	19
No protection	3	3	18	8

2.2.6 Costs and benefits

The average cost of production of eggplant was Rs.94,000/ha (US$1 = Rs.44) and gross return was Rs.165,000/ha (Table 12). The average yield was 28.0 t/ha and the benefit-cost ratio was 1.76. Gross as well as net returns were highest in Sainthia in comparison with Bolpur and Illambazar. This is largely due to the higher yields in Sainthia. Eggplant cultivation in the study area was, thus, quite profitable. Being highly labor intensive and profitable, eggplant cultivation in this area should help generate employment, a chronic problem in countryside in West Bengal as well as much of India.

Table 12. *Economics of eggplant cultivation in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Item	Bolpur	Illambazar	Sainthia	Mean
Cost of cultivation (000 Rs./ha)	69	86	110	94
Gross return (000 Rs./ha)	101	164	191	165
Net return (000 Rs./ha)	32	78	81	71
Average cost of production (Rs./kg)	2.89	3.22	3.12	3.36
Average price received (Rs./kg)	4.77	4.46	5.46	4.91
Eggplant yield (t/ha)	23.9	26.7	35.3	28.0
Benefit-cost ratio	1.46	1.91	1.74	1.76

Yields in the survey area exceeded those of the national average, 16.1 t/ha (FAOSTAT data, 2006). All farmers in Sainthia exceeded the national average. Among all blocks, 40% of farmers obtained yields of 21–30 t/ha, 30% of farmers produced yields of 31–40 t/ha, 11% of farmers exceeded 40 t/ha (Table 13). In Sainthia, 28% of farmers exceeded 40 t/ha.

Table 13. *Yield distribution among eggplant growers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Yield (t/ha)	Bolpur	Illambazar	Sainthia	Mean
Less than 10	4	0	0	2
10 to 20	22	27	0	17
21 to 30	52	40	22	40
31 to 40	22	20	50	30
More than 40	0	13	28	11

2.2.7 Post-harvest handling and marketing

For disposal of pest-damaged eggplant fruits, which become visible readily during harvest, farmers used various methods. Most farmers (86%) preferred to feed such fruits to cattle (Table 14). Fifty-six percent of farmers sold the damaged fruits at the market, albeit at lower prices. Only 1% farmers burned the damaged fruits in field. Damaged fruits were also consumed by 47% of the farmers themselves.

For disposal of plant residues at the end of the season, 88% farmers used crop residue as fuel. Only 8% of them destroyed the residues in the field. IPM strategy requires proper disposal of damaged shoots and fruits, as well as plant residues after final harvest, or else these plant parts become sources of EFSB re-infestation.

Table 14. *Disposal practices of damaged eggplant fruits and crop residues among farmers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Item	Bolpur	Illambazar	Sainthia	Mean
Damaged fruits				
Sale in market	56	64	48	56
Self consumption	56	52	33	47
Use as cattle feed	88	76	94	86
Use as manure	71	39	30	47
Burning in field	0	3	0	1
Crop residue				
Fuel for household use	88	85	91	88
Stacked along bunds	18	9	21	16
Burning in field	9	6	9	8

On-farm grading of fruits is a common practice before marketing of eggplant. Grading of fruits was done by 92% of growers in the survey area (Table 15). Similarly, 89% of farmers sold their produce at the local market and 11% sold only on the farm itself. Wholesalers (72%) and farias (petty traders) (47%) were the most active intermediaries in the marketing channel. Direct selling to consumers was done by only 12% of farmers, while selling to beparis (professional large volume traders) and retailers was each done by 24% growers.

Being a winter crop in this part of West Bengal, nearly 75% of the harvest was sold between January and April. The volume of sale was relatively even during January to April: January (21%), February (22%), March (13%), and April (18%). During summer months, a traditional rice growing season, few farmers planted this crop due to heavy rains, which at times results in flooding and diseases such as bacterial wilt (*Ralstonia solanacearum*).

Table 15. *Marketing behavior of eggplant growers in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Percentage of farmers			
Activity	Bolpur	Illambazar	Sainthia	Mean
Grading				
Yes	92	94	90	92
No	8	6	10	8
Place of selling				
In local market	88	88	91	89
On farm	12	12	9	11
Marketing intermediaries[1]				
Wholesaler	71	76	70	72
Faria[2]	50	45	45	47
Retailer	24	21	27	24
Bepari[3]	21	27	24	24
Consumers	24	3	12	12
Commission agents	6	6	3	5

[1] Some farmers used more than one outlet to sell their produce
[2] Petty trader who purchases produce from growers in village or local market and sells to bepari
[3] Professional trader who purchases produce from growers at local markets and sells to retainers through commission agents

3 Pesticide Misuse and Adoption of IPM

Our current survey of pesticide use in West Bengal and similar surveys conducted in Gujarat and Uttar Pradesh States of India revealed that there is gross overuse of pesticides in combating EFSB (Alam et al., 2006). A similar survey conducted three years earlier in neighboring Bangladesh also revealed similar overuse of pesticides in protecting eggplant crops (Rashid et al., 2003).

Adoption of this IPM strategy requires withholding of pesticide use for as long as possible to allow native natural enemies, which were getting decimated by the excessive use of pesticides, to survive and flourish. These natural enemies in combination with sex pheromone, pre-planting sanitation, and prompt cutting of EFSB-damaged shoots, establish a natural balance between the pest and its natural enemies. Adoption of this IPM strategy, therefore, will require a drastic reduction in pesticide use.

In this study, we analyzed pesticide use patterns to determine the factors that led farmers to overuse these toxic chemicals. Simultaneously, we studied both IPM adopters and non-adopters to determine the factors that led some farmers to embrace IPM while others refused it in spite of its obvious advantages.

3.1 Analysis tools

3.1.1 Model I: Factors for misuse of pesticides

In order to identify the factors responsible for misuse of pesticide use, an ordinary least squares (OLS) model was used with misuse index as dependent variable. A composite index for misuse of pesticides for individual farmers was constructed modifying the technique given by Roy et al. (2000). The modification is required as this technique attaches equal weights to all the indicators, and does not reflect their relative importance. Thus, a weighted index was constructed assigning suitable weights to each indicator. The selection of indicators as well as assigning weights was devised after consultation with agricultural as well as social scientists including statisticians. In this study, the following indicators were considered while developing the misuse indices:

1. Number of pesticide applications
   Less or recommended number = 0; up to 25% excess = 1; up to 50% excess = 2; 50% or more excess = 3
2. Pesticide dose
   Less or recommended dose = 0; up to 25% excess = 1; up to 50% excess = 2; 50% or more excess = 3
3. Use of pheromone trap
   Full use = 0, partial use = 1; trial use = 2; no use = 3
4. Use of other IPM practices
   Use all = 0; use two or more but not all = 1; use one = 2; use none = 3

5. Timeliness of pesticide application
   Per government recommendations/no use = 0; delayed use until initial attack = 1; use without observing pests = 2; use after severe attack = 3

The composite index for i^{th} farmer was thus obtained as follows:

$$I_i = (w_j A_{ji})/\Sigma w_j$$

Where, I_i is the misuse index of i^{th} farmer; A_{ji} is score for the j^{th} indicator for i^{th} farmer, and w_j is the weight associated with j^{th} indicator. The weights (w_j's) were devised on a scale of 1 to 4 after consultation with the multidisciplinary research team.

A number of factors were hypothesized to affect pesticide misuse. These included the farmer's personal and household characteristics; availability of IPM components and alternative pest management technologies; awareness of negative effects of pesticides vis-à-vis IPM; decision maker's experiences and perceptions regarding the efficacy and efficiency of IPM components vis-à-vis pesticides; and other socio-economic factors such as land tenure status, availability of credit, trainings, and association with development organizations. A multiple linear regression equation (which turned out to provide the best fit) of the following type was estimated to identify the factors leading to misuse of pesticides in eggplant production.

3.1.2 Model II: Determinants of adoption of IPM

In order to identify the factors influencing adoption of IPM practices, a probit model was used. The dependent variable is dichotomous, taking a value of 1 if a farmer has used any of the IPM components, and 0 otherwise. A number of demographic, social, economic and biological factors were hypothesized to influence the adoption decision. These included the decision maker's personal and household characteristics; availability of IPM components and alternative pest management technologies; awareness about negative effects of pesticides; perceptions regarding usefulness, efficiency and convenience of IPM components vis-à-vis pesticides; and other social impediments. Most of these hypothesized factors were included in previous adoption studies. The original functional relationship was $Y_i^* = \beta_0 + \Sigma\beta_i X_{ij} + u_i$, where Y_i^* is not observed, i.e., a latent variable. We observed a dummy variable, Y_i, i.e., whether the respondent is using any IPM component or not, and defined it as:

$$Y_i = 1 \text{ if } Y_i^* > 0$$
$$= 0 \text{ otherwise}$$

The general form of the probit model is: $P_i^* = F(\beta'X) = 1/[\exp(-\beta'X)]$ (Maddala, 1989)

The marginal effects were computed using the equation $\delta P/\delta X_{ij} = \beta_j P_i(1 - P_i)$.

3.2 Results

3.2.1 Model I: Results of the OLS model

Results of the OLS model are presented in Table 16. The F-value for the OLS model is significant at less than the 1% level, implying that the specification of the model is good. The adjusted R^2 value is also very high. The results show that the coefficient for decision makers' age and landholding size are positive, indicating that the level of pesticide misuse is more in the case of aged farmers and those farmers having large farm sizes. These farmers are not much inclined to adopt IPM, which is a new strategy in the study area.

The probability for pesticide misuse decreases as farming experience and level of education increases. Greater awareness about IPM technologies as well as awareness about technological failures of chemical pesticides also reduce the level of pesticide misuse. As expected, IPM training and membership with a farmer organizations reduces the level of pesticide misuse.

We found a highly significant and negative relationship between availability of IPM inputs and level of pesticide misuse, i.e., pesticide misuse can substan-

Table 16. *Socio-economic determinants of pesticide misuse in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Explanatory variables	Coefficient	Level of significance
Constant	35.746	0.000
Age (years)	0.049	0.119
Education (years of schooling)	–0.211	0.014
Farming experience (years)	–0.163	0.006
Size of land holding (hectare)	0.504	0.044
Land tenure status[1]	–0.324	0.631
Members of society/organization[2]	–1.490	0.031
Awareness about IPM[3]	–2.810	0.018
Perception about profitability of IPM[4]	–2.220	0.068
Awareness about health impairment due to pesticides[3]	–1.185	0.134
Attended IPM training[5]	–1.148	0.006
Degree of crop damaged by ESFB (%)	–0.038	0.179
Availability of IPM inputs[6]	–18.286	0.000
Easy availability of pesticides[6]	3.008	0.006
Information sources about pesticides[7]	1.197	0.072
Received credit[8]	–1.032	0.031
Adjusted R^2	95.02	
F-Value	154.85	
No. of observations	130	

[1]Rated as 1 = owner/operator, 0 = otherwise; [2]Rated as 1 = member, 0 = not member; [3]Rated as 1 = aware, 0 = not aware; [4]Rated as 1 = profitable, 0 = otherwise; [5]Rated as 1 = attended, 0 = not attended; [6]Rated as 1 = available, 0 = not available; [7]Rated as 1 = pesticide dealer, 0 = otherwise; [8]Rated as 1 = received credit, 0 = otherwise.

tially be reduced if IPM inputs can be made available in the study area. This is as we expected. During the field survey, it was observed that farmers were ready to procure the pheromone trap and lure even at a premium price. We also found a significant negative relationship between farmers' access to institutional credit and pesticide misuse. However, easy availability of chemical pesticides and aggressive marketing strategies (importance of information from a pesticide agent) by the pesticide dealers/agents increases the level of pesticide misuse substantially.

3.2.2 Model II: Results of the probit model

Results of the probit model are presented in Table 17. The threshold coefficient is positive and significant at the 2% level, implying that there is no specification error in the model. The McFadden R^2 value, chi-squared value, and estimated value for the log-likelihood functions are indicative of a good fit for the model.

Table 17. *Socio-economic determinants of adoption of IPM strategy in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Ordered probit estimates		
Explanatory variables	Coefficient	Level of significance	Marginal effects
Constant	0.303	0.433	-
Threshold coefficient	0.563	0.021	-
Age (years)	–0.010	0.054	–0.001
Education (years of schooling)	0.001	0.374	0.001
Awareness about IPM[1]	0.189	0.033	0.006
Awareness about health impairment[1]	0.261	0.052	0.013
Size of holding (hectare)	–0.092	0.016	–0.001
Eggplant area (hectare)	0.266	0.235	0.048
Degree of crop damaged by ESFB (%)	0.096	0.041	0.004
Availability of IPM inputs[2]	0.532	0.009	0.005
Easy availability of pesticides[2]	–0.096	0.103	–0.009
Perception about IPM			
Convenient[3]	0.083	0.076	0.006
Useful[3]	–0.007	0.149	–0.001
Economic[3]	0.198	0.004	0.001
Price premium[3]	0.025	0.091	0.002
McFadden R^2	0.517		
Chi-squared	48.52		
Log-likelihood	–71.27		
P-Value	0.021		

[1] Rated as 1 = aware, 0 = not aware
[2] Rated as 1 = available, 0 = not available
[3] Rated as 1 = yes, 0 = no

The most significant factors promoting adoption of the IPM strategy to control EFSB were the perceived economic benefits, availability of IPM inputs, farmers' awareness about IPM, the degree of crop damage due to EFSB, and perceived negative externalities of pesticide use on health. Although less significant, other contributing factors were the convenience of the technology and the possible price premiums for pesticide-free produce.

The most significant factor hindering the adoption of IPM technology was the size of landholding. Other factors limiting adoption were the easy availability of pesticides and the age of the decision maker.

The eggplant production area and education level of the decision maker did not have a significant bearing on the adoption decision.

4 Impact Assessment

4.1 Introduction

Integrated pest management (IPM) is a significant improvement in the management of insect pests and diseases of crops. Despite its techno-economic superiority over conventional chemical control, the adoption of IPM has been limited to only 2% of cropland treated with plant protection inputs (Birthal and Sharma, 2004). There are a number of technological, social, economical, institutional and policy factors restricting the adoption of IPM. Therefore, in recent years, progressive incorporation of socio-economic issues is viewed as an important component in farm research, development, and extension processes worldwide.

It is expected that significant gains will ensue from the adoption of IPM. While it is difficult to estimate the full extent of such gains, it is expected that the adoption of IPM of EFSB being promoted through this project will not only reduce the pesticide content in eggplant but also increase the profitability of eggplant cultivation.

IPM technologies have multiple dimensions of impacts. It is therefore important to evaluate the impact of IPM technologies in this project on individual eggplant growers and consumers as a whole.

4.2 Methodology

The crux of impact evaluation is a comparison of what did happen after implementing the project with what would have happened had the project not been implemented (Mohr, 1992). This comparison is the impact of the project. It also explores unintended positive or negative consequences on beneficiaries. Analyzing socio-economic factors in absence of the project is clearly problematic because it cannot be observed directly. Therefore, one needs to compare the impact with another controlled situation with a similar baseline condition. Best practices prescribed by experts suggest a construction of a 'with and without' approach with a 'before and after' approach that uses baseline and follow-up data. Therefore both 'with and without' and 'before and after' approaches are followed in this study. Accordingly, the sample household constitutes both farmers who are adopting IPM ('adopters', 100 farmers) and farmers who have not adopted IPM ('non-adopters', 30 farmers) in the same villages.

Further, such a program can have multiple impacts and there are several tools to measure such impacts including benefit-cost ratio (BCR), discounted cash flow analysis, the economic surplus model, and the impact indicator approach. The selection of a particular tool is based on certain factors such as the type of technology, the stakeholders and their spatio-temporal adoption pattern, the way research and development are conducted, the legitimacy of using estimates of averages in place of distribution, the risk factor associated with the technology, and the stability of the benefits imputed to the technology. In this study, considering the above aspects, we have followed the impact indicator approach as well as the economic surplus model. The impact of IPM technology may have economic and social dimensions; the former relates to the potential for enhancing levels of yield, profit and price, while the latter is concerned with health, convenience, and perceptions. Adoption of IPM also helps in raising the awareness about modern farm technologies and related issues. The following indicators were considered for analysis in this study:

a. Increase in yield and percentage of EFSB-free eggplant fruits
b. Income augmentation (annual income)
c. Better price realization
d. Pesticide content in eggplant (number of pesticide applications)
e. Employment generation/labor cost
f. Change in cropping pattern/crop diversification
g. Change in perception toward IPM vis-à-vis non-IPM

4.3 Economic surplus model

The ex-ante impact analysis of agricultural technology is increasingly gaining importance now by many national and international institutions. Such an exercise is difficult and uncertain but helps the research-extension-development system before popularizing any technology. It builds on the body of knowledge gained from ex-post analysis of research, and also involves a more demanding prediction of expected effects on a speculative basis. Many impact assessment models have been proposed in the recent literature but few have been institutionalized into a decision making practice of national and international agricultural research systems.

The economic surplus model is one such tool having wide acceptance internationally, and thus, is used in this study. This model has the advantage of incorporating several criteria related to economic efficiency and distribution into one or two measures. However this method can be difficult to apply to a large number of commodities or areas because types of data necessary for such analysis are very large and often do not exist. Like any ex-ante analysis, this model incorporates expert opinions or crude estimates on expected research impacts (e.g., expected yield gain or expected price), adoption rates, demand and supply elasticities, and probabilities of success of the technology; and thus, the accuracy levels of the results are constrained by the availability of best estimates on the above items of observation.

In the economic surplus model, economic impacts (or returns to investment) are measured by the changes in consumer and producer surpluses that result from technological change. The approach recognizes the changes in costs of production, supplies and prices resulting from the technological change and consequently the changes in the welfare of consumers and producers. Consumer and producer surpluses are commonly used empirical measures of how much better (or worse) consumers or producers are when commodity prices are altered. Consumer surplus is defined as the area under the demand curve and above the price line. It represents a willingness to pay beyond what is actually paid. Producer surplus is defined as the area below the price line and above the supply curve. It measures the excess of gross receipts over total variable costs. These effects include both changes in the prices of the commodity as a result of changes in yields, and changes in economic welfare following altered patterns of consumption and production of that commodity. A graphical representation of the concept of the economic surplus model is shown in Fig. 3.

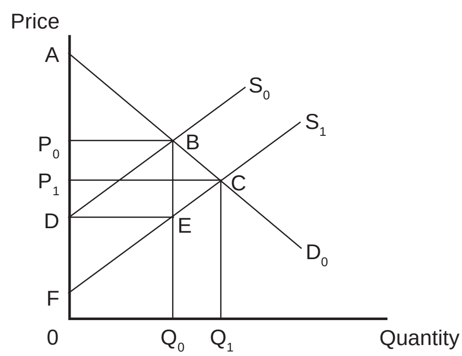

Fig. 3. *Effects of technological change on economic surplus*

This figure illustrates the effect of technological change on economic surplus. The supply curve with the original technology is S_0 and the demand curve is D_0. The corresponding equilibrium quantity and price are Q_0 and P_0, respectively. The consumer surplus in this case is ABP_0 and the producer surplus is $DBP_{0.}$ Adoption of the technology, which reduces the unit cost of production and increases the yield, shifts the supply curve rightwards from S_0 to S_1. This results in a new equilibrium quantity and price, i.e., Q_1 and P_1. The consumer surplus now is ACP_1 and the producer surplus is FCP_1. The consumer gains from the new technology because they can consume more at a lower price, and the producer gains because their unit cost of production is reduced due to increase in yield. The net social benefit or economic surplus is the sum of consumer and producer surplus. The size of this benefit depends on the elasticity of demand and the nature of supply shift, i.e., the functional form of the supply curve. In the case of IPM, the available literature provides little guidance on the nature of shifting supplies. Birthal (2003) suggests that one can expect a parallel shift in the supply curve in case of IPM in India. Therefore, assuming a parallel shift, change in consumer surplus (ΔCS), change in producer surplus (ΔPS), and change in economic surplus (ΔES) is calculated as follows:

$$\Delta CS = ACP_1 - ABP_0 = BCP_1P_0$$

$$\Delta PS = FCP_1 - DBP_0 = CEDP_1$$

$$\Delta ES = BCP_1P_0 + CEDP_1$$

Mathematically the surpluses are estimated using the following equations:

$$\Delta CS = P_0Q_0Z(1 + 0.5Z\eta)$$

Where, $Z = k\varepsilon/ (\varepsilon + \eta)$, ε is price elasticity of commodity supply, η is price elasticity of demand and k is the proportionate supply shift. The shift factor k is calculated as:

$$k = \{(Y/\varepsilon - C/(1 + Y)\}pA(1 - \delta)$$

Where, Y is the proportionate change in yield, C is the proportionate change in variable costs, A is the adoption rate for the technology, p is the probability of research success and δ is the annual rate of depreciation of the technology. However, in such evaluation, p and δ can be ignored (Birthal, 2003).

The change in producer surplus (ΔPS) is estimated as:

$$\Delta PS = (k - Z)\ P_0Q_0(1 + 0.5Z\eta)$$

The change in economic surplus (ΔES) is estimated as summing the change in consumer and producer surpluses:

$$\Delta ES = P_0Q_0k(1 + 0.5Z\eta)$$

Demand and supply elasticity parameters are crucial in the economic surplus model. The magnitude of demand elasticity largely depends on the income level of the consumer and his/her preferences for the commodity in the consumption basket. The magnitude for supply elasticity is dependent on the profitability of the commodity and the availability of land, among many other factors. In this study, estimates of demand and supply elasticity of vegetables have been taken from another relevant study conducted by the Indian Agricultural Research Institute (Kumar, 1998). This is a limitation of this study but perhaps the best possible solution given the non-availability of data.

The impact of this project is significant both in terms of reducing the cost of growing eggplant as well as in increasing returns from eggplant production. Growers who adopted IPM practices experienced increases of 4.7%, 34.0% and 53.8% in yield, percentage of pest-free fruit, and profit at nominal price, respectively (Table 18). However, for non-adopters there was no increase in yield and the returns regarding percentage of pest-free fruit and profit were less than those of adopters. Similarly, pest management expenses decreased 45.2% for adopter farmers while it increased 30.2% for non-adopters. Also, the labor requirement (human days/ha) decreased by 5.9% for adopters but increased by 1.2% for non-adopters.

Besides costs and returns, there are some structural impacts of IPM on changes in cropping patterns and pesticide usage. Adopters of IPM increased their production area by 21.6% while non-adopters reduced their production area by 8.7%. Farmers adopting IPM practices sprayed pesticides 52.6% less often than before; however, non-adopters sprayed 14.1% more often. The cropping intensity of adopters rose by 4.0% compared to only 1.0% for non-adopters.

Table 18. *Impact of IPM on eggplant production in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

	Before (2001–2003)		Present (2003–2005)		Change (%)	
Impact indicators	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter
Returns						
Yield (t/ha)	298	328	312	328	+4.7	0.0
Pest-free fruit (%)	53	56	71	57	+34.0	+1.8
Profit at nominal price (Rs./ha)	133,795	129,500	205,075	170,500	+53.8	+31.7
Costs						
Pesticide + IPM (Rs./ha)	22,754	14,870	12,460	19,363	–45.2	+30.2
Labor (human days/ha)	510	492	481	498	–5.9	+1.2
Others						
Eggplant area (% of cropland)	6.02	1.96	7.32	1.79	+21.6	–8.7
Pesticide sprays (no./season)	39.9	45.0	18.9	51.4	–52.6	+14.1
Cropping intensity (%)	164	168	168	169	+4.0	+1.0

All farmers adopting IPM technology agreed that the high cost of pesticide was a reason for adopting IPM. Other reasons stated by farmers for adopting IPM were convenience of IPM practices (stated by 91% of adopters), potential health hazards of pesticides (75%), and profitability of IPM strategy (71%) (Table 19). Similarly, reasons stated by non-adopters for rejecting IPM practices included no premium on price for IPM produce (100%), unavailability of traps and lures (100%), easy availability of pesticides (98%), and lack of training on IPM practices (13%).

Table 19. *Reasons for adoption or non-adoption of IPM in eggplant production in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Adopter		Non-adopter	
Incentive	(% farmers)	Constraint	(% farmers)
High cost of pesticide	100	No premium on price for IPM produce	100
Convenience of IPM practices	91	Unavailability of traps and lures	100
Potential health hazards of pesticides	75	Easy availability of pesticides	98
Profitability of IPM strategy	71	Lack of training on IPM practices	13

There has been a considerable change in perception about pest management practices among the eggplant growers. Nearly all (99%) of the adopters would like to continue using IPM practice next year and 73% of non-adopters plan on switching to IPM next year (Table 20). Adopters were satisfied with the IPM technology because it was very useful and efficient (99%), more convenient (98%), and increased profits (92%). Forty-eight percent of adopters expressed concern over health hazards related to pesticides and 10% of adopters expect there will be increased demand for pesticide-free eggplant in the near future.

Table 20. *Changes in perception regarding pest management practices in eggplant production among adopters and non-adopters of IPM in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Items	Percentage of farmers	
	Adopters	Non-adopters
Planning to adopt IPM next year	99	73
IPM practices are very useful/efficient	99	-
IPM use is more convenient	98	-
Profit increased due to IPM practices	92	-
IPM practices reduced health hazards	48	-
Predict increased demand for pesticide-free eggplant in near future	10	7

Ninety-four percent of IPM adopters reduced their use of pesticides; the remaining 6% used the same amount of pesticides as before (Table 21). In contrast, 53% of non-adopters increased their use of pesticides, with the remaining 47% using the same amount as before.

Table 21. *Changes in pesticide use in eggplant production among adopters and non-adopters of IPM in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India from 2001–2005*

Pesticide use	Percentage of farmers	
	Adopters	Non-adopters
Increased	0	53
Reduced	94	0
No change	6	47

4.4 Results of the economic surplus model

The results obtained from the economic surplus model, as described in the previous section, are presented in Table 22. Farm-level economic benefits of the IPM strategy are scaled up to the level of the study area (Birbhum District) by multiplying the per hectare benefit from the technology and the potential area on which it can be adopted, i.e., the area under eggplant in the district.

It is noteworthy that the size of economic surplus for adopting the IPM strategy in the study area is quite large, of which the producers gain a larger share compared to consumers in the total surplus generated. The internal rate of return and benefit-cost ratio values are also very high, indicating large potential economic impact of the IPM technology. Economic benefits of the IPM strategy appear to be attractive enough to induce farmers to adopt it.

Table 22. *Estimated economic impact of IPM control strategy for EFSB in Bolpur, Illambazar and Sainthia blocks of Birbhum District, West Bengal, India*

Measurement	Impact
Economic surplus (Rs. million)	325.77
Consumer surplus (%)	37
Producer surplus (%)	63
Benefit-cost ratio	2.78
Internal rate of return (%)	38

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Appendix

1 Questionnaire for field survey

Date of interview ______________________

Respondent ______________ District __________ Thana/Taluka __________

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. Farming experience
   Agricultural farming experience: ______ years
   Eggplant farming experience: ______ years

5. Total cultivated land: ______ ha
   Total cultivable vegetable land: ______ ha
   Total cultivated vegetable land: ______ ha
   Total eggplant cultivated land (2001): ______ ha
   (2002): ______ ha
   (2003): ______ ha

6. Eggplant variety cultivated: ____________
   Source of seeds: self / outside
   Source of seedlings: self / outside
   Date of transplanting: ____________

7. Land tenure status
   Owner-operated: ______ ha
   Rented in: ______ ha
   Mortgage in: ______ ha
   Rented out: ______ ha
   Mortgage out: ______ ha
   Other (specify) ______ ha ____________________________________

8. Labor force data:

Age	Persons (no.)	Level of education	Persons (no.)
Below 14 years	_____	Illiterate	_____
Between 15 to 59 years	_____	Primary	_____
Above 59 years	_____	Secondary	_____
		College and above	_____

9. Are you a member of any farmers' organization? Yes / No
   If yes, which farmers' organizations are you a member of? (✔)
   ______ Village panchayat
   ______ Farmers' association
   ______ Marketing co-operative society
   ______ Youth club
   ______ Thana/taluka panchayat
   ______ Village co-operative society
   ______ Milk co-operative society
   ______ Other

10. Have you attended any training on pest management? Yes / No
    If yes, what was the training about?
    Who organized the training?

11. What cropping pattern(s) do you follow? (✔)
    ______ Eggplant–eggplant
    ______ Eggplant–rice
    ______ Eggplant–wheat
    ______ Eggplant–potato
    ______ Eggplant–other vegetables
    ______ Eggplant–other crops

Pest management practices

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

13. 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?
    When do you think the damage is worst?

14. What percentage of your total eggplant production was damaged by EFSB during:
    2002: ______ %
    2003: ______ %

15. How did you control this pest? (✔)
    _______ Apply pesticide
    _______ Hand picking/shoot clipping
    _______ Other method(s), please specify: ______________________________

16. When did you take action to apply pesticides? (✔)
    _______ After severe attack
    _______ After initial attack
    _______ Without observing any insect
    _______ As per government recommendations
    _______ Schedule-based sprays
    _______ Not at all

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

	Crop stage	No. of application(s)	Pesticide name(s)	Qty. of pesticide (s)	Rationale
a)					
b)					
c)					
d)					
e)					

18. How many days apart were pesticide applications?
    _______ January _______ February _______ March
    _______ April _______ May _______ June
    _______ July _______ August _______ September
    _______ October _______ November _______ December

19. How many days after spraying did you wait before harvesting eggplant?
    _______ January _______ February _______ March
    _______ April _______ May _______ June
    _______ July _______ August _______ September
    _______ October _______ November _______ December

20. In general, estimate the percentage of damage reduced by the insecticides that you used (✔)
    _______ less than 25% _______ 50–75%
    _______ 25–50% _______ more than 75%

21. Do you have any idea about natural enemies of pests? Yes / No
    If yes, which of the following are useful? (show color photographs) (✔)
    _______ Larva of EFSB _______ Spider _______ Coccinelid beetle

22. 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 people and animal
    _______ Harmful to crops
    _______ Reduces profits

23. Was there any pesticide(s) which was not effective at all after spraying?
    Yes / No
    If yes, name the pesticide(s): ____

24. How do you spray pesticide(s)? (✔)
    _______ With sprayer machine
    _______ Other means (please specify): ________________________________

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

26. Do you smoke/chew tobacco? (Yes / No)
    If yes, when?
    _______ During spraying _______ Between spraying _______ After spraying

27. Do you wash your hands after spraying? Yes / No
    If yes, with: water only / use soap / use soil

28. Who sprays pesticides on your crop? (Yourself / Hired laborer)

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

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

31. Where do you purchase/collect pesticide(s)? ___________________________
    Do you pay cash or buy on credit? ____________________________________

32. Do you agree that applying pesticides to eggplant will boost up the yield?(✔)
    ______ Agree
    ______ Disagree
    ______ Not sure

33. 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 ______%
    ______ Co-operative society at an interest rate of ______%
    ______ Private source at an interest rate of ______%
    ______ Relative/friend at an interest rate of ______ %

34. What was your eggplant yield and market price for last season?
    ______ kg per ha, and sold at a price of ______ Tk or Rs./kg

35. How much money did you spend last season to cultivate eggplant? (Tk or Rs./ha)
    ______ Human labor
    ______ Machine power
    ______ Seed
    ______ Farmyard manure
    ______ Triple superphosphate
    ______ Muriate of potash
    ______ Liquid fertilizer/micronutrients
    ______ Growth regulators/hormones
    ______ Rental value of land
    ______ Animal labor
    ______ Sprayer machine
    ______ Cowdung /oil cake
    ______ Urea
    ______ Diammonium phosphate
    ______ Ammonium sulphate
    ______ Pesticides
    ______ Irrigation
    ______ Others (specify)________

36. What was the net return from eggplant cultivation last year? ____________ Tk/ Rs./ha

Post-harvest care/cleanup

37. How do you dispose of crop residue? (✔)
    ______ Stack along bunds. If yes, for how long? ________________
    ______ Use as fuel
    ______ Burn in field after drying

38. When do you plow the field after uprooting? (✔)
    ______ Immediately
    ______ After one week
    ______ After one month

39. How do you dispose of your damaged fruits? (✔)
   _______ Sell in the market   _______ Self consumption
   _______ Cattle feed   _______ Throw on bunds
   _______ Other

40. Do you provide advice to other farmers regarding eggplant cultivation? (Yes/No)

41. Do you grade the harvest (Yes / No)

42. Where do you sell your eggplant? (✔)
   _______ Farm sale
   _______ Local market sale
   _______ Other (please specify): ____

43. Types of intermediaries to whom you sell their eggplant (%):
   _______ Bepari
   _______ Faria
   _______ Wholesaler
   _______ Retailer
   _______ Commission Agent
   _______ Consumer

44. Monthwise sale of eggplant (kg):
   _______ January   _______ February   _______ March
   _______ April   _______ May   _______ June
   _______ July   _______ August   _______ September
   _______ October   _______ November   _______ December

45. Monthwise price received from eggplant (Tk/Rs./kg):
   _______ January   _______ February   _______ March
   _______ April   _______ May   _______ June
   _______ July   _______ August   _______ September
   _______ October   _______ November   _______ December

2 Questionnaire for impact assessment

Date of interview ______________________

Respondent __________________________

Village __________ Block __________ P.S. __________ District __________

1. Are you aware of IPM practice in brinjal? (Yes / No)
   If yes, did you adopt the same? (Yes / No)

   What are the reasons for adoption of non-adoption? (✔)

Adopters	Non-adopters
___ High cost of pesticides	___ Lack of awareness
___ Health hazards (potential)	___ Non-availability of trap
___ IPM brinjal fetch higher price	___ Non-availability of pheromone/lure
___ Profitable	___ Lack of training/extension on IPM
___ Convenient	___ Chemical pesticides are convenient/easily availaible
___ Others: ________________	___ Others: ________________

2. Where do you sell your brinjal and to whom?

3. Area under eggplant
   2–3 years before: _______ ha
   At present: _______ ha
   At present under IPM: _______ ha

4. Did you change your cropping pattern during the last 2–3 years? (Yes / No)
   Reason for your action (changing or not changing):

5. Please complete:

	Pattern and land area (ha)	
Season	2–3 years before	At present
Kharif		
Rabi		

6. What source of IPM do you use?
   a) Newspaper (Yes / No). If yes, state newspaper ______________________
   b) Magazine (Yes / No). If yes, state magazine ______________________
   c) TV (Yes / No). If yes, state program and channel ____________________
   d) Radio (Yes / No). If yes, state program and channel __________________
   e) Friends (Yes / No)
   f) Relatives (Yes / No)
   g) Pheromone and/or pesticide vendors (Yes / No)
   h) Others (Yes / No). If yes, please state ____________________________

7. Which of the following IPM components do you use: (✔)
   ______ Cutting damaged shoot
   ______ Pheromone
   ______ Withholding pesticide use despite some damage
   ______ Botanical or other bio-product. If yes, specify: ____________________
   ______ Sanitation (removal of old plant debris)
   ______ Others, specify: ____

8. For each pesticide used, please describe how you used it:

	2–3 years before				At present			
	Pesticide	Dose	Stage of crop	No. of applications	Pesticide	Dose	Stage of crop	No. of applications
a.								
b.								
c.								

9. Profit from eggplant in a year (Rs./ha)
   a) Before: ___________________ b) Now: ___________________

10. Are you getting a better price for pesticide residue-free products as compared to other products (Yes / No)

11. Do you feel IPM is:
    Convenient? (Yes / No) Useful? (Yes / No) Economic? (Yes / No)

12. What are your perceptions of IPM vis-à-vis chemical pesticide use?
    a) Do you think use of chemical pesticide is a must? (Yes / No)
    b) Do you think consumption of brinjal grown with pesticides is injurious to health? (Yes / No)
    c) Do you think over time, there will be a demand for pesticide-free brinjal in your locality? (Yes / No)

13. Will you continue to use IPM (Yes / No)
    Please state reason: ____

14. What was your source of: lure ________________ trap ________________
    What was the cost of: lure ________________ trap ________________

15. Please complete the following table:

Item	2–3 years before	At present
Yield of brinjal (qt/ha)		
Marketable fruit (%)		
Price received (Rs./kg)		
Labor use (no./ha)		
- Family labor		
- Hired labor		
Pesticide cost (Rs./ha)		
Cost of IPM (Rs./ha)		

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