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In collaboration with

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Data Analysis and Technical Assistance

International Food Policy Research Institute
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ACRONYMS

ADS	Automated Directive System
ANCOVA	Analysis of covariance
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APSU	Agricultural Policy Support Unit
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BFS	Bureau for Food Security
BIHS	Bangladesh Integrated Household Survey
BPH	Brown plant hopper
Bt	<i>Bacillus thuringiensis</i>
CAPI	Computer-assisted personal interviews
CARE	Cooperative for Assistance and Relief Everywhere, Inc.
CGIAR	Consultative Group on International Agricultural Research
CLAD	Censored least absolute deviations
DAE	Department of Agricultural Extension
DAM	Department of Agricultural Marketing
DATA	Data Analysis and Technical Assistance
DDL	Development Data Library
DID	Difference-in-differences
EC	Emulsifiable concentrate
EIQ	Environmental Impact Quotient
EIQ-FUR	EIQ Field Use Rating
EXTOXNET	Extension Toxicology Network
FSB	Fruit and shoot borer
FTF	Feed the Future
GH	Grasshopper
GHS	Globally Harmonized System
Gm	Gram
GM	Genetically modified
GMO	Genetically modified organism
GoB	Government of Bangladesh
GPS	Global positioning system

GR	Granule
Ha	Hectare
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IRIS	Integrated Risk Information System
ISD	Ishurdi
LR	Leaf roller
Mahyco	Maharashtra Hybrid Seeds Co. Pvt. Ltd.
ml	Milliliter
MOA	Ministry of Agriculture
MoP	Muriate of Potash
NARS	National Agricultural Research System
NCB	National Committee on Biosafety
NGO	Non-governmental organization
PIM	CGIAR Research Program on Policies, Institutions, and Markets
PRSSP	Policy Research and Strategy Support Program
PUTS	Pesticide Use Toxicity Score
RCT	Randomized controlled trial
RIDIE	Registry for International Development Impact Evaluations
SAAO	Sub-assistant agriculture officer
SC	Suspension concentrate
SG	Soluble liquid
SB	Stem borer
SP	Soluble powder formulation
Tk	Taka
TSP	Triple Super Phosphate
UAO	Upazila agriculture officer
USA	United States of America
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization
WG	Water (Dispersible) Granule

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EXECUTIVE SUMMARY

Background

This study examines the impact of genetically modified (GM) eggplant in Bangladesh. Eggplant, called brinjal in Bangladesh, is a high-value crop that is widely grown and consumed. Brinjal is highly vulnerable to fruit and shoot borer (FSB) pest. In response, farmers spray the crop heavily and repeatedly with highly toxic pesticides but with limited success. Over a 10-year period, public sector Bangladeshi agricultural researchers, with support from Maharashtra Hybrid Seeds Co. Pvt. Ltd. (Mahyco) and researchers based in the United States, have developed a series of GM varieties of Bt brinjal that are resistant to FSB. Extensive biosafety work has demonstrated that there are no significant differences between Bt brinjal and its non-GM counterparts (APAARI 2018). Following regulatory review, Bangladesh approved Bt brinjal for human consumption (APAARI 2018). Other studies suggest that these varieties convey higher yields with lower applications of pesticides.

The introduction of GM crops remains controversial in Bangladesh and globally. Frequent criticisms include claims that they are harmful to the environment, damaging to human health, and inaccessible to small farmers for cost or intellectual property reasons. It is also claimed that GM crops (including Bt brinjal) convey no yield benefits, with critics noting that much of the work on economic benefits was based on observational data rather than randomized controlled trials (RCTs). Furthermore, research on GM crops is perceived to be industry-influenced or biased in some way.

This study was designed to provide independent rigorous scientific information that could address some of these key criticisms. Specifically:

- (1) The treatment crop studied, BARI Bt brinjal-4, is an open pollinated variety.
- (2) Bt brinjal, like conventional brinjal varieties, can be grown on small plots, making its cultivation accessible to farmers with limited access to land.
- (3) The study was implemented as a randomized controlled trial with a pre-intervention baseline survey and a post-intervention endline survey. The comparison crop, ISD-006, is genetically identical to Bt brinjal-4 except it lacks the genetic construct containing a crystal protein gene (*Cry 1 Ac*), which produces an insecticidal protein that is toxic to FSB. Under the study, 1,200 farmers living in 200 villages were randomly selected to receive either seedlings of *Bt* brinjal-4 or non-*Bt* brinjal (ISD-006). The study does not suffer from attrition bias or imbalance between treatment and control groups.

(4) Implementation of the intervention was undertaken by the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE) under the Ministry of Agriculture. Both treatment and comparison groups received near-identical access to agricultural extension services. The only meaningful difference was that treatment farmers were informed that pesticides are not needed to control for FSB as Bt brinjal is resistant to this pest. Both treatment and comparison farmers received extensive training in the use of non-pesticide methods to control for pests.

(5) The intervention was evaluated by an independent, external group of researchers based both inside and outside Bangladesh. These researchers have no financial stake or other conflicts of interest associated with Bt brinjal.

Results

Impacts of growing Bt brinjal are:

(1) On pesticide use:

- 47 percent reduction in the cost of applying pesticides, equivalent to a reduction of Tk 7,196 (US\$85.53) per hectare (ha).¹
- 51 percent reduction in the number of pesticide applications.
- 39 percent reduction in the quantity of pesticides applied.
- 41 percent reduction in the toxicity of pesticides applied, as measured by the Pesticide Use Toxicity Score (PUTS).
- 56 percent reduction in environmental toxicity, as measured by the Field Use Environmental Impact Quotient (EIQ-FUR).

(2) On fruit and shoot borer (FSB) infestation:

- At baseline, 34.9 percent of all brinjal plants were infested by FSB for the treatment group, and 36.0 percent of all brinjal plants were infested by FSB for the control group.
- At endline, only 1.8 percent of all Bt brinjal plants grown by the treatment farmers were infested by FSB. In contrast, 33.9 percent of all ISD-006 brinjal plants grown by the control farmers were infested by FSB. This shows that Bt brinjal has been successful in repelling infestation by the FSB pest.

¹ The official exchange rate for the taka (Tk), the currency of Bangladesh, was Tk 84.13 per US\$1.00 on March 31, 2019.

(3) On yields, revenues, costs, and profits:

- Net yields (kilograms (kg) produced per ha of brinjal cultivated) were 42 percent higher, equivalent to a 3,622 kg per ha increase. Distributional statistics show that these increases were widespread. This increase occurs both because production is higher and because fewer fruit are discarded after harvest.
- A 31 percent reduction (per kg) in the cost of growing Bt brinjal. On a per ha basis, the cost of growing Bt brinjal was reduced by Tk 9,620. Most of this cost reduction results from reduced use of pesticides.
- An increase of 27.3 percent in gross revenues per ha.
- An increase of Tk 33,827 (approximately US\$400) per ha in net profits. This profit per hectare is 13.9 percent higher for Bt brinjal.

(4) On self-reported health impacts:

- Individuals in households growing Bt brinjal were 10 percentage points less likely to report symptoms consistent with pesticide exposure.
- Individuals in households growing Bt brinjal were 6.5 percentage points less likely to report that they needed to seek medical care for these symptoms.
- Both men and women from households growing Bt brinjal were less likely to report symptoms consistent with pesticide exposure.
- Reductions in reported symptoms were larger for individuals who, at baseline, reported symptoms related to chronic respiratory illnesses or skin disease.

1. INTRODUCTION

1.1 Background and Motivation

Brinjal (eggplant) is among the crops most heavily treated with pesticides in Bangladesh, largely due to its susceptibility to the fruit and shoot borer pest (FSB) and other secondary pests. Farmers spray their brinjal crop many times throughout a season to keep pests at bay and reduce yield losses, which have been reported to affect up to 86 percent of conventional brinjal (Ali, Ali, and Rahman 1980). Various studies in Bangladesh have found that brinjal farmers apply pesticides excessively, from 23 times to as many as 140 times per season (Rashid, Mohiuddin, and Mannan 2008; Dey 2010; Sabur and Molla 2001; Ahsanuzzaman and Zilberman 2018; Raza 2018). Further, numerous studies have found that very few farmers use protective measures during pesticide application, risking negative health effects (Sabur and Molla 2001; Rashid, Mohiuddin, and Mannan 2008; Dey 2010).

Bangladesh is the first South Asian country to approve commercial cultivation of a genetically modified (GM) food crop: brinjal spliced with a gene from the soil bacterium *Bacillus thuringiensis* (Bt). On October 28, 2013, Bangladesh's National Committee on Biosafety (NCB) approved cultivation of four indigenous varieties of Bt brinjal, which are resistant to attacks by the FSB, a common pest in South and Southeast Asia. According to scientists of the Bangladesh Agricultural Research Institute (BARI) who developed the four varieties, the protein in Bt brinjal disrupts the digestive systems of certain pests, causing them to die within three days of ingestion. The NCB approved Bt brinjal for use, stating that the GM crop would significantly reduce the need to use pesticides. In 2014, 20 farmers received seedlings of four varieties of Bt brinjal from the Ministry of Agriculture to grow on a trial basis (Shelton et al. 2018). In the following years, Bt brinjal adoption increased tremendously—reaching over 27,000 farmers in 2018 (Shelton et al. 2018).

Widespread adoption of productivity-enhancing technologies has shifted production, with economic and environmental effects. Agricultural technologies, such as the Bt brinjal technology, offer new opportunities that must be evaluated in an increasingly complex world. A number of factors influence the effect of new or improved agricultural technologies on production and consumption. These include the characteristics of the existing agricultural and market systems, the agroecological conditions, socioeconomic status, and sources of information about these technologies, as well as beliefs, norms, and cultural practices. Adoption of agricultural technologies has proven to be effective in improving food availability and food quality and responsive to environmental risks and uncertainties.

Upon request of the Ministry of Agriculture, the International Food Policy Research Institute (IFPRI) evaluated the impacts of the Bt brinjal technology on production systems, marketability, and health. In collaboration with BARI and the Department of Agricultural Extension (DAE), IFPRI conducted a Bt brinjal impact evaluation in selected districts of north-western Bangladesh. IFPRI has outstanding capacity to conduct rigorous and state-of-the-art impact evaluations, and has conducted numerous impact evaluations in Bangladesh and many countries in Asia, Africa, and Latin America.

IFPRI conducted the study under the ongoing Bangladesh Policy Research and Strategy Support Program (PRSSP) for Food Security and Agricultural Development, funded by the United States Agency for International Development (USAID) and implemented by IFPRI. PRSSP conducts applied research to fill knowledge gaps on critical food security and agricultural development issues in Bangladesh, and thereby facilitates evidence-based policy formulation and policy reforms to achieve the goal of sustainably reducing poverty and hunger.

1.2 Research on Bt Brinjal in Bangladesh

There is a growing body of evidence on the potential of Bt brinjal in Bangladesh.

In an ex ante study, Islam and Norton (2007) found positive economic benefits of cultivating Bt brinjal for 60 farmers in Narsingdi and Jamalpur Districts. The study estimated a 44.8 percent increased gross margin for Bt brinjal nationwide. Moreover, the study indicates that Bt brinjal may reduce insecticide costs by US\$36 per hectare (ha) and insecticide labor cost by \$34 per ha.² The total incremental benefit was \$1,930 per ha against an incremental cost of \$62 per ha, yielding a net benefit of \$1,868 per ha. The Islam and Norton (2007) findings are derived from a farmer survey.

Another study in 14 districts compared 74 Bt brinjal farmers and 30 non-Bt brinjal farmers during the 2014/15 winter season. The study documented various positive impacts of Bt brinjal. For conventional brinjal, pesticide costs were approximately four times higher (Tk 34,298³ per ha for conventional brinjal versus Tk 9,046 for Bt brinjal), total costs of production were significantly higher (Tk 219,090 per ha for Bt brinjal versus Tk 297,526 per ha for conventional brinjal), and yields were lower. BARI Bt brinjal-2 gave the highest yield (Tk 29.51 per ha), followed by BARI Bt brinjal-4 (Tk 23.37 per ha) and BARI

² All dollar figures in the text refer to US dollars.

³ The official exchange rate for the taka (Tk), the currency of Bangladesh, was Tk 84.13 per US\$1.00 on March 31, 2019.

Bt brinjal-3 (Tk 20.48 per ha). Moreover, Bt brinjal net returns were Tk 166,980 per ha compared to Tk 33,089 per ha for non-Bt brinjal (five times larger for Bt brinjal farmers).⁴

A subsequent study by Rashid, Hasan, and Matin (2018) assessed the impacts of four varieties of Bt brinjal during the 2016/17 winter season in 105 villages in 35 districts among 505 Bt brinjal farmers and 350 farmers growing conventional brinjal. The study reinforced many of the positive impacts documented in Rashid's prior study. Net returns were Tk 179,602 per ha for Bt brinjal versus Tk 29,841 per ha for conventional brinjal (six times larger for Bt brinjal farmers). Pesticide costs for conventional brinjal were more than three times higher than Bt brinjal. Treatment farmers growing Bt brinjal experienced minimal losses from FSB infestation and received higher net returns compared to control farmers. Infestation by FSB averaged 2 percent in Bt brinjal compared to 49.4 percent in conventional brinjal, and pesticide use dropped. All Bt brinjal farmers and 86 percent of farmers growing conventional brinjal wanted to cultivate Bt brinjal the next year.

Prodhan et al. (2018) conducted a two-year study on a research farm, which compared the impacts of four Bt brinjal varieties and conventional brinjal. The study found a 0–2 percent fruit infestation of FSB among the Bt brinjal varieties versus a 36–45 percent infestation in conventional brinjal varieties. The study also found that Bt brinjal had no impact on non-target beneficial insects. In both years, Bt brinjal varieties consistently had higher gross margins than conventional varieties, regardless of whether they were sprayed or not. The difference in gross return per ha varied between Bt brinjal lines and their non-Bt counterparts but was significant. For example, the return for non-sprayed Bt-2 was \$4,534.50 as opposed to its non-sprayed counterpart of \$951.39—a 4.8-fold difference.

Collectively, these four studies in Bangladesh suggest that Bt brinjal provides excellent control of FSB, provides a better return (about a 5- to 6-fold return), and dramatically reduces farmers' use of pesticides. Ongoing research continues to build strong evidence on the potential benefits of Bt brinjal for rural Bangladeshi farmers.

1.3 Development of the Study

IFPRI-PRSSP developed an initial concept note for a Bt brinjal impact evaluation in the Feed the Future (FTF) zone of influence in south-western Bangladesh, and submitted the concept note to USAID in January 2015. Based on this initial design, USAID decided to fund the evaluation research. In April 2015, IFPRI gave a presentation at BARI and

⁴ These data come from an unpublished 2014 BARI report by Rashid et al. Tony Shelton (personal communication) provided these details.

explained the Bt brinjal impact evaluation design to scientists involved in Bt brinjal research and promotion. BARI, an autonomous organization under the Ministry of Agriculture that is responsible for Bt brinjal research, and IFPRI agreed to conduct the Bt brinjal study jointly. The Ministry of Agriculture agreed to provide funding through BARI for Bt brinjal seed production, other inputs, and farmers' training.

IFPRI conducted field visits and interviewed key informants to validate assumptions before study implementation. During a scoping visit to the FTF zone, the IFPRI team learned that brinjal cultivation in the FTF zone primarily takes place in the summer season. BARI scientists were concerned about growing Bt brinjal during the summer because the available Bt brinjal varieties were developed for winter cultivation. Therefore, BARI advised IFPRI to relocate the study from the south-western to the north-western region, where winter cultivation of brinjal is more prevalent.

In April 2017, IFPRI went on a second scoping visit to assess the feasibility of conducting the study in the north-western region. IFPRI learned that there is a higher concentration of farmers growing brinjal during the winter in that region. So, IFPRI and its partners decided to implement the study for winter cultivation of Bt brinjal in four north-western districts—that is, Bogura, Gaibandha, Naogaon, and Rangpur Districts.

1.4 Objectives of the Study

The Bt brinjal impact evaluation is designed to provide a thorough understanding of the impact of uptake and adoption of the Bt brinjal technology among Bangladeshi farmers, mimicking as much as possible the real-world context of a roll-out. To this end, this study aimed to provide important insights regarding the efficacy of this new technology, based on which the Ministry of Agriculture may guide its future implementation strategy. The results of the study will also be useful for various other stakeholders such as scientists at the National Agricultural Research System (NARS), policymakers, USAID, the media, and civil society in Bangladesh. The study had the following specific objectives:

1. Estimate, using a rigorous impact evaluation, the impact of farmers growing Bt brinjal on key outcomes:
 - a. Use of pesticide for brinjal cultivation
 - b. Brinjal yields
 - c. Cost of production
 - d. Net crop income
 - e. Human health outcomes

2. Document and disseminate results and lessons learned from the study.

Appendix A provides the scope of work for this study.

1.5 Research Questions

IFPRI used quantitative and qualitative data to address the following research questions:

Production

1. Does the cultivation of Bt brinjal change the quantity of pesticides applied to brinjal? (Yes/No). How large is this change?
2. Does the cultivation of Bt brinjal change the frequency with which pesticides are applied to brinjal? (Yes/No). How large is this change?
3. Does the cultivation of Bt brinjal change the cost of applying pesticides to brinjal? (Yes/No). How large is this change?
4. Does the cultivation of Bt brinjal change the prevalence of secondary insect infestations? (Yes/No). How large is this change?
5. Does the cultivation of Bt brinjal change the amount of labor used to produce brinjal? (Yes/No). How large is this change? If this change occurs, does it reflect a change in the use of hired labor (Yes/No; how large is the change) or family labor (Yes/No; how large is the change)? If family labor changes, who in the family changes their labor supply and by how much?
6. Does the cultivation of Bt brinjal change other production practices? (Yes/No). If so, what are those changes?
7. Does the cultivation of Bt brinjal change other costs associated with brinjal production (not pesticides or labor)? (Yes/No). What costs change? How large is this change?
8. Does the cultivation of Bt brinjal change the amount of brinjal produced? (Yes/No). How large is this change?
9. Does the cultivation of Bt brinjal change brinjal yields (that is, production/area cultivated)? (Yes/No). How large is this change?
10. Why do these changes occur? Are they observed uniformly across the sample or are they associated with specific farmer or locational characteristics?

Marketing

11. Compared to conventional varieties, is Bt brinjal easier or more difficult to sell in local markets? Why?
12. Has the introduction of Bt brinjal brought new traders into local markets for brinjal? If so, who are these individuals? Have other traders left these markets?

13. Is Bt brinjal sold at a different price compared to conventional brinjal? (Yes/No). Is this a higher or lower price? How large is the price differential? Is this a constant price differential or does it vary? If it varies, by how much and why?
14. How do farmers' experiences in marketing Bt brinjal compare to marketing conventional brinjal? What factors affect these experiences?

Income

15. Does the cultivation of Bt brinjal cause gross revenues from brinjal production (total production x price received) to change? How large is this change?
16. Does the cultivation of Bt brinjal cause net revenues from brinjal production (gross revenues minus all costs) to change? How large is this change?
17. If changes in gross or net revenues occur, what accounts for these? Changes in revenues, in costs, or some combination of these?

Health

18. Does the cultivation of Bt brinjal reduce household self-reports of symptoms consistent with pesticide exposure? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?
19. Does the cultivation of Bt brinjal reduce the number of days that household members are too ill to work? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?
20. Does the cultivation of Bt brinjal change healthcare and expenditures related to healthcare? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?

2. RESEARCH DESIGN

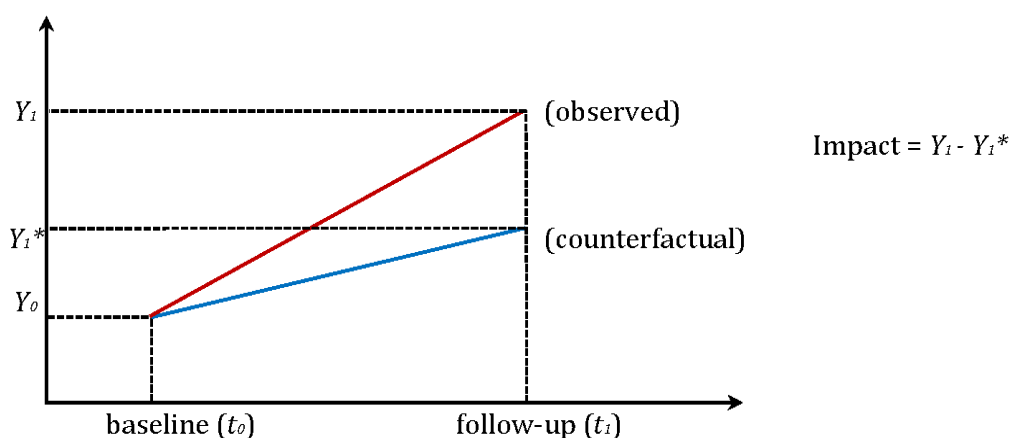
2.1 Designing an Impact Evaluation: An Overview

The purpose of an impact evaluation is to compare outcomes for beneficiaries in a particular program (observed outcomes) with the beneficiaries' outcomes had they not participated in the program (counterfactual outcomes). The difference between the observed outcomes for beneficiaries and the counterfactual outcomes represent the causal impact of the program. The fundamental challenge of an impact evaluation is that it is not possible to observe exactly the same beneficiaries both participating in the program and not participating in the program at exactly the same time; therefore, the counterfactual outcomes for beneficiaries are unknown. All evaluation strategies are designed to find a method for constructing a proxy for these counterfactual outcomes.

Most evaluations measure counterfactual outcomes for beneficiaries by constructing a comparison group of similar households from among non-beneficiaries. Collecting data on this comparison group makes it possible to observe changes in outcomes for people not participating in the program and to control for other factors that affect outcomes, which reduces bias in the impact estimates.

Figure 2.1 shows how information on a comparison group can be used to measure program impact by removing the counterfactual from the observed outcome for beneficiaries. In the figure, the outcome variable is represented on the Y axis, and time is represented on the X axis. A household survey is conducted to measure the outcome in two periods: the baseline at t_0 and the follow-up at t_1 . In the figure, at baseline the average outcome for both the households benefiting from the program and those in the comparison group is at the level of Y_0 . After the program is completed, the follow-up survey (t_1) demonstrates that the group participating in the program has an outcome level of Y_1 , while the comparison group has an outcome level of Y^*_1 . The impact of the program is measured as $Y_1 - Y^*_1$. If a comparison group had not been included, the impact might have been misrepresented (and overstated) as the observed change in the outcome for the beneficiary group: $Y_1 - Y_0$.

Figure 2.1 Measuring impact based on outcomes from beneficiary and comparison groups



Source: Constructed by authors.

In constructing a comparison group for the evaluation, it is important to ensure that the group is as similar as possible to the program group before the start of the program. To understand why, consider estimating the impact of introducing a new agricultural technology among smallholder farmers on rice yields as the difference in average rice yields between beneficiaries and a random sample of non-beneficiary farmers. The problem with this approach is that non-beneficiaries may be different from program beneficiaries in ways that make them an ineffective comparison group. If the evaluation does not control for these differences prior to initiating the program, impact estimates will be biased. The most common sources of bias are targeting or program placement bias and bias due to self-selection by beneficiaries concerning the decision to participate.

2.2 Evaluation Methods

A randomized controlled trial (RCT) was used to quantitatively measure the impact of the introduction of Bt brinjal among a study population. Qualitative research methods complemented the quantitative study.

RCTs are widely considered to be the most rigorous approach to constructing a comparison group for an evaluation. The method involves designing a field experiment by random assignment of the program among comparably eligible communities or households. Those that are randomly selected out of the program form a control group, while those selected for the program are the treatment group. When an RCT is properly implemented, differences in outcomes between the treatment and control groups should be free of bias and can reliably be interpreted as causal impacts of the program. The logic is that, because assignment of the program is randomly determined and not correlated with the outcome variables, differences in outcomes over time between randomly selected treatment and control groups must be a result of the program.

RCT estimates are further strengthened by measuring outcome variables for treatment and comparison groups before and after the program begins. This makes it possible to construct “difference-in-differences” (DID) estimates of program impact, defined as the average change in the outcome in the treatment group, T , minus the average change in the outcome in the comparison group, C . Mathematically, this is expressed as:

$$\Delta_{DID}^{ATT} = (y_1^T - y_0^T) - (y_1^C - y_0^C)$$

The main strength of DID estimates of program impact is that they remove the effect of any unobserved variables that represent persistent (time-invariant) differences between the treatment and comparison group. This helps to control for the fixed component of various contextual differences between treatment and comparison groups, including depth of markets, agro-climatic conditions, and any persistent differences in infrastructure development. As a result, DID estimates can lead to a substantial reduction in selection bias of estimated program impacts.

2.3 Method Used for Estimating Impacts of the Bt Brinjal Technology

IFPRI’s impact estimation strategy for the Bt brinjal impact evaluation relied on the clustered RCT design of the evaluation. Random assignment of clusters (villages) assured that, on average, farm households had similar baseline characteristics across treatment and control groups. Such a design eliminates systematic differences between treatment and control households and minimizes the risk of bias in the impact estimates due to “selection effects” (Hidrobo et al. 2014).

Analysis of Covariance (ANCOVA) regression was used to estimate impacts of the Bt brinjal technology using the longitudinal data on treatment and control households. The ANCOVA specification allows a household’s outcome at follow-up to depend on the same household’s outcome at baseline, as well as on the household’s treatment status and an error term (accounting for any omitted observable or unobservable factors). In case of high variability and low autocorrelation of the data at baseline and follow-up, ANCOVA estimates are preferred over DID estimates (McKenzie 2012). Intuitively, if autocorrelation is low, then DID estimates will over-correct for baseline imbalances. ANCOVA estimates, on the other hand, will adjust for baseline imbalances according to the degree of correlation between baseline and follow-up, as the specification allows estimating autocorrelation rather than imposing it to be unity. The ANCOVA model that was estimated is below:

$$Y_h = \alpha + \beta T_h + \gamma Y_{h,base} + \varepsilon_h$$

where α is a scalar, Y_h is the outcome of interest (for example, Bt brinjal yields) for farm household h at follow-up, and $Y_{h,base}$ is the outcome of interest at baseline. T is an indicator for whether household h is in the treatment group (treatment = 1, control = 0), β is the ANCOVA impact estimator, and ε_h is an error term. In other words, β represents the amount of change in outcome, Y , which is due to household h being assigned to the treatment group. To test whether the ANCOVA impact estimator is statistically different for the treatment group, Wald tests of equality are conducted and p-values are reported.

The randomization of treatment status, the selection of farmers based on their willingness to grow Bt brinjal and the use of the ANCOVA estimator collectively ensure that changes in outcome variables can be ascribed to the application of Bt brinjal.

Throughout the report, for outcomes where two rounds of data can be used, the “base” ANCOVA specification above is estimated, with standard errors adjusted for clustering at the village level, and an “extended” ANCOVA specification. The extended specification includes additional baseline covariates to improve precision and further address any baseline imbalances between arms. A parsimonious list of baseline covariates for the extended specification was selected, roughly following two criteria (Bruhn and McKenzie 2009): (1) we believe the covariates “matter” for our outcomes of interest, meaning they are likely to be significantly associated with key outcomes; and (2) differences in the baseline covariates between intervention arms appear “large.” Also, baseline covariates with non-missing values in the data were selected so that including them does not drop household observations from the estimation. The final list of baseline covariates included in the extended specifications is as follows: age, years of education of household head, number of years worked as a farmer or person with primary responsibility for brinjal production, wealth index, and land operated (acres) at baseline.

The robustness of the findings was assessed by comparing results from the basic model, the extended model, winsorizing (this deals with outliers in the outcome variable by setting the values of the bottom two percentiles equal to the second percentile and by setting the values of the top two percentiles equal to the 98th percentile), and by taking the log of the dependent variable (taking the log reduces the influence of outliers on the impact estimates).

All data were aggregated at the household-level. The statistical software STATA 15.1 was used for analyzing the survey data.

2.4 Selection of Study Area

BARI's Bt brinjal varieties are best suited for winter cultivation, with sowing of seeds beginning in September/October and transplanting seedlings in November; therefore, the study aimed to concentrate on localities where farmers predominantly cultivate brinjal in the winter (*Rabi*) season. Further, given the research interest in assessing Bt brinjal as a cash crop (rather than one simply for home consumption), these localities had to be characterized by good physical infrastructure and well-functioning markets for brinjal.

DAE officials provided IFPRI with lists of villages, by upazilas (sub-districts), in the selected districts where brinjal is cultivated predominantly in the winter season and with the number of brinjal farmers in each village. Using these lists, 10 upazilas with a high concentration of villages with a substantial number of brinjal farmers were purposively selected. Table 2.1 provides the list of the selected upazilas for the Bt brinjal impact evaluation.

Table 2.1 List of study districts and upazilas

District	Upazila
Bogura	Shahjahanpur
Gaibandha	Gaibandha Sadar Palashbari Gobindaganj
Naogaon	Dhamoirhat Manda
Rangpur	Pirgachha Pirganj Mithapukur Gangachara

Source: Constructed by authors.

2.5 Sample Size Calculations

2.5.1 Overview

It is important to ensure that the sample size is sufficiently large for treatment impacts to be feasibly detected in the outcomes of interest. While increasing sample size requires devoting additional resources, having too small a sample can lead to data that is insufficient to serve the purpose of the evaluation. If the sample is too small, even a substantial treatment impact in a key outcome may be indistinguishable from inherent variability in the outcome.

The role of sample size calculations is to formally analyze what study designs will allow sufficient power to detect a specified minimum change in a given outcome. These calculations can also be used to consider implications of known limitations in study design. For example, if there are specific constraints on sample size (for example, for practical/logistical reasons), the minimum detectable effect in each outcome can be calculated, given the constraints. If the minimum detectable effect in a particular outcome is unreasonably large to expect as a treatment impact, this insight can then guide the choice of outcomes considered to be the focus of the study, which can in turn guide the research questions that are posed and shape the design of the survey questionnaire. To summarize—and to be clear on this point—sample size calculations do not indicate what the sample size must be. Rather, they indicate what magnitude of effects we can reasonably expect to observe, given the design of the intervention.

2.6 Sample Size Calculations for the Bt Brinjal Impact Evaluation

The sample size needed for the Bt brinjal impact evaluation depended on several factors: (1) the outcomes that are of the greatest interest to researchers and program managers; (2) the minimum size of change in those outcomes that researchers would like to observe; (3) the degree of variability in those outcomes; (4) the extent to which there is correlation in outcomes within localities; (5) the desired level of statistical power; and (6) the level of desired statistical significance. Sample sizes increase with reductions in the size of change that the evaluation is attempting to uncover, greater variability in outcomes, increased correlation of outcomes, and higher statistical power.

In the context of the Bt brinjal impact evaluation, the calculations also accounted for treatment being cluster randomized at the village-level. In sample size calculations for cluster-randomized studies, not only the number of households and the number of clusters matter, but also the inherent similarity of households within a cluster. The

measure that captures this similarity for each outcome is referred to as its "intra-cluster correlation"—that is, in the absence of any treatment, a measure of the extent to which the outcome varies across households within a cluster relative to how much it varies across clusters.

The value of the intra-cluster correlation for any outcome is likely to depend on the context of the data. Since it is necessary to conduct sample size calculations prior to collecting the data, the accepted approach to estimating intra-cluster correlations for sample size calculations is to use values calculated from existing comparable datasets.

For the Bt brinjal impact evaluation, parameters were derived from IFPRI's 2011–2012 nationally representative IFPRI survey, the Bangladesh Integrated Household Survey (BIHS).⁵ Brinjal yields per ha and total cost of pesticide use per ha were used as the outcome indicators. BARI officials stated that the cost of pesticides is a major cost of brinjal production, and FSB infestation causes considerable loss in brinjal production, resulting in a significant reduction in brinjal yields.

The standard practice of calculating the sample size was followed that, given the expected change in the selected outcome indicators, would provide an 80 percent chance (the power of the test) of correctly rejecting the null hypothesis that no change occurred, with a 0.05 level of significance.

The estimated necessary minimum sample size is reported in Table 2.2. For example, to detect a minimum, statistically significant increase in brinjal yields per ha of 30 percent between treatment and control groups, a minimum total sample size of 180 clusters (villages) and 1,046 farm households are required, with 523 farm households for the treatment group and 523 households for the control group. For reduction of pesticide cost per ha as an outcome indicator, 187 clusters and 1,120 farm households (560 treatment and 560 control households) are required to detect a minimum of 40 percent reduction in pesticide costs.

A sample size large enough to assess both impacts (that is, at least 1,120 farm households) and allow for the possibility that some households may drop out between baseline and endline is necessary. Therefore, for the Bt brinjal impact evaluation, 200 clusters/villages (100 treatment and 100 control villages) and 1,200 farm households (600 treatment and 600 control households) were used. Each cluster included six farm households.

⁵ Dataset: Ahmed, A.U. 2013. "Bangladesh Integrated Household Survey (BIHS) 2011-2012", <http://hdl.handle.net/1902.1/21266> UNF:5:p7oXR2unpeVoD/8a48PcVA== International Food Policy Research Institute [Distributor] V3 [Version]

Table 2.2 Minimum sample size required for detecting changes in selected outcome indicators

Indicators	Minimum impact	Required number of clusters	Required number of farm households		
			Treatment	Control	Total
Brinjal yield per ha	An increase of 25%	281	701	701	1,402
Brinjal yield per ha	An increase of 30%	180	523	523	1,046
Pesticide cost per ha	A reduction of 35%	250	731	731	1,462
Pesticide cost per ha	A reduction of 40%	187	560	560	1,120

Source: Calculated using data from the IFPRI Bangladesh Integrated Household Survey, 2011–2012.

2.6.1 Selecting Treatment and Control Groups

The sampling process for the treatment and the control groups included the following steps:

- As previously noted in Section 2.5, study areas were selected based on (1) winter (*Rabi*) brinjal cultivation, with planting of seeds beginning in September/October (*Ashwin/Kartik* month of the Bangla calendar), (2) localities characterized by good physical infrastructure, and (3) well-functioning markets for brinjal. In consultation with officials from BARI and DAE, four districts were identified that satisfy these criteria: Bogura, Gaibandha, Naogaon, and Rangpur. Consideration was given to balancing the value of surveying a diverse set of localities with the practicalities of ensuring timely delivery of Bt brinjal seeds prior to the start of the planting season.
- DAE officials in the four selected districts provided IFPRI with lists of villages, by upazila, where brinjal is cultivated predominantly in the winter season and with the number of brinjal farmers in each village. Using these lists, upazilas with a high concentration of “brinjal” villages were purposively selected, defined as having at least 15 brinjal farmers per village.
- A list was compiled of villages within these upazilas where there were at least 15 brinjal farmers.
- From this list, 100 villages were randomly assigned to the treatment group and 100 villages to the control group (200 villages selected).
- A 100 percent census of the 100 selected treatment villages and the 100 selected control villages was conducted, and all brinjal farmers from the village census were listed.
- From the census list of brinjal farmers of the selected treatment and control villages, farmers who were willing to grow Bt brinjal-4 and farmers willing to grow non-Bt

- brinjal (ISD-006) on 10-decimal (0.10 acre or 0.04 ha) plots during the planting season beginning in November 2017 were identified. This selection criteria ensured that farmers selected for the study have similar attributes in terms of interest and willingness to grow Bt brinjal.
- Six farmers were randomly selected from each of the treatment and control villages and confirmed their participation in the study (1,200 male brinjal farmers selected).

2.7 Limitations of the Bt Brinjal Impact Evaluation Study

All impact studies face challenges and have limitations. Here, salient examples of the limitations faced during this study are described:

- Some upazilas in the north experienced flash floods during the study period. Study farmers in the flood-affected areas had to replant their brinjal seedlings. As a result, the replanting took place after the optimal period of planting brinjal crops (September-October), which lowered brinjal yields. Note, however, that this will have affected both control and treatment brinjal farmers.
- The weather during the study period was colder than the usual winter season and was marked by sporadic spells of very low temperatures. This delayed the flowering of the brinjal plants, ultimately lowering crop yields. Bt brinjal yields observed in this study were lower than yields reported in other studies, such as Prodhon et al. (2018). Again, this will have affected both control and treatment brinjal farmers.
- Brinjal prices plummeted in the market during the study period. Hence, the combination of lower yields and low prices resulted in lower revenue and profits compared to what was reported in other studies.
- The Bt brinjal impact evaluation study is an RCT; therefore, the study outcomes may deviate from the real-world setting—an issue of external validity. For example, under this study, the intensity and quality of training and attention received by the agricultural extension officials, referred to as sub-assistant agriculture officers (SAAOs), may not be maintained as Bt brinjal is scaled up. SAAOs closely monitored both treatment and control farmers to see that they were following the instructions on better production practices meticulously, including maintaining a refuge border in the case of the treatment farmers. At scale, it is not clear whether such monitoring can be maintained. Potential strategies to address this issue for sustainability are briefly discussed in Section 10 of this report.

3. DATA COLLECTION METHODOLOGY

The information collection approach used to evaluate the Bt brinjal impact evaluation combined quantitative surveys and qualitative semi-structured key informant interviews and focus group discussions. This mixed methods approach provided a rich pool of data and powerful analysis that would not have been available using any of these methods on their own. Gender-disaggregated information was collected for individual household members.

The required quantitative data for the impact evaluation came from two household surveys. A baseline survey was carried out from November 25 to December 13, 2017, and an endline survey was conducted from July 4 to 17, 2018. The surveys included farm households cultivating Bt brinjal (treatment) and conventional brinjal (control).

The qualitative data came from nine focus group discussions with Bt brinjal farmers, nine key informant interviews with concerned DAE officials, and nine key informant interviews with market traders operating in these villages.

3.1 Baseline and Endline Surveys

3.1.1 Survey Questionnaires

The Bt brinjal survey questionnaires included modules that, together, provide an integrated data platform to answer the research questions. The Bt brinjal baseline survey questionnaire served as the basis for the endline survey questionnaire design. Although the survey questionnaires remained relatively consistent between the two survey rounds, there were some modifications to the survey instruments between baseline and endline. For instance, data on assets, personal history and sense of agency, and savings were only collected at baseline. On the other hand, data on shocks affecting brinjal production and program participation were only collected at endline. Table 3.1 summarizes the survey modules in the baseline and endline questionnaires. Appendix B features the combined baseline and endline survey questionnaire.

Table 3.1 List of survey modules in baseline and endline surveys

Name of the Module	Baseline Survey (Nov-Dec 2017)	Endline Survey (July-Aug 2018)
Module A: Sample Household and Identification	INCLUDED	INCLUDED
Module B: Household Composition and Education	INCLUDED	INCLUDED
Module C: Health	--	--
<i>C1: General health questions</i>	INCLUDED	INCLUDED
<i>C2: Health status during crop growing season(s)</i>	INCLUDED	INCLUDED
Module D: Assets	--	--
<i>D1: Current household assets</i>	INCLUDED	NOT INCLUDED
<i>D2: Agricultural implements and other productive assets</i>	INCLUDED	NOT INCLUDED
<i>D3: Housing, water and sanitation</i>	INCLUDED	NOT INCLUDED
Module E: Savings	INCLUDED	NOT INCLUDED
Module F: Loans	INCLUDED	INCLUDED
Module G: Roster of land and pond/water bodies owned or under operation	INCLUDED	INCLUDED
Module H: Brinjal Production	--	--
<i>H1: Seedling/seedbed production and planting</i>	INCLUDED	INCLUDED
<i>H2: Area planted and irrigation</i>	INCLUDED	INCLUDED
<i>H3: Usage of fertilizers</i>	INCLUDED	INCLUDED
<i>H4: Pesticide usage</i>	INCLUDED	INCLUDED
<i>H5: Pest infestation</i>	INCLUDED	INCLUDED
<i>H6: Use of tools, machinery and draft animals for brinjal</i>	INCLUDED	INCLUDED
<i>H7: Household labor usage for brinjal production</i>	INCLUDED	INCLUDED
<i>H8: Hired labor usage by gender for brinjal production</i>	INCLUDED	INCLUDED
<i>H9: Harvesting and sales</i>	INCLUDED	INCLUDED
<i>H10: Marketing of brinjal</i>	INCLUDED	INCLUDED
<i>H11: Shocks affecting brinjal production</i>	NOT INCLUDED	INCLUDED
Module I: Knowledge, Use and Exposure to Pesticides	INCLUDED	INCLUDED
Module J: Agriculture (for all crops except brinjal)	--	--
<i>J1: Crop production</i>	INCLUDED	INCLUDED
<i>J2: Access to agricultural extension for crops (including brinjal)</i>	INCLUDED	INCLUDED
Module K: Personal History, Sense of Agency	INCLUDED	NOT INCLUDED
Module L: Program Participation	NOT INCLUDED	INCLUDED

Source: Constructed by authors.

3.1.2 Survey Training

For implementing the baseline and endline household surveys, IFPRI contracted Data Analysis and Technical Assistance (DATA), a Bangladeshi consulting firm with expertise in conducting complex surveys and data analysis. DATA worked under the supervision and guidance of senior IFPRI researchers. DATA's capacity to conduct surveys that collect high quality data was largely built by IFPRI over the past two decades.⁶

IFPRI provided a village list and the draft census questionnaire to DATA. In August 2017, the villages were randomized, with 100 control and 100 treatment villages selected (Table 3.2). From July 29 to August 8, 2017, DATA trained a 40-person all-male survey team to conduct the household census, which was conducted from August 9 to 21, 2017. On August 31, 2017, farmers were selected to participate in the study.

IFPRI prepared a draft baseline survey questionnaire, which was peer reviewed and revised to address comments and suggestions. In October 2017, IFPRI and DATA pre-tested the Bt brinjal baseline survey questionnaire in Belabo Upazila in Narsingdi District and Trishal Upazila in Mymensingh District—two major vegetable growing areas. Field testing identified issues with the questionnaires and additional rules that were needed to address difficult cases. The questionnaire was revised and finalized. DATA programmed the questionnaire for computer-assisted personal interview (CAPI) under IFPRI-PRSSP's supervision.

DATA provided experienced survey enumerators and supervisors to administer the survey, most of whom hold master's degrees in social science, nutrition, or home economics. From November 6 to 22, 2017, IFPRI researchers and DATA experts conducted the baseline survey enumerator training, which trained 45 experienced male enumerators and 10 male field supervisors. Survey enumerators' training consisted of a formal classroom component and closely monitored practice fieldwork, during which they learned how to explain and interpret interview questions, the flow and skip-patterns, definitions, how to handle unusual cases, and when to contact the supervisor for assistance. Field supervisors received additional training on their supervisory role, specifically on the quality control process and security and confidentiality issues.

⁶ DATA carried out all IFPRI surveys in Bangladesh, including more than 50 household surveys and several market, school, and other institutional surveys. In addition, DATA has conducted numerous surveys for various international organizations, such as the World Food Programme (WFP)-Bangladesh, the World Bank, the European Union, the US Department of Agriculture, CARE-Bangladesh, World Vision-Bangladesh, the Population Council—New York, Save the Children (USA), Tufts University School of Nutrition Science and Policy, and the IRIS Center at the University of Maryland.

The endline survey enumerator training was conducted from June 20 to July 2, 2018, and trained 50 male enumerators and 10 male supervisors. The training followed the same format as the baseline survey enumerator training described above.

Table 3.2 Selected study villages

Division	District	Upazila	Unions	Treatment Village	Control Village
Rajshahi	Bogura	Shahjahanpur	4	8	12
Rajshahi	Naogaon	Dhamoirhat	7	12	8
Rajshahi	Naogaon	Manda	8	12	8
Rangpur	Gaibandha	Gaibandha Sadar	8	9	11
Rangpur	Gaibandha	Gobindaganj	6	10	10
Rangpur	Gaibandha	Palashbari	9	8	12
Rangpur	Rangpur	Gangachara	7	10	10
Rangpur	Rangpur	Mithapukur	6	12	8
Rangpur	Rangpur	Pirgachha	7	10	10
Rangpur	Rangpur	Pirganj	12	9	11
Total			74	100	100

Source: Constructed by authors.

3.1.3 Survey Administration

DATA carried out the baseline household survey from November 25 to December 13, 2017, and the endline household survey from July 6 to July 16, 2018, under the supervision and guidance of IFPRI-PRSSP researchers. Going into the field, the teams of enumerators were equipped with various documents (for example, survey manuals and tablets for CAPI) and GPS units for geo-referencing.⁷ Prior to survey administration, the APSU Research Director, Ministry of Agriculture, Government of Bangladesh issued letters of authorization to conduct the survey.

The enumerators conducted the interviews one-by-one and face-to-face with the respondents assigned to them. The enumerators were supervised by the male field supervisors. Each field supervisor was responsible for his defined region. All field staff reported their activities to their supervisors using a standard progress report form. Completed questionnaires were delivered electronically to the DATA central office on a regular basis for further quality control and validation during data entry.

⁷ GPSs were imported from the USA for the household survey.

3.1.4 Quality Control

IFPRI and DATA worked diligently to ensure the quality of both rounds of the household survey data. The use of CAPI reduced the possibility of human error during data entry, using skip pattern and other programmed responses. In the field, survey supervisors routinely oversaw interviews conducted by enumerators, reviewed CAPI entry for problems, and sat with enumerators to discuss and correct any problems arising in the field before submitting the data to the server every day. At the DATA central office in Dhaka, all submitted data were checked for any errors in data collection or entry. If errors were found during checking, supervisors were instructed by phone immediately to rectify any problems. The survey manager also visited survey sites without prior notice to oversee the survey.

IFPRI made concerted effort to protect the privacy and confidentiality of study participants. Collecting data using CAPI helped minimize the risk of possible data leakage associated with paper questionnaires. Identifiers were used to uniquely identify individuals and households. When the datasets were created, any information allowing the identification of an individual or household (for example, names and addresses) were stripped from the datasets. A separate dataset linking identifiers with the information allowing identification of individuals or households was securely kept at the DATA and IFPRI offices in password-protected files. This allowed the investigators to follow up with the respondents should it be necessary. Any information obtained in connection with this study was used in a manner that does not publicly disclose any participant's identity and will be kept confidential.

IFPRI will take steps to structure the longitudinal dataset to be fully discoverable and usable by end users through the USAID Development Data Library (DDL), in compliance with USAID's ADS 579 Development Data Policy.

3.2 Randomization and Balance

IFPRI's impact estimation strategy for the Bt brinjal study relied on the clustered RCT design of the evaluation, using villages as clusters. The randomization method used for this study is described in Section 2.3, and the process of selecting treatment and control groups is described in Section 2.6.1. A straightforward randomization exercise was conducted; multiple phases or stratification were not completed.

As specified in the pre-analysis plan submitted on the Registry for International Development Impact Evaluations (RIDIE),⁸ balance over the following characteristics was assessed: age of household head; education of household head; wealth status (based on a principal components analysis of ownership of consumer durables and housing quality); land operated during baseline; and number of years working as a farmer.⁹ In addition, balance over baseline values was assessed for the two primary outcomes: (1) brinjal yields (production per ha) and (2) pesticide costs (Tk per ha). Following McKenzie (2015), the magnitude of the differences between treatment and control households and an omnibus test of joint orthogonality were focused. Results are shown in Tables 3.3 and 3.4.

Table 3.3 Mean values of baseline characteristics and primary outcomes, by treatment status

Baseline Controls	Treatment mean	Control mean	Difference	T statistic
Years of education of the brinjal grower	5.8	5.3	0.5	1.90*
Age of brinjal grower	46.1	46.2	-0.1	-0.20
Years of working as a farmer	26.9	26.6	0.3	0.41
Size of operated land (acres)	1.6	1.4	0.2	2.09**
Wealth Index	0.020	-0.025	0.045	0.58
Brinjal yield in baseline (kg per ha)	27893	33746	-5853	3.99***
Cost of pesticides used in baseline (Tk per ha)	28605	31620	-3015	1.63

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The one noteworthy difference between treatment and control households is that, at baseline, yields were higher in control households. As shown in Table 3.4, a Wald test does not reject the null hypothesis that the regressors are jointly equal to zero, implying that imbalance between treatment and control households in baseline characteristics is not a concern for this study.

⁸ IFPRI's pre-analysis plan for this study is available at the following link:

<http://ridie.3ieimpact.org/index.php?r=search/detailView&id=682>

⁹ As noted in the pre-analysis plan, since more than 95 percent of households are male-headed, balance on this characteristic was not assessed.

Table 3.4 Omnibus test of joint orthogonality where outcome is treatment status

Baseline characteristic	Marginal effects	Standard error
Years of education of the brinjal grower	0.007	0.004
Age of brinjal grower	-0.001	0.002
Years of working as a farmer	0.002	0.002
Size of operated land (in acres)	0.020	0.017
Wealth Index	-0.003	0.010
Brinjal yield in baseline (kg per ha)	$-2.11 \times 10^{-6}^{**}$	1.04×10^{-6}
Cost of pesticides used in baseline (Tk per ha)	-2.45×10^{-7}	7.25×10^{-7}
Joint test of orthogonality		
Wald $\chi^2 = 10.91$		
p-value = 0.14		

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: Standard errors clustered at the village level. *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Sample size is 1166.

3.3 Attrition

The baseline sample consists of 1,196 households (598 treatment households and 598 control households). Of these, 1,176 households were successfully traced and re-interviewed at endline, including 593 treatment households and 583 control households. Only 20 households were lost to follow-up for an attrition rate of 1.7 percent, which is acceptably low. Attrition is typically low in rural surveys because of low mobility of families. For instance, IFPRI's Bangladesh Integrated Household Survey had a 1.26 percent attrition rate per year (Ahmed 2016). Table 3.5 gives the reasons why households were lost to follow-up.

Table 3.5 Reason for household being lost to follow-up, by treatment status

Reason for household being lost to follow-up	Treatment	Control
	Number	
Migrated	0	2
Chose not to continue cultivating brinjal	2	7
Cultivated other brinjal variety	0	4
Not traced for other reasons	3	2

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Next, a model was estimated where the outcome variable equals zero if the household remained in the study and one if the household was lost to follow-up for any reason. Regressors include treatment status, the control variables included in all mode specifications, and the two primary outcomes—that is, brinjal yield at baseline and cost of pesticides (Tk per ha). Standard errors account for clustering at the level of randomization, the village. Results, reported as marginal effects, are featured in Table 3.6.

Table 3.6 Probit showing associations with loss to follow-up

Baseline Controls	Marginal effects	Standard Error
Treatment status is Bt brinjal	-0.016**	0.008
Years of education of the brinjal grower	0.001*	0.0006
Age of brinjal grower	0.0002	0.0004
Years of working as a farmer	-0.0003	0.0003
Size of operated land (acres)	-0.002	0.004
Wealth Index	-0.001	0.001
Brinjal yield in baseline (kg per ha)	-2.07×10^{-7}	1.40×10^{-7}
Cost of pesticides used in baseline (Tk per ha)	5.68×10^{-8}	6.14×10^{-8}
Joint test of orthogonality		
Wald chi ² = 12.70		
p-value = 0.12		

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: Standard errors clustered at the village level. ** significant at the 5% level; * significant at the 10% level. Sample size is 1,196.

A Wald test does not reject the null hypothesis that the regressors are jointly equal to zero. Households randomized into Bt brinjal cultivation were less likely to attrit, but while this coefficient is statistically significant, the magnitude is small (1.6 percentage points). Given the results shown in Table 3.5, and given the very low level of attrition, the weighting methodology proposed by Fitzgerald et al. (1998) is not implemented. Attrition is not a concern for this study.

3.4 Qualitative Research

IFPRI's three-member qualitative research team, coordinated by IFPRI's senior project manager, conducted the qualitative component of the Bt brinjal study.

The qualitative field research aimed to validate and explore changes in the quantity, frequency, and cost of applying pesticides; the prevalence of secondary insect infestations; the amount of labor used to produce brinjal; influence on production and yield; and farmers' perspectives on differences in marketing Bt brinjal versus non-Bt brinjal.

To this end, IFPRI conducted nine focus group discussions with Bt brinjal farmers, nine key informant interviews with concerned DAE officials, and nine key informant interviews with market traders operating in these villages to respond to the evaluation's research questions.

3.4.1 Qualitative Protocol

IFPRI planned to conduct two rounds of qualitative research in March and June 2018. However, due to heavy rain and consequent flooding, there were delays in transplanting seedlings from the seedbed to the main plots, in some places by three to four weeks. As a result, IFPRI postponed the first round of qualitative fieldwork, which was originally planned for March to May 2018. Given that the second round was scheduled for June 2018, IFPRI combined the two rounds of fieldwork, which was conducted in July 2018.

The qualitative fieldwork included nine upazilas from three study districts: Gaibandha, Naogaon, and Rangpur. From each of the nine upazilas, the study randomly selected one village from the treatment group to get diversity on locational characteristics, brinjal production-related issues, marketing, and application of pesticides from a total of nine treatment villages (three villages per district x three districts).

IFPRI-PRSSP removed Bogura District from the qualitative research for two reasons. First, Bogura only had one upazila in the study; thus, including this area would have delayed data collection and increased costs, but provided very little data. Second, because Bogura has similar agricultural marketing and production characteristics to Rangpur and Gaibandha Districts, it was assumed that the study could glean representative insights from these other districts.

Data were collected from three different groups of stakeholders: Bt brinjal farmers, sub-assistant agriculture officers (SAOs) from the DAE, and market traders.

- **Focus group discussions with Bt brinjal farmers:** From each of the nine randomly selected villages, all six Bt brinjal farmers per village participated in the focus group discussions. Therefore, in total, there were nine focus group discussions conducted with a total of 54 participants (six farmers per village x nine villages). The focus group discussions sought to ascertain farmers' experiences with Bt brinjal production and marketing. Although some farmers were reluctant to participate in interviews due to their agricultural activities, IFPRI communicated with farmers to assess their availability and adjusted the interview timing to accommodate their schedules, which ensured participation of all selected farmers.
- **Key informant interviews with SAAOs:** A semi-structured questionnaire collected information from SAAOs responsible for each of the villages selected for the qualitative fieldwork on Bt brinjal production. In total, nine key informant interviews were undertaken, with one SAAO from each of the nine villages selected for the fieldwork. Since there were very few agricultural extension officials in the treatment villages in the three study districts, interviews were scheduled according to their availability during the qualitative fieldwork period to ensure their participation.
- **Key informant interviews with market traders:** To identify market traders to participate in the key informant interviews, the types and number of market traders per village were listed, based on information from Bt brinjal farmers and SAAOs. One trader per village was interviewed using a semi-structured questionnaire, for a total of nine informants. All market traders who participated in the key informant interviews had purchased Bt brinjal from the treatment farmers under this study.

Qualitative data collection focused on the 10 research questions about Bt brinjal production listed in Section 1.5. Particular attention was given to question #10, seeking to understand in farmers' own words why these changes have occurred and why they might vary with specific farmer or locational characteristics. Key informant interviews with the SAAOs gathered their perspectives on the cultivation of Bt brinjal, again with a particular focus on question #10.

Discussions on marketing centered on the four research questions about the marketing of Bt brinjal, with attention to question #14, seeking to understand farmers' experiences in marketing Bt brinjal. Key informant interviews with market traders in the study villages provided insights into the challenges and opportunities associated with Bt brinjal.

3.4.2 Qualitative Fieldwork

Data collection for the qualitative research was undertaken from July 1 to 28, 2018. Prior to conducting the interviews, informed consent was collected from the participants. Table 3.7 describes the types of interviews and number of informants who participated in the study.

During fieldwork, audio files were uploaded daily to the server, which helped expedite data transcription and cleaning. Following completion of the fieldwork on July 28, 2018, the transcription of audio recordings was outsourced to a local qualitative research firm. IFPRI's qualitative research team reviewed the transcripts, which were then outsourced to a local survey firm for translation into English. The qualitative research team prepared a code list (both Bengali and English) according to the study objectives and extracted the information from the transcripts using the qualitative analysis software NVivo Pro 11.

Table 3.7 Qualitative data collection sample and activities

Data collection activity	Description of data collection activity	Estimated time of interview	Total interviews
Activity (i). Focus group discussion: Bt brinjal farmers	Group interviews to collect information on Bt brinjal production and marketing experience from 54 Bt brinjal farmers in the 9 randomly selected treatment villages across 9 upazilas of the impact evaluation.	90-120 minutes per group	9 x 1 = 9
Activity (ii). Key informant interview: SAAOs	Semi-structured questionnaire administered to collect information on Bt brinjal production experiences from the 9 SAAOs responsible for the 9 randomly selected treatment villages across 9 upazilas of the impact evaluation.	40-60 minutes per interview	9 x 1 = 9
Activity (iii). Key informant interview: Market traders	Semi-structured questionnaire administered to collect information on brinjal marketing processes to at least one market actor/trader from the available local market chain from each of the 9 randomly selected treatment villages across 9 upazilas of the impact evaluation.	40-60 minutes per interview	9 x 1 = 9
Total number of interviews			27

Source: Constructed by authors.

Qualitative findings from focus group discussions, key informant interviews, and field visit observations are integrated with quantitative findings in relevant sections throughout the report.

4. BT BRINJAL STUDY IMPLEMENTATION

Maintaining a high fidelity of implementation and documenting the processes that produced the outcomes is key to better understanding how and why an intervention works, and how the introduction of Bt brinjal could affect Bangladeshi farmers more broadly. This section reviews the partners involved and study activities conducted from design through implementation.

4.1 Trainings for Agricultural Extension Officials and Farmers

DAE identified and assigned 150 SAAOs to the 100 treatment and 100 control villages. These selected SAAOs participated in the training-of-trainers sessions conducted by BARI, which focused on how to monitor the study and how to advise participating farmers on proper production practices for Bt brinjal-4 and non-Bt brinjal (ISD-006). The identified SAAOs worked within the 100 treatment and 100 control villages.

In August 2017, BARI conducted a day-long training-of-trainers on Bt brinjal cultivation for 30 DAE officials at its Gazipur headquarters. From September 5 to 19, 2017, the SAAOs visited 1,200 farmers in 100 treatment and 100 control villages to confirm their involvement in the study. From September 16 to 19, 2017, DAE held 10 day-long sessions in the study upazilas to train the 150 SAAOs on agronomic practices of cultivating Bt brinjal. In September 2017 in Bogura District, BARI organized a training for 10 DAE officials who were absent from previous trainings to ensure all SAAOs received the same content.

Between September 20 and October 1, 2017, DAE organized several batches of farmers' trainings for 600 treatment and 600 control farmers at the upazila-level, led by the BARI-trained SAAOs. DAE developed a manual on brinjal production, which covered integrated pest management (IPM) extensively. The same IPM training was given to both treatment and control farmers. Farmers were trained on the management of the following pests: FSB leaf hoppers/jassids, beetles, red spiders, white flies, thrips tabaci, and aphids.

From November 25 to 27, 2017, IFPRI, DAE, and BARI trained 177 DAE officials from different ranks, including one Deputy Director, four Additional Deputy Directors, four district training officers, 11 agricultural extension officers, and 10 upazila agriculture officers (UAOs), with the aim of establishing a mutual understanding between the field-level SAAOs and their superiors. This training covered fundamentals of entomology, how SAAOs may diagnose and respond to infestation issues, and how to verify farmer registries—a tool developed by DAE and IFPRI for farmers to record their input use, production costs, and brinjal harvesting and selling weekly—are completed correctly. The farmers' registry was intended to verify the results and triangulate the survey data, not as a primary source of data.

4.2 Input Packages for Farmers

For the study, the Ministry of Agriculture provided all 1,200 brinjal farmers with an input package funded by the Government of Bangladesh. To do this, BARI certified, packaged, and supplied Bt brinjal-4 seeds for 600 treatment farmers' 10-decimal plots and the refuge border, and provided sufficient non-Bt brinjal seeds (ISD-006) for 600 control farmers' 10-decimal plots. Except for seed variety, all 1,200 brinjal farmers in the study received the same input package. Moreover, BARI scientists used the ISD-006 variety for developing Bt brinjal-4. ISD-006 is genetically identical to Bt brinjal-4 except for the introduction of a genetic construct containing *Cry 1 Ac*, which produces an insecticidal protein that is toxic to FSB. Therefore, the only difference between Bt brinjal-4 and ISD-006 is that the former has the *Bt* gene and the latter does not.

Table 4.1 shows the items and corresponding costs of inputs provided for a 10-decimal plot for treatment and control farmers. The input package did not include pesticides.

Table 4.1 Individual input package and cost

Items	Quantity (kg)	Unit cost (Tk per kg)	Cost (Tk)
Organic fertilizer for seedbed	40		
Urea	15	16	272
Triple Super Phosphate (TSP)	6	22	374
Muriate of Potash (MoP)	10	15	150
Gypsum	4	12	84
Zinc Sulphate	1	100	100
Boric acid	1	150	150
Yellow sticky trap	3		
Polythene sheet for seedbed covering	N/A		
Watering can	1		
Signboard	1		
Irrigation			350
Netting to prevent bird attack and support for plants (posts)			350
Seed sorting			150
Seed treatment			50
Total cost for 10 decimal plot			2,030

Source: Department of Agricultural Extension (DAE)

4.3 Seedling Production and Transplantation

There were six farmers in each study village (treatment and control), one of whom was randomly selected as a lead farmer to grow seedlings until maturity on behalf of the other five farmers, resulting in 200 lead farmers total. The selected lead farmers did not receive any additional incentives or benefits.

Once the seedlings were mature, DAE coordinated and monitored the distribution of transplanted seedlings to the other five farmers in each of the 200 study villages. According to BARI monitoring reports, all seedlings were taken care of and beds were properly enclaved by nets to protect seedlings from insects. Per BARI's instructions, treatment farmers included a four-sided non-Bt brinjal refuge—that is, four border rows of non-Bt brinjal around the field of Bt brinjal, as a strategy to slow the development of Bt resistance. During field visits to the trial plots, BARI confirmed that refuge crop management was executed properly on Bt brinjal plots. All plots were prepared by November 25, 2017.

4.4 Monitoring

During the first three and a half months of cultivation, DAE monitored Bt brinjal and non-Bt brinjal growth monthly on all treatment and control plots. Monitoring was more frequent during the harvesting period (that is, every 15 days). IFPRI and DAE jointly developed a registry that was distributed to farmers to record costs and input use on a weekly basis, and verified that treatment and control farmers completed the registry properly.

During a field visit in late November 2017, various farmers lamented that brinjal production was delayed due to adverse weather. One farmer in Gaibandha District confirmed that he transplanted seedlings on November 20 and faced three to four days of heavy rains immediately after, which affected the initial productivity of his brinjal plants. Although seedling production was delayed by 10 to 15 days in some areas, BARI indicated that most seedlings were transplanted at the optimum maturity and around the same time in all study districts. In February 2018, IFPRI researchers observed that despite slow growth of plants due to cold temperatures during the winter, brinjal plants appeared to have “caught up” in growth due to the warmer temperatures.

5. PROFILE OF SURVEY HOUSEHOLDS

5.1 Introduction

Using the 2017 baseline household survey data, this section describes the treatment and control farm households just before study implementation. Since an RCT design was used to assign farmers to treatment and control groups, similarity in household characteristics is expected across all groups at the start of the intervention.

This section reviews the household and individual characteristics of surveyed households at baseline, including household size, education, and occupation, followed by greater detail about household infrastructure and assets. It also provides information on the land tenure arrangements and share of crops on total cropped land.

5.2 Characteristics of Survey Households

Table 5.1 shows household characteristics of treatment and control households under the Bt brinjal impact evaluation sample. The average household size is 4.6, which is relatively consistent between treatment and control. The dependency ratio is the ratio (expressed as a percentage) of people in the household who are considered dependent (ages 0–14 and over 60) to the number of working-age household members (ages 15–60). The dependency ratio does not vary significantly across treatment arms, ranging from 56.5 to 59.0 percent.

Given the nature of the research design, in which geographic areas with a high concentration of brinjal farmers were purposively selected and willing brinjal farmers were enrolled into the study sample, it is unsurprising that farming is the main occupation for most surveyed households (84.1 percent), followed by business and trade (9.1 percent of treatment households and 7.9 percent of control households).

Males and females older than age 15 have an average of 6.3 years of schooling. Adult males and females with no schooling make up 23.6 and 29.5 percent of the sample, respectively, with minimal variation between treatment and control groups.

Table 5.1 Characteristics of survey households

Item	Treatment	Control	All
Household size (number)	4.7	4.5	4.6
Dependency ratio (percent)	56.5	59.0	57.7
Primary school-age children (6-11 years) who never went to school (percent)	2.5	3.3	2.9
Secondary school-age children (12-18 years) who never went to school (percent)	1.5	0.8	1.2
Years of schooling, male household head	5.5	5.3	5.4
Years of schooling, wife of household head	5.2	5.0	5.1
Years of schooling, adult male aged 15 and above	6.9	6.7	6.8
Years of schooling, adult female aged 15 and above	6.0	5.6	5.8
No schooling, adult male (percent)	22.9	24.3	23.6
No schooling, adult female (percent)	28.8	30.2	29.5
<i>Principal occupation of household head (percent)</i>			
Agricultural day laborer	1.5	0.7	1.1
Nonagricultural day labor	0.8	0.5	0.7
Salaried	1.3	2.2	1.8
Self Employed	2.2	1.5	1.9
Business/Trade	9.1	7.9	8.5
Farming	82.5	85.7	84.1
Non-earning occupations	1.8	0.8	1.3
Total	100.0	100.0	100.0

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Table 5.2 shows the status of electricity and dwelling type of surveyed households. In the absence of reliable income data in Bangladesh, household characteristics such as electricity and dwelling structure are often used by government safety net programs as proxy indicators for socioeconomic status of households in order to target the poor in Bangladesh.

Most surveyed farmers (81.6 percent) have access to electricity. Ahmed and Tauseef (2018) find that access to electricity is a key factor in preventing households from backsliding into poverty and helping households climb out of chronic poverty in rural Bangladesh. Nearly all (95.1 percent) surveyed households live in households with roofs made of tin.

Table 5.2 Electricity and structure of dwelling

Characteristics	Treatment	Control	All
	(percent)		
Household has electricity	82.4	80.8	81.6
<i>Structure of walls</i>			
Permanent*	84.7	89.2	87.0
<i>Roofing material</i>			
Concrete/brick	5.6	3.7	4.6
Tin	94.1	96.1	95.1
Other	0.3	0.2	0.3

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: *Permanent materials include field bricks, concrete, wood and tin sheets.

Table 5.3 shows the types of latrines used by surveyed households. Over one-half (57.1 percent) of all households use a sanitary latrine without a flush, followed by 35.6 percent who use a *pucca* (unsealed) toilet. There is almost no open defecation in the survey sample, with only 1.7 percent of households having no identified latrine at baseline.

Table 5.3 Types of latrines

Item	Treatment	Control	All
	(percent)		
None (open field)	2.4	1.0	1.7
<i>Kutcha</i> (fixed place)	3.9	4.4	4.1
<i>Pucca</i> (unsealed)	35.0	36.2	35.6
Sanitary without flush	56.0	58.3	57.1
Sanitary with flush	2.5	0.2	1.4
Community latrine	0.2	0.0	0.1
Other	0.2	0.0	0.1
Total	100.0	100.0	100.0

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Table 5.4 details the ownership status of selected assets, categorized by consumption and productive assets, across surveyed households. Mobile phone ownership is nearly universal (98.1 percent). With the growth of digital agricultural extension services, mobile phones have emerged as an important tool for farmers to receive agricultural extension messages. About three-fourths (76.2 percent) of surveyed households own a

bicycle, which concords with quantitative findings and focus group discussions with treatment farmers indicating that bicycles are one of the main modes of transport for bringing crops to the market (Table 8.1).

About one-half (48.1 percent) of households own a fishing net and 83.9 percent own a cow, signifying farmers' participation in crop *and* non-crop agricultural activities, such as livestock and fisheries.

About four-fifths (80.8 percent) of all surveyed households own a pesticide sprayer, which is expected given brinjal's susceptibility to pest infestations. About one-quarter (24.7 percent) of surveyed households own a plough and yoke. Data were not collected on ownership of personal protective equipment for pesticide application.

Table 5.4 Household asset ownership

Asset	Treatment	Control	All
		(percent)	
<i>Consumer Assets</i>			
Electric fan	85.4	82.8	84.1
Radio	1.0	0.7	0.8
Audio cassette/CD player	0.5	1.0	0.8
Television (black and white)	3.4	3.9	3.6
Television (color)	40.2	39.4	39.8
Sewing machine	9.6	8.2	8.9
Bicycle	75.5	76.9	76.2
Rickshaw	0.3	0.7	0.5
Boat	0.2	0.2	0.2
Motorcycle	16.5	12.0	14.2
Mobile phone set (functioning)	98.2	98.1	98.1
Fishing net	47.7	48.5	48.1
Solar energy panel	15.3	16.3	15.8
Hand tubewell	23.4	23.7	23.6
Cow	83.4	84.3	83.9
Buffalo	0.7	0.0	0.3
Goat/sheep	45.7	46.1	45.9
Duck/hen	87.7	88.4	88.1
<i>Productive Assets</i>			
Plough and yoke	25.9	23.6	24.7
Pesticide sprayer	77.8	83.8	80.8
Equipment for showering plant (<i>Jhorna/Jhajhara</i>)	10.6	7.6	9.1
Net for covering field/seedbed	15.0	11.8	13.4
Insect trap (Pheromone trap)	4.7	3.5	4.1
Jerry can (container) for mixing pesticide	11.4	8.1	9.8
Wheelbarrow	0.5	0.0	0.3
Tractor	0.3	0.5	0.4
Power tiller	9.4	10.6	10.0
Thresher	17.0	19.7	18.3
Swing basket	8.1	5.6	6.8
Don	1.2	0.7	0.9
Low lift pump (LLP) for irrigation	13.5	14.5	14.0
Shallow tubewell (STW)	32.3	33.3	32.8
Deep tubewell (DTW)	0.5	0.3	0.4
Electric motor pump	5.4	4.9	5.1
Diesel motor pump	2.9	5.2	4.0

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Land is the most important factor in agricultural production. In Bangladesh, land tenure arrangements represent a major determinant of socioeconomic status and technology adoption. Sharecropping is the dominant land tenure arrangement in Bangladesh. Produce is shared between the cultivator and the landowner in proportions agreed upon prior to cultivation. Table 5.5 shows that nearly one-half of surveyed farmers are sharecroppers (46.7 percent of treatment farmers and 44.1 percent of control farmers). The group of sharecroppers includes those who do not own any cultivable land (that is, pure tenant), as well as those who own land and sharecrop others' land. Cash lease is also a common land tenure arrangement among the surveyed farmers (10 percent and 13.1 percent of treatment and control farmers, respectively), either as pure tenants or as those with their own land plus cash-leased land. The proportion of farmers with mixed-tenancy arrangements (operating sharecropped plus cash-leased land, either as pure tenants or landowners) is around 46 percent. Almost 48 percent of treatment farmers and control farmers cultivate their own land.

Table 5.5 Land tenure arrangements

Land tenure arrangements	Treatment	Control
	(percent)	
Pure tenant	6.2	6.7
Sharecropping	62.2	65.0
Cash lease	27.0	15.0
Both	10.8	20.0
Own land	47.9	48.5
Mixed tenant	45.9	44.8
Sharecropping	83.5	75.9
Cash lease	8.1	14.3
Both	8.5	9.8
All sharecroppers	46.7	44.1
All cash lease	10.0	13.1

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Table 5.6 presents the distribution of study farmers by four operated farm size groups: (1) marginal farmers (operating less than 0.5 acres of land), (2) small farmers (operating 0.5 to 1.49 acres of land), (3) medium farmers (operating 1.5 to 2.49 acres of land), and (4) large farmers (operating at least 2.5 acres of land). These four farm size groups are based on the cut-off points of the six operated farm size groups presented in the 2010

Household Income and Expenditure Survey (HIES) report of the Bangladesh Bureau of Statistics (BBS). For this study, the smallest two HIES farm size groups are aggregated under the marginal farm category and the largest two groups under the large farm category (BBS 2011).

About half of all brinjal farmers in both treatment and control groups are small farmers operating 0.5 to 1.49 acres of land. The second largest group is the medium farmer category, working 1.5 to 2.49 acres.

Table 5.6 Distribution of study farmers by farm size groups

Farm size group	Treatment	Control
	(percent)	
Marginal farmer (< 0.5 acres)	10.5	10.9
Small farmer (0.5-1.49 acres)	53.6	54.0
Medium farmer (1.5-2.49 acres)	21.4	22.1
Large farmer (≥2.5 acres)	14.5	13.0
Total	100.0	100.1

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Lastly, Table 5.7 shows the share of different crops on total cropped land among surveyed farm households at baseline. Despite being identified as brinjal farmers for this study, brinjal occupies only 10 percent of total cropped area for surveyed farmers (9.5 percent and 10.7 percent for treatment and control farmers, respectively). Over one-half of total cropped area was under rice (63.1 percent and 57.2 percent for treatment and control farmers, respectively), which is a mainstay of the Bangladeshi diet. Nearly all farmers were cultivating rice at baseline (93.6 percent of treatment farmers and 92.1 percent of control farmers). In addition to brinjal and rice, farmers diversified agriculture production into other crops. For instance, about one-fifth of surveyed farmers cultivated maize, which is mainly used for fish and livestock feed in Bangladesh. Farmers also cultivated a variety of other high-value vegetables, fruits, and spices, including potatoes, jute, chili, *patal* (pointed gourd), bitter gourd, and arum and other leafy vegetables.

Table 5.7 Share of crops on total cropped land at baseline

Crop	Farmers who grew this crop		Total cropped area under this crop	
	Treatment	Control	Treatment	Control
	(percent)		(percent)	
Rice	93.6	92.1	63.1	57.2
Brinjal	99.2	99.3	9.5	10.7
Wheat	5.5	2.7	0.7	0.4
Maize	20.7	21.9	3.9	3.9
Pulse	4.0	2.5	0.3	0.2
Oilseed	5.5	3.9	0.6	0.5
Potato	40.3	42.6	6.1	6.5
<i>Patal</i> (pointed gourd)	14.1	18.4	1.6	1.9
Bitter gourd	8.6	11.6	1.2	1.6
Arum	10.9	10.3	0.9	0.9
Bean	5.2	9.4	0.5	1.1
Other vegetable	19.5	30.8	2.8	4.3
Leafy vegetable	9.9	11.4	1.1	1.6
Banana	8.7	14.8	1.2	2.5
Other fruit	1.7	0.5	0.2	0.0
Onion	7.9	5.2	0.5	0.4
Chili	14.6	18.5	1.3	1.7
Other spice	10.4	10.6	0.8	1.0
Jute	18.2	16.7	2.4	2.0
Other crops	10.3	11.3	1.6	1.8

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

5.3 Summary

Most of the brinjal farmers selected for the study primarily engage in farming, and secondarily in business and trade. Although identified as brinjal farmers under this study, these farmers engage in a rich portfolio of crop and non-crop agricultural activities, as evidenced by the data on owned assets and the share of different crops in total cropped land. Treatment and control farmers are similar in terms of wealth, livelihoods, and crop portfolios.

6. IMPACTS OF BT BRINJAL: PEST INFESTATION AND INSECTICIDE USE

6.1 Introduction

Bt brinjal-4 was developed to resist the fruit and shoot borer (FSB) pest. This resistance should enable farmers to grow Bt brinjal with fewer applications of pesticides and lower FSB infestation. This section reviews results on pesticide use and pest infestation.

6.2 Pests and Insecticides

At both baseline and endline, farmers were asked about the prevalence and extent of damage due to pests.

The percentage of all brinjal plants infested by FSB, disaggregated by treatment status, is presented in Table 6.1. At baseline, farmers in both treatment and control plots grew conventional varieties of brinjal. In the treatment plots, the percentage of plots infested by FSB was 98.4 percent. The percentage of plants affected by the pest in the infested plots was 35.5 percent. Therefore, 34.9 percent ($0.984 \times 0.355 = 0.349$) of all brinjal plants were infested by FSB for the treatment group. For the control group at baseline, 98.9 percent of all plots were infested by FSB, and 36.4 percent of the plants were infested in those plots. Therefore, 36.0 percent ($0.989 \times 0.364 = 0.360$) of all brinjal plants were infested by FSB for the control group.

At endline, there was a dramatic fall in plot-level and plant-level FSB infestation in the treatment group. Plot-level FSB infestation for the treatment group fell to 10.6 percent. The percentage of plants affected by FSB in those infested plots was 17.2 percent. This means that only 1.8 percent ($0.106 \times 0.172 = 0.018$) of all Bt brinjal plants grown by the treatment farmers were infested by FSB. By contrast, 90.3 percent of all plots of the control group and 37.5 percent of the plants in those plots were infested by FSB at endline. Thus, 33.9 percent ($0.903 \times 0.375 = 0.339$) of all ISD-006 brinjal plants grown by the control farmers were infested by FSB. This shows that plant-level FSB infestation across all treatment plots was negligible, suggesting that the Bt brinjal-4 variety is successful in repelling FSB infestation.

Table 6.1 Crop-level infestation across all farmers

Name of Pest	Baseline		Endline	
	Treatment	Control	Treatment	Control
	(percent)		(percent)	
Fruit and shoot borer	34.9	36.0	1.8	33.9
Leaf eating beetles	21.7	22.9	8.7	15.8
Thrips, white fly, jassid or aphids	16.5	19.1	9.1	14.3
Mites, mealy or leaf wing bugs or leaf roller	10.9	13.8	6.3	13.1

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

During a focus group discussion, a treatment farmer noted that Bt brinjal was less vulnerable to pests compared with the non-Bt brinjal variety (ISD-006):

By the grace of Allah, the Bt brinjal you gave us from the office is far better than the local variety. From four maunds¹⁰ (160 kg) of local brinjal, we found significant loss due to pest infestation. But that doesn't happen with Bt. This is a huge savings.

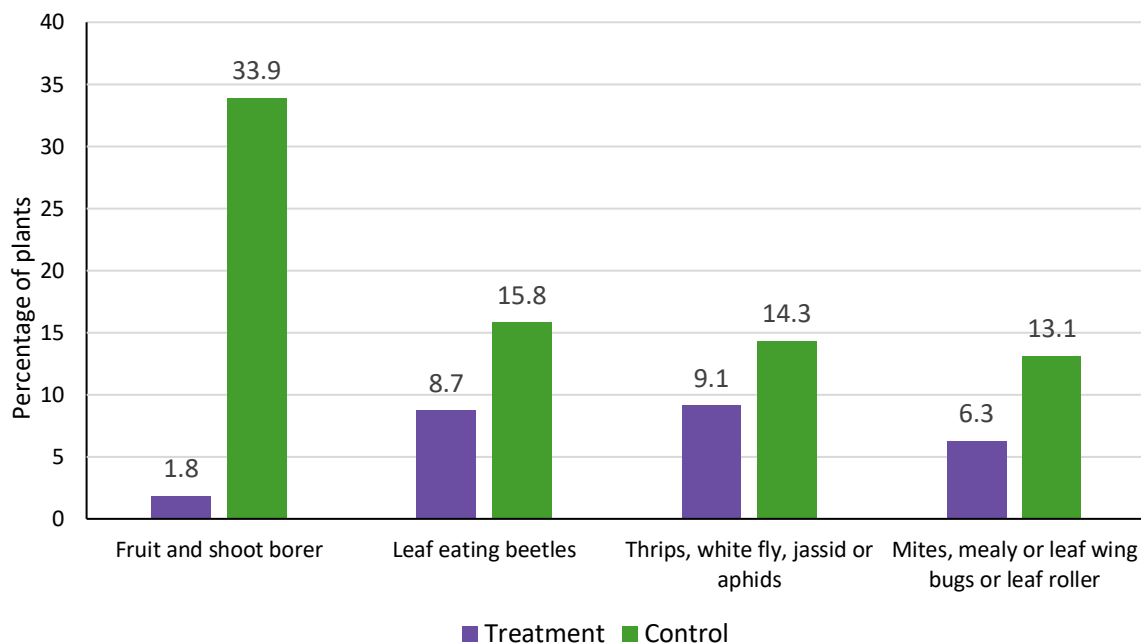
— Bt brinjal farmer, Pirganj Upazila, Rangpur District

Table 6.1 also contains information on crop-level infestation by secondary pests: leaf-eating beetles, thrips, white flies, jassids, aphids, mites, leaf bugs, and leaf rollers. The descriptive statistics show that plant-level infestation of secondary pests fell for treatment and control farmers at endline compared to their baseline rates. Several factors may be responsible for these decreases in secondary pest infestations. First, the DAE trained all treatment and control farmers on integrated pest management (IPM) and gave them instructions on preventive and combative pest infestation measures. Additionally, the DAE provided inputs such as yellow sticky traps to all treatment and control farmers. It is possible that greater use of IPM along with these traps reduced secondary pest infestation for both groups at endline. Temperatures during the endline winter season were lower than the baseline winter season, which may have also contributed to lower pest infestation.

The endline results from Table 6.1 are presented in Figure 6.1 below. The differences in crop-level infestation rates between the treatment and control groups at endline is statistically significant across all four pest categories at the 1 percent level.

¹⁰ A *maund* is a unit of weight used in Bangladesh that is equivalent to 40 kilograms.

Figure 6.1 Crop-level infestation of brinjal pests (endline)



Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: The differences in crop-level infestation between treatment and control plots are statistically significant for all pests at the 1% level.

Table 6.2 focuses on pesticide use by treatment and control farmers. At baseline, farmers sprayed 29 (treatment) to 33 times (control) for all pests. FSB accounted for a large share of these applications, with treatment farmers spraying 11 times and control farmers spraying 12.8 times for FSB on average.

At endline, control farmers sprayed on average 21.5 times, while treatment farmers sprayed 13.9 times. Much of this reduction in overall spraying frequency by treatment farmers can be attributed to reduced pesticide application for FSB. To control for FSB infestation, control farmers sprayed as much as 5.5 times more often than treatment farmers. Average number of sprays for all pests also declined for the control households, possibly because of greater use of IPM techniques, but this reduction is smaller than that observed for treatment farmers.

Table 6.2 Number of times pesticides were applied

Average number of sprays	Baseline		Endline	
	Treatment	Control	Treatment	Control
	(n=630)	(n=628)	(n=603)	(n=589)
All pests, including fruit and shoot borer	29.6	33.5	13.9	21.5
Only fruit and shoot borer	11.0	12.8	1.4	7.7

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: n = number of plots.

Table 6.3 examines trends in the quantity of pesticides applied, expressed as grams (gm) or milliliters (ml) per ha. At baseline, treatment households applied 17,948.0 ml or gm of pesticides per ha, and the control households applied 20,587.7 ml or gm of pesticides per ha, with quantities applied for FSB accounting for about one-third of these amounts.

At endline, the quantity of pesticides applied by treatment and control farmers was 11,451 ml or gm per ha and 16,270 ml or gm per ha, respectively. This means treatment farmers applied around 4,800 fewer ml or gm per ha of pesticides compared with control farmers. Comparing endline pesticide applications for FSB between treatment and control plots shows that control farmers applied almost five times the amount of pesticides that treatment farmers used for FSB infestation. For a discussion of the popular types of pesticides used by farmers in this study, see Section 6.4.

Table 6.3 Quantity of pesticides used

Quantity (gm or ml per ha)	Baseline		Endline	
	Treatment	Control	Treatment	Control
	(n=630)	(n=628)	(n=603)	(n=589)
All pests including fruit and shoot borer	17,948.0	20,587.7	11,450.6	16,270.0
Only fruit and shoot borer	6,384.7	7,163.5	1,025.1	5,099.4

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: n: number of plots

Costs of applying these pesticides show a similar pattern (Table 6.4). Since the three different measures of pesticide use are highly correlated with one another, the direction of variation between treatment and control groups remains consistent.

Table 6.4 Cost of pesticides used

Cost (Tk per ha)	Baseline		Endline	
	Treatment	Control	Treatment	Control
	(n=630)	(n=628)	(n=603)	(n=589)
All pests including fruit and shoot borer	26,986.8	29,865.4	14,417.8	21,713.8
Only fruit and shoot borer	9,980.3	10,684.6	1,233.9	7,669.9

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: n: number of plots

Bt brinjal farmers stated that Bt brinjal required less pesticide than non-Bt brinjal varieties, which, in turn, led to increased savings. Similarly, during a key informant interview, a SAAO echoed that Bt brinjal required less pesticide than conventional brinjal:

“Since this brinjal is free of *Majra poka* (fruit and shoot borer), the cost of medicine spraying is reduced a lot, so farmers are eager to grow it [Bt brinjal].”

Similarly, another treatment farmer in Mithapukur Upazila, Rangpur District, remarked:

The good characteristic of Bt brinjal is that blowfly does not attack this crop. Although some poison [pesticide] is still needed to control other pests, insect infestations on Bt brinjal is much less compared to deshi (local) brinjal.

Treatment farmers in Dhamoirhat Upazila, Naogaon District, indicated that while Bt brinjal resists FSB, it was susceptible to other pests, such as white fly. Bt brinjal farmers noted, however, that the negative impacts from secondary pests were considerably minimized by using pheromone traps and yellow sticky traps, which the DAE provided as part of its input package to all farmers.

Bt brinjal’s unique characteristic of resisting FSB combined with the application of improved agricultural production practices such as yellow sticky traps and pheromone traps protected the plants from pest infestation, thereby reducing pesticide-related costs for treatment farmers. Since control farmers received the same IPM training, their pesticide-related costs were also reduced.

6.3 Impact Analysis: Pesticide Use

An ANCOVA model is used to formally assess the impact of Bt brinjal on pesticide use. Table 6.5 focuses on one of the study's pre-specified primary outcomes: pesticide cost per ha of brinjal cultivated. Additionally, estimates of impact on the number of pesticide applications and quantity of pesticides applied per ha are reported. Each outcome variable is estimated twice: once using the base specification, which only controls for the baseline outcome and treatment status, and once using the extended specification, which controls for the baseline outcome, treatment status, and relevant baseline covariates (mentioned in the notes below the table).

Column (1) shows that farmers growing Bt brinjal spent Tk 7,174.6 less on pesticides per ha compared to control farmers. When selected baseline characteristics are controlled for, column (2) shows a nearly identical figure, Tk 7,196.3 per ha. This impact is statistically significant at the 1 percent level. Bt brinjal farmers reduced the number of sprays by 7.4 (column 6) and the quantity of pesticide sprayed by 4,616.7 gm (ml) per ha (column 10). These impacts are also statistically significant at the 1 percent level.

Logarithmic estimates of impact on cost of pesticides show that cost fell by 47 percent for the treatment group (column 4). Pesticide applications were reduced by 51 percent (column 8) and quantity of pesticides used fell by around 40 percent (column 12). All results are significant at the 1 percent level.

Table 6.5 Impact of Bt brinjal cultivation on use of pesticides

Outcome	(1) Cost of pesticides used (Tk per ha)	(2) Cost of pesticides used (Tk per ha)	(3) Log of cost of pesticides used (Tk per ha)	(4) Log of cost of pesticides used (Tk per ha)
Treatment: Bt brinjal	-7,174.6*** (1,213.3)	-7,196.3*** (1,209.7)	-0.46*** (0.06)	-0.47*** (0.06)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,166	1137	1137

Table 6.5 Impact of Bt brinjal cultivation on use of pesticides (*continued*)

Outcome	(5) Number of pesticide applications	(6) Number of pesticide applications	(7) Log of number of pesticide applications	(8) Log of number of pesticide applications
Treatment: Bt brinjal	-7.32*** (1.23)	-7.37*** (1.22)	-0.51*** (0.06)	-0.51*** (0.06)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,166	1137	1137

Table 6.5 Impact of Bt brinjal cultivation on use of pesticides (*continued*)

Outcome	(9) Quantity of pesticides used (ml or gm per ha)	(10) Quantity of pesticides used (ml or gm per ha)	(11) Log of quantity of pesticides used (ml or gm per ha)	(12) Log of quantity of pesticides used (ml or gm per ha)
Treatment: Bt brinjal	-4,669.5*** (1,101.6)	-4,616.7*** (1,093.7)	-0.39*** (0.07)	-0.39*** (0.07)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,166	1137	1137

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Household characteristics include characteristics of the individual responsible for brinjal production (age, education, years working as a farmer), land operated by the household, and household wealth index derived from principal components (using number of rooms in the dwelling; whether the dwelling has electricity; physical states of the dwelling and ownership of the following consumer durables: wrist watch, color tv, bicycle, tri van, motorcycle and solar panels). Standard errors (in parentheses) clustered at the village level. *** significant at the 1 percent level. Columns (1), (3), (5), (7), (9), and (11) do not control for household characteristics. Columns (2), (4), (6), (8), (10), and (12) do account for these household controls.

Additionally, when disaggregated by median farmer age, education, and total land holdings, there is no evidence of differential impact related to pesticide application.

6.4 Impact on the Toxicity Levels from Pesticides

Surveyed farmers were asked to name the pesticides used for different brinjal pests, and toxicity levels of these pesticides were examined. This section describes the toxicity analyses of commonly used pesticides in brinjal cultivation and explains changes in toxicity levels due to changes in pesticide use by treatment and control farmers in the study between baseline and endline.

From the baseline and endline survey data, pests for which farmers applied the most pesticides were identified. These pests were grouped into three categories based on brinjal insect groups that farmers largely identify with: (1) fruit and shoot borer, (2) white flies and white insects, and (3) beetles, spiders, and worms.¹¹ The farmers were also asked to name the pesticides used for different brinjal pests. For each category of pest, pesticides that were most often used by the farmers were identified. The trade names of these pesticides (as reported by farmers) were then matched with the *DAE List of Registered Agricultural Bio Pesticides and Public Health Pesticides in Bangladesh* (DAE 2016) to obtain their respective chemical names. Next, the toxicity levels of the chemicals in these pesticides were checked against the *Globally Harmonized System (GHS) Acute Toxicity Hazard Categories*. GHS toxicity classification is an internationally recognized classification and labeling scheme for chemical substances and mixtures of chemicals according to their physical, health, and environmental hazards (United Nations 2011). Combining information primarily from these two sources, a list of pesticides widely used against common brinjal pests was compiled, along with information on DAE's recommendation for which types of pests and crops they are appropriate for and their GHS toxicity classification. The information is presented in Tables 6.6 and 6.7.

Table 6.6 Globally Harmonized System of Classification and Labelling of Chemical (GHS)

Categories	Oral Hazard Statement	Dermal Hazard Statement	Inhalation Hazard Statement
1	Fatal if swallowed	Fatal in contact with skin	Fatal if inhaled
2	Fatal if swallowed	Fatal in contact with skin	Fatal if inhaled
3	Toxic if swallowed	Toxic in contact with skin	Toxic if inhaled
4	Harmful if swallowed	Harmful in contact with skin	Harmful if inhaled
5	May be harmful if swallowed	May be harmful in contact with skin	May be harmful if inhaled

Source: United Nations (2011).

Note: Although categories 1 and 2 have the same hazard labels, the lethal dose (expressed in mg per kg of bodyweight) is lower for chemicals classified under category 1 compared to those under category 2 (United Nations 2011).

¹¹ Common worms that attack brinjal crops include cut worms and beet armyworms.

Table 6.7 Features of popular pesticides used against common brinjal pests

Trade/ Brand Name	Generic/ Chemical Name	Name of Registration Holder	Recommended Crops	Recommended Pests	GHS Hazard Classification
Actara (25 WG)	Thiamethoxam	Syngenta Bangladesh Limited	Rice, Cotton, Sugarcane, Mango, Mustard, Banana, Tea, Brinjal, Marigold	BPH, Aphid, Jassid, Termite, Hopper, Beetle, Helopeltis	4 (Oral)
Alba (1.8 EC)	Abamectin	SAMP Limited	Rice	Brown Planthopper (BPH), Hispa	2 (Oral); 1 (Inhalation)
Basuden (10 GR)	Diazinon Organophosphate	Raven Agro Chemicals Limited	Tea	Aphid	4 (Oral)
Dursban (20 EC)	Chlorpyrifos Organophosphate	Auto Crop Care Limited	Rice, Tea, Potato, Cotton and Sugarcane	BPH, Hispa, Stem Borer (SB), Leafroller (LR), Grasshopper (GH), Rice bug, Termite, Cutworm, Bollworm, Aphid, Jassid	3 (Oral); 3 (Dermal); 4 (Inhalation)
Furadan (5G)	Carbofuran	Padma Oil Company Limited	Rice, Sugarcane, Potato	Stemborer, BPH, Ufra Nematode, White grub, Top and Early Shoot borer, Cutworm	2 (Oral); 2 (Inhalation)
Guilder (5 SG)	Emamectin Benzoate	Aama Gree Care	Bean, Tea	Pod borer, Termite	3 (Oral); 4 (Dermal)
Imitaf (20 SL)	Imidacloprid	Auto Crop Care Limited	Rice, Cotton, Tea, Sugarcane	BPH, Hispa, Aphid, Jassid, Whitefly, Bollworm, Termite	4 (Oral)
Licar (1.8 EC)	Abamectin	Corbel International Limited	Rice	BPH, Hispa	2 (Oral); 1 (Inhalation)
Pegasus (500 SC)	Diafenthion	Polo/Pegasus	Cotton, Vegetables	Whitefly, mites, aphids, jassids	4 (Oral); 3 (Inhalation); 2 (Dermal)
Ripcord (10 EC)	Cypermethrin	BASF Bangladesh Limited	Cotton, Mango, Jute, Brinjal	Bollworm, Hopper, Hairy caterpillar, Field cricket, Semilooper, Shoot and fruit borer	3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)
Shobicon (425 EC)	Profenofos (40%) + Cypermethrin (2.5%)	Syngenta Bangladesh Limited	Teasel & Bitter Gourd, Brinjal, Guava, Cotton, Mango, Banana	Fruit fly, Shoot and Fruit Borer, White fly, Aphid, Jassid, Bollworm, Hopper, Beetle	Profenofos: 4 (Oral); 4 (Dermal); Cypermethrin: 3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)

Table 6.7 Features of popular pesticides used against common brinjal pests (*continued*)

Trade/ Brand Name	Generic/ Chemical Name	Name of Registration Holder	Recommended Crops	Recommended Pests	GHS Hazard Classification
Tundra (20 SP)	Acetamiprid	Auto Crop Care Limited	Bean, Cotton	Aphid, Jassid, White fly	4 (Oral); 2 (Inhalation)
Vertimec (1.8 EC)	Abamectin	Syngenta Bangladesh Limited	Tea, Brinjal, Jujube, Litchi	Red spider mite, mite	2 (Oral); 1 (Inhalation)
Volium Flexi (300 SC)	Thiamethoxam (20%) + Chloraniliprole (20%)	Syngenta Bangladesh Limited	Tomato, Brinjal	Fruit borer, Shoot and fruit borer	4 (Oral); The toxicological properties have not been thoroughly investigated for Chloraniliprole
Wonder (5 WG)	Emamectin Benzoate	Asia Trade International	Cotton	Bollworm	3 (Oral); 4 (Dermal)

Source: WHO (2010); United Nations (2011); DAE (2016).

Note: Pesticide Formulation Abbreviations

EC: Emulsifiable Concentrate; SC: Suspension Concentrate; WG: Water Dispersible Granule; SG: Soluble Granule; SP: Soluble Powder Formulation; SL: Soluble Liquid; GR: Granule

Table 6.8 summarizes data on the percentage of total brinjal plots that used the selected pesticides and the quantity applied (ml or gm) per ha, disaggregated by treatment and control status for both baseline and endline. The data were disaggregated according to the three categories of brinjal pests described above. Farmers were asked which pests they applied various pesticides for. Their responses indicate that one type of pesticide can be used for various types of pests. For example, the table below shows that Actara 25 WG, Alba 1.8 EC, Dursban 20 EC, Ripcord 10 EC, and Shobicron 425 EC are used for all major brinjal pests.

Table 6.8 Pesticides commonly used by treatment and control farmers

GHS Hazard Classification	Name of Pesticides	Percentage of total plots that used this pesticide				Quantity (ml or gm) per ha			
		Baseline		Endline		Baseline		Endline	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
	Pesticides for Fruit and Shoot Borer Infestation								
4 (Oral)	Actara 25 WG	3.5	3.5	1.2	5.8	85.1	53.8	14.3	96.9
2 (Oral); 1 (Inhalation)	Alba 1.8 EC	15.4	12.6	2.5	9.3	1,270.0	1,506.0	76.8	376.5
3 (Oral); 3 (Dermal); 4 (Inhalation)	Dursban 20 EC	7.9	6.5	2.8	8.3	247.2	174.6	66.1	269.4
3 (Oral); 4 (Dermal)	Guilder 5 SG	1.1	3.5	1.2	8.0	22.5	105.7	42.1	286.4
3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)	Ripcord 10 EC	13.3	14.0	1.3	5.4	545.5	914.7	34.0	233.4
(3-4 Oral); (4 Dermal); 4 (Inhalation); 1 (Skin Sensitization)	Shobicron 425 EC	3.8	3.2	2.7	4.9	209.0	139.1	98.7	167.8
4 (Oral)	Volium 300 SC	4.0	5.1	0.3	3.4	93.0	218.7	6.2	105.0
3 (Oral); 4 (Dermal)	Wonder 5 WG	3.8	5.6	0.2	6.1	136.8	176.0	3.1	189.4
	Pesticides for White Flies/White Insects								
4 (Oral)	Actara 25 WG	3.2	6.7	3.8	5.3	85.1	128.5	51.2	88.0
2 (Oral); 1 (Inhalation)	Alba 1.8 EC	4.4	1.3	2.5	2.9	222.9	85.4	76.5	108.2
3 (Oral); 3 (Dermal); 4 (Inhalation)	Dursban 20 EC	5.1	4.1	6.0	3.9	168.8	110.4	146.7	124.4
4 (Oral)	Imitaf 20 SL	1.4	1.8	7.8	2.2	92.4	87.3	405.8	110.8
3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)	Ripcord 10 EC	5.2	5.1	5.3	5.3	249.0	107.5	175.6	155.0

Table 6.8 Pesticides commonly used by treatment and control farmers (*continued*)

GHS Hazard Classification	Name of Pesticides	Percentage of total plots that used this pesticide				Quantity (ml or gm) per ha			
		Baseline		Endline		Baseline		Endline	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
(3-4 Oral); (4 Dermal); 4 (Inhalation); 1 (Skin Sensitization)	Shobicron 425 EC	5.4	4.6	2.7	3.7	248.2	216.9	79.4	156.2
4 (Oral); 2 (Inhalation)	Tundra 20 SP	4.8	4.9	6.5	4.9	214.9	215.1	133.7	166.8
4 (Oral); 3 (Inhalation); 2 (Dermal)	Pegasus 500 SC	Not used in baseline		5.1	1.0	Not used in baseline		163.0	23.4
Popular Pesticides for Beetles, Spiders and Worms									
4 (Oral)	Actara 25 WG	1.8	3.2	4.3	6.6	17.8	58.8	73.5	130.8
2 (Oral); 1 (Inhalation)	Alba 1.8 EC	2.7	0.6	5.5	3.6	220.2	16.6	137.3	234.0
4 (Oral)	Basudin	1.9	1.9	1.2	1.2	274.1	293.0	169.5	266.4
3 (Oral); 3 (Dermal); 4 (Inhalation)	Dursban 20 EC	5.2	4.6	2.5	3.4	281.2	228.7	94.1	177.3
2 (Oral); 2 (Inhalation)	Furadan 5G	1.6	2.6	3.7	3.6	187.3	276.2	862.7	864.1
2 (Oral); 1 (Inhalation)	Licar 1.8 EC	1.9	3.5	3.8	6.5	140.9	130.1	124.2	239.9
3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)	Ripcord 10 EC	2.4	2.2	2.0	3.4	99.1	60.8	55.7	90.0
(3-4 Oral); (4 Dermal); 4 (Inhalation); 1 (Skin Sensitization)	Shobicron 425 EC	1.6	3.2	0.8	1.5	150.1	224.2	26.1	59.8
2 (Oral); 1 (Inhalation)	Vertimec 1.8 EC	3.0	4.3	4.3	9.0	182.7	274.0	137.7	338.6
4 (Oral); 3 (Inhalation); 2 (Dermal)	Pegasus 500 SC	Not used in baseline		4.8	1.5	Not used in baseline		122.4	34.5

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Pesticide Formulation Abbreviations

EC: Emulsifiable Concentrate; SC: Suspension Concentrate; WG: Water Dispersible Granule; SG: Soluble Granule; SP: Soluble Powder Formulation; SL: Soluble Liquid; GR: Granule

The prevalence of pesticides commonly applied against FSB declined in treatment plots between baseline and endline periods for all selected brands. The prevalence of use of these popular pesticides is also lower in treatment plots compared with control plots at the endline. Similarly, the quantity (ml or gm) of pesticides used per ha against FSB also fell between baseline and endline periods in treatment plots, and quantities used in treatment plots are lower compared with control plots at endline. Alba 1.8 EC, Dursban 20 EC, and Ripcord 10 EC are the three pesticides most commonly used against FSB. Although Alba 1.8 EC is the one of the most widely used pesticides (not only against FSB but other common pests as well), it is extremely toxic. The GHS hazard scale of the chemical component of this pesticide, Abamectin, indicates that it is fatal to inhale and ingest. Use of this dangerous pesticide against FSB dropped from 15.4 percent at baseline to 2.5 percent at endline among treatment plots, and the quantity also fell from 1,270.0 ml or gm per ha at baseline to only 76.8 ml or gm per ha at endline. The prevalence of use of selected pesticides for FSB among control plots between baseline and endline is less consistent, with the use of some pesticides increasing and others decreasing. It is unclear why control farmers chose to increase the use of some pesticides and decrease the use of others between baseline and endline.

Use of pesticides against secondary pests rose and fell inconsistently for both treatment and control plots between baseline and endline. Overall, farmers tend to use pesticides that have an oral and inhaled hazard rank between 3 and 4. Exceptions include the use of Alba 1.8 EC, Licar 1.8 EC, Furadan 5G, and Vertimec 1.8 EC, which are classified as fatal in the GHS hazard scale and yet are still quite widely used by farmers. The use of these pesticides is largely influenced by market availability and promotions, and farmers are rarely informed about their toxicity.

One way of summarizing these data is to group their prevalence and use by the GHS Oral Hazard classification.¹² This information is presented in Table 6.9, which shows that fewer treatment farmers applied pesticides of high toxicity levels (levels 2 and 3) compared with control farmers at endline. The mean number of times highly toxic (levels 2 and 3) pesticides were applied during the endline season was also lower for treatment farmers compared with the control farmers. The use of pesticides against FSB was lower among treatment farmers compared with control farmers for all toxicity classifications at endline, and is lower compared with treatment farmers' usage in baseline. The mean number of times pesticides were applied for FSB by treatment

¹² Although the inhalation hazard classification would have been more appropriate, this information is not available for all the pesticides identified during these surveys.

farmers was also lower compared with their control counterparts at endline and lower compared with quantities applied by treatment farmers in the baseline.

Table 6.9 Disaggregation of pesticide toxicity

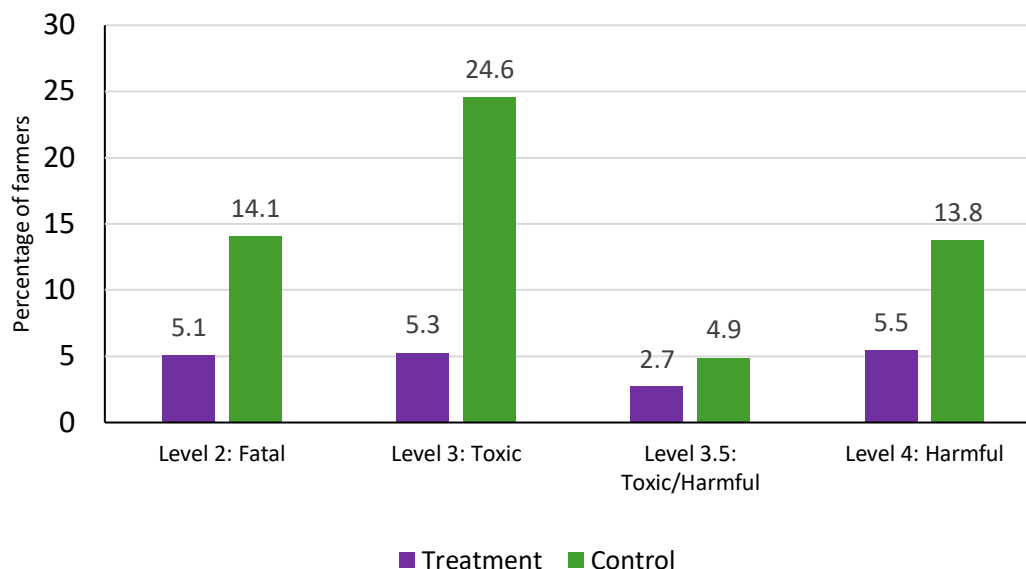
Toxicity Scale	Frequency				Mean Sprays			
	Baseline		Endline		Baseline		Endline	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
<i>Pesticides used for all pests</i>								
1	N/A*				N/A			
2	31.4	34.1	34.2	43.0	3.8	4.1	1.7	3.1
3	45.7	46.7	28.0	45.2	4.1	5.2	1.7	3.5
3.5 (avg. scale)	11.8	10.8	6.8	11.2	1.2	1.0	0.4	0.8
4	32.2	36.2	43.8	42.8	3.0	3.8	3.5	3.0
5	N/A				N/A			
<i>Pesticides used for fruit and shoot borer</i>								
1	N/A*				N/A			
2	17.8	17.0	5.1	14.1	2.0	2.5	0.2	0.9
3	24.3	26.4	5.3	24.6	1.8	2.6	0.2	1.7
3.5 (avg. scale)	3.8	3.2	2.7	4.9	0.3	0.2	0.1	0.3
4	9.7	11.0	5.5	13.8	0.6	0.8	0.3	0.9
5	N/A				N/A			

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: N/A* indicates that none of the pesticides selected for this analysis corresponded to the respective toxicity scale. Toxicity scale is based on GHS Oral Ingestion Hazard level. Frequency: Percentage of farmers using pesticides of corresponding toxicity level. Mean Sprays: Average number of times pesticides of corresponding toxicity level were applied. Analysis is based on a select few pesticides, which have been identified as most popularly used by farmers.

The data on percentage of farmers using pesticides of varying toxicity levels for FSB are graphically presented in Figure 6.2 below.

Figure 6.2 Percentage of farmers using pesticides for fruit and shoot borer by toxicity level (endline)



Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

Differences in the percentage of farmers using pesticides of toxicity levels 2, 3, and 4 are statistically significant at the 1 percent level. The difference in percentage of farmers using pesticides of toxicity level 3.5 is statistically significant at the 5 percent level.

These data are summarized by constructing a toxicity score, the Pesticide Use Toxicity Score (PUTS), which assigns a score based on the GHS Oral Hazard category of the selected pesticides and the frequency of use of the respective pesticides. In the GHS Hazard Classification scale, lower numbers (1, 2) correspond to more severe levels of toxicity. For PUTS to be easily interpretable, the GHS scale is inverted so that higher values correspond to higher toxicity levels. The toxicity score was calculated in the following method:

$$\begin{aligned}
 &PUTS \\
 &= \text{Inversed GHS Oral Hazard Classification} \\
 &\times \text{Number of times the respective pesticide was applied in a season}
 \end{aligned}$$

Summary statistics are shown in Table 6.10 below. This shows that average toxicity score for treatment farmers is much lower than for control farmers at endline; at baseline, they were approximately equal. There are two possible explanations for this decrease in average toxicity score: (1) treatment farmers are applying pesticides less frequently compared to control farmers, and (2) treatment farmers are using less

harmful pesticides compared to control farmers. The disaggregation in Table 6.9 above suggests that this difference arises largely from treatment farmers applying toxic pesticides less often than control farmers.

Table 6.10 Pesticide use toxicity score (PUTS) summary statistics

	Baseline		Endline	
	Treatment	Control	Treatment	Control
Mean	22.3	24.5	9.5	17.0
Standard Deviation	29.4	32.5	14.1	23.2
Minimum	0.0	0.0	0.0	0.0
Maximum	207.0	177.5	150.0	247.0

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Range for PUTS: 0 to 438 (max. based on highest toxicity level times maximum number of sprays recorded in baseline).

The ANCOVA model is estimated, with PUTS as the outcome (Table 6.11). This shows that cultivating FSB-resistant Bt brinjal reduces the toxicity score by 7 points and this impact is statistically significant at the 1 percent level.

Logarithmic estimates of impact on PUTS show that the score decreased by 41–42 percent. Limited exploration of sample disaggregations by median farmer age, education, and total land holdings did not produce any evidence of differential impact on PUTS.

Table 6.11 Impact of Bt brinjal cultivation PUTS

Outcome	(1) PUTS	(2) PUTS	(3) Log of PUTS	(4) Log of PUTS
Treatment: Bt brinjal	-7.20*** (1.57)	-7.17*** (1.57)	-0.42*** (0.09)	-0.41*** (0.09)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observation	1,166	1,166	634	634

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: See notes in Table 6.5. Columns (1) and (3) do not control for household characteristics. Columns (2) and (4) do account for these household controls.

6.5 Environmental Impact Quotient (EIQ) of Pesticides

In addition to the PUTS analysis, the environmental impact of selected pesticides used against FSB by surveyed farmers was examined. The Integrated Pest Management (IPM) Program at Cornell University developed a model called the Environmental Impact Quotient (EIQ), which estimates the environmental impact of specific pesticides based on the toxicity level of the active ingredient and rate of application. This section presents the results from the EIQ analysis.

Kovach et al. (1992) developed the EIQ as a measure of the environmental effect of specific pesticides. This model was designed to be an easily interpretable measure of pesticide toxicity for use by IPM practitioners. The project gathered data from various sources, including the Extension Toxicology Network (EXTOXNET), a database developed by environmental toxicology and pesticide education departments of Cornell University, Michigan State University, Oregon State University, and the University of California. Data were also gathered from CHEM-NEWS of CENET, the Cornell Cooperative Extension Network. This database includes pesticide fact sheets with detailed information on their health, ecological, and environmental effects. The IPM program team at Cornell University organized information on dermal toxicity, chronic toxicity, systemicity,¹³ fish toxicity, leaching potential, surface loss potential, bird toxicity, soil half-life, bee toxicity, beneficial arthropod toxicity, and plant surface half-life of specific pesticides to generate EIQ values.

There are three components to the EIQ score:

1. Farm worker risk = (Applicator Exposure + Picker Exposure) × Chronic Toxicity
2. Consumer (end user of the product) = Consumer Exposure Potential + Potential Ground Water Effects
3. Ecological = Sum of effects of chemicals on fish, birds, bees, and beneficial arthropods

Both consumer exposure potential and picker exposure are functions of the residue potential in soil and plant surfaces, which is the time required for one-half of the chemical to break down. The residue factor accounts for the erosion of pesticides that occur in agricultural systems (Kovach et al. 1992). It can be reasonably expected that since the effect of the pesticides decline over time, consumers are subjected to relatively lower levels of exposure than farm workers. Each component in the EIQ

¹³ According to Goertz and Mahoney (2012), systemicity refers to the uptake and distribution of pesticides in the leaves and roots.

equation is given equal weight. The possible range for EIQ is from 6.7 to 226.7 for all pesticides (Kniss and Coburn 2015). A high EIQ means greater potential impact on the environment. To account for different formulations of the same active ingredient in various pesticides, and differences in rate of application, the following EIQ Field Use Rating (EIQ-FUR) was formulated:

$$\text{EIQ-FUR} = \text{EIQ} \times \% \text{ Active Ingredient} \times \text{Rate of Application}$$

EIQ-FUR can be used to compare the potential environmental effect of specific pesticides and pest management strategies. For more information, please refer to Kovach et al. (1992).

6.6 EIQ Analysis for Pesticides Used Against Fruit and Shoot Borer

For IFPRI's analyses of environmental impact of pesticides used against FSB, the pesticides most commonly used by farmers in this survey were identified. The final list includes eight pesticides that are most widely used by the farmers against FSB: Alba 1.8 EC, Dursban 20 EC, Ripcord 10 EC, Volium Flexi 300 SC, Wonder 5 WG, Actara 25 WG, Guilder 5 SG, and Shobicron 425 EC. These pesticides were used by 43 percent of all treatment and control farmers at baseline and 23 percent of all farmers at endline. Table 6.12 below presents information on the chemical name, percent of active ingredient, Field Use EIQ, and EIQ component scores of the selected pesticides.

Table 6.12 Details on pesticides commonly used at baseline and endline

Sl. No.	Trade/brand name	Active Ingredients	Field Use EIQ (1000 ml per ha)	Field Use EIQ Components (1000 ml per ha)		
				Consumer	Field worker	Ecological
1	Alba (1.8 EC)	Abamectin: 18 gm/liter (1.8%)	0.5	0.1	0.2	1.3
2	Dursban (20 EC)	Chlorpyrifos (20%)	4.6	0.3	1	12.4
3	Ripcord (10 EC)	Cypermethrin (10%)	3.1	0.5	1.2	7.6
4	Volium Flexi (300 SC)	Thiamethoxam: 200 gm/liter (20%)	5.7	2.1	1.8	13.3
		Chlorantraniliprole: 100 gm/liter (10%)	1.6	0.6	0.6	3.6
		Weighted Average	4.3	1.6	1.4	10.1
5	Wonder (5 WG)	Emamectin Benzoate (5%)	1.1	0.2	0.4	2.8
6	Actara (25 WG)	Thiamethoxam: 250gm/kg (25%)	7.1	2.6	2.2	16.6
7	Guilder (5 SG)	Emamectin Benzoate (5%)	1.1	0.2	0.4	2.8
8	Shobicron (425 EC)	Profenofos: 400 gm/liter (40%)	20.4	1	2.8	57.3
		Cypermethrin: 25 gm/liter (2.5%)	0.8	0.1	0.3	1.9
		Weighted Average	19.2	0.9	2.7	54.0

Source: Eshenaur, B., J. Grant, J. Kovach, C. Petzoldt, J. Degni, and J. Tette. 1992-2015. www.nysipm.cornell.edu/publications/EIQ. Environmental Impact Quotient: "A Method to Measure the Environmental Impact of Pesticides." New York State Integrated Pest Management Program, Cornell Cooperative Extension, Cornell University. Data from 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

The EIQ values in Table 6.12 are reported for an application rate of 1,000 ml per ha. In this quantitative analysis, the EIQ values were adjusted according to the application rate (in ml/ha) of individual plots in baseline and endline survey periods. Table 6.13 presents descriptive statistics on EIQ values of pesticides used in treatment and control plots in both survey periods.

Table 6.13 Descriptive statistics of EIQ-FUR and EIQ components

	Baseline				Endline			
	Treatment		Control		Treatment		Control	
	n=630		n=628		n=603		n=589	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
EIQ-FUR	8.66	35.41	8.70	24.60	2.52	14.29	7.03	19.97
<i>EIQ Components</i>								
Consumer	1.06	2.83	1.33	3.21	0.19	0.86	0.90	2.49
Farm Worker	2.10	5.99	2.48	5.78	0.45	2.15	1.63	3.81
Ecological	22.95	98.47	22.48	66.42	6.93	40.02	18.66	54.70

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: n = number of plots, St. Dev = standard deviation

At baseline, the average EIQ values of both treatment and control groups are very similar. The EIQ-FUR is between 8.66 and 8.70; consumer impact value is 1.06 for treatment and 1.33 for control; farm worker impact is 2.10 and 2.48 for treatment and control groups, respectively; ecological impact value is 22.95 for the treatment group and 22.48 for the control group.

At endline, there are remarkable differences in EIQ values between the treatment and control groups. The EIQ-FUR for the control group is 7.03, while that of the treatment group is 2.52. The individual component scores of the control group were also considerably higher compared with the treatment group. Much of this can be attributed to the reduced rate of pesticide application against FSB by treatment farmers at endline compared with baseline. It may also be the case that treatment farmers used more of less toxic pesticides from our list, as infestation levels were lower.

6.7 Impact Analysis: EIQ of Pesticides

An ANCOVA model is used to assess the impact of Bt brinjal on EIQ-FUR and EIQ component values. The results are presented in Table 6.14. Each outcome variable is estimated twice: once using the base specification that only controls for the baseline outcome and treatment status, and once using the extended specification that controls for the baseline outcome, treatment status, and relevant baseline covariates (mentioned in the notes below the table).

Columns (1) and (2) show that the EIQ-FUR of Bt brinjal plots was around 4.6 points less than that of control plots. Logarithmic estimates of impact find that EIQ-FUR fell by 56 percent, as shown in columns (3) and (4). All impact estimates of EIQ-FUR are statistically significant at the 1 percent level.

Columns (5) and (6) present results from impact estimate on the EIQ consumer component. The analysis indicates that impact would be 0.7 points less for Bt brinjal consumers than for ISD-006 consumers. These results are significant at the 1 percent level. The logarithmic estimates of impact find that the EIQ consumer component fell by 4 percent, as shown in columns (7) and (8); however, the results are not statistically significant.

Impact estimate results on the EIQ farm worker component are presented in columns (9) and (10). The EIQ farm worker score in Bt brinjal plots is 1.18 points less than in conventional brinjal plots. The logarithmic impact estimates show that there is a 23 percent reduction in toxicity exposure for farm workers, as presented in columns (11) and (12). All EIQ estimates of impact on farm workers are statistically significant at the 1 percent level.

Columns (13) and (14) present the estimates of impact on the ecological component of EIQ. The ecological impact is 12 points less in treatment plots than in control plots. Logarithmic estimates show that there is an 82 percent reduction in ecological impact in plots cultivating Bt brinjal, shown in columns (15) and (16). All results are statistically significant at the 1 percent level.

Table 6.14 Impact of Bt brinjal cultivation on EIQ-FUR and EIQ component values

Outcome	(1) EIQ-FUR	(2) EIQ-FUR	(3) Log of EIQ-FUR	(4) Log of EIQ-FUR
Treatment: Bt brinjal	-4.67*** (1.57)	-4.63*** (1.62)	-0.56*** (0.09)	-0.56*** (0.09)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,165	1,166	1,165

Table 6.14 Impact of Bt brinjal cultivation on EIQ-FUR and EIQ component values (continued)

Outcome	(5) EIQ-Consumer	(6) EIQ-Consumer	(7) Log of EIQ-Consumer	(8) Log of EIQ-Consumer
Treatment: Bt brinjal	-0.71*** (0.13)	-0.70*** (0.13)	-0.04 (0.05)	-0.04 (0.05)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,165	1,166	1,165

**Table 6.14 Impact of Bt brinjal cultivation on EIQ-FUR and EIQ Component Values
(continued)**

Outcome	(9) EIQ-Farm Worker	(10) EIQ-Farm Worker	(11) Log of EIQ-Farm Worker	(12) Log of EIQ-Farm Worker
Treatment: Bt brinjal	-1.20*** (0.25)	-1.18*** (0.25)	-0.23*** (0.06)	-0.23*** (0.06)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,165	1,166	1,165

**Table 6.14 Impact of Bt brinjal cultivation on EIQ-FUR and EIQ Component Values
(continued)**

Outcome	(13) EIQ-Ecological	(14) EIQ-Ecological	(15) Log of EIQ-Ecological	(16) Log of EIQ-Ecological
Treatment: Bt brinjal	-12.17*** (4.38)	-12.08*** (4.53)	-0.83*** (0.11)	-0.82*** (0.11)
<i>Controls</i>				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Observations	1,166	1,165	1,166	1,165

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: See notes in Table 6.5. Columns (1), (3), (5), (7), (9), (11), (13), and (15) do not control for household characteristics. Columns (2), (4), (6), (8), (10), (12), (14), and (16) do account for these household controls.

Overall, the EIQ toxicity assessment reveals that the environmental impact of pesticides used against FSB in treatment plots was lower than in control plots. The most likely reason is the reduced rate of pesticide application in treatment plots due to a fall in FSB infestation. Another possible reason is that treatment farmers at endline are using pesticides that are less toxic.

6.8 Summary

Bt brinjal-4 was developed to resist the FSB pest. This section assesses whether Bt brinjal successfully repels the FSB pest, and whether, as a result, farmers reduce their use of pesticides and exposure to toxicity, and how changes in toxicity levels reflect environmental outcomes.

Overall, Bt brinjal farmers spent Tk 7,175 less on pesticides per ha compared with control farmers (Table 6.6). This impact is statistically significant at the 1 percent level. This result is robust to the inclusion of controlling for selected baseline characteristics. Furthermore, Bt brinjal farmers reduced the number of applications by 7.3 and the

quantity of pesticide sprayed by 4,617 gm (ml) per ha. These impacts are also statistically significant at the 1 percent level.

The PUTS impact analysis reveals that the toxicity scale was 7 points lower for Bt brinjal households, and this impact is statistically significant at the 1 percent level. Relative to the baseline value for the control group, this represents a 29 percent reduction in the toxicity of pesticides applied in brinjal production. An additional toxicity analysis conducted using EIQ-FUR shows that environmental toxicity is 56 percent lower for the treatment group compared with the control group; this impact is statistically significant at the 1 percent level.

At baseline, 34.9 percent of all brinjal plants were infested by FSB for the treatment group, and 36.0 percent of all brinjal plants were infested by FSB for the control group.

At endline, there is a dramatic fall in crop-level infestation of FSB pest in the treatment group. Only 1.8 percent of all Bt brinjal plants grown by the treatment farmers were infested by FSB. By contrast, 33.9 percent of all ISD-006 brinjal plants grown by the control farmers were infested by FSB. This shows that Bt brinjal has been successful in repelling FSB infestation.

Fewer plants were affected by secondary pests for both control and treatment groups at endline compared to baseline. Since the Bt brinjal-4 variety is only resistant to FSB, the reduction in infestation rates of secondary pests can be largely attributed to IPM trainings that were given to both treatment and control farmers.

7. IMPACTS OF BT BRINJAL: PRODUCTION AND YIELDS

7.1 Introduction

A prerequisite for the widespread adoption of Bt brinjal is evidence that it produces higher yields than non-Bt brinjal varieties in the presence of FSB. In this section, impact of Bt brinjal cultivation on brinjal yields is assessed, defined as kilogram (kg) produced per ha of brinjal cultivated. As outlined in the pre-analysis plan, this is one of the study's primary outcomes. In addition, the mechanisms that underlie yield differences are also explored. Do they arise because of differences in quantity harvested or area planted? Also, do Bt brinjal farmers retain more (or less) for home consumption, give it to other households, or use it as in-kind payment? Finally, do Bt brinjal farmers sell more or less of their harvest relative to control farmers? This section concludes with an exploration of whether these results differ by age, education, or land operated.

7.2 Data and Descriptive Statistics

At endline, farmers were asked to identify the months during which they harvested brinjal. For each month, they then indicated how much they had: harvested (including fruit that they harvested, but on inspection had to discard because of pest infestation or other disease); retained for home consumption; paid to owners of leased plots; paid to hired labor; given away as a gift; discarded for any other reason, including damage due to pests or other diseases; and how much they had sold. All quantities were recorded in kg. While a few farmers indicated some harvesting in November and December 2017, most harvesting took place between January and June 2018.¹⁴

As described in Section 4, farmers agreed to grow brinjal on 10-decimal (0.10 acre or 0.04 ha) plots. At endline, these plots were measured using GPS.

Using these data, gross yields per ha (quantity harvested in kg divided by area planted in ha) and net yields per ha (where net production is quantity harvested in kg minus fruit

¹⁴ A similar method was used to collect baseline data. While this approach is consistent with what was described in the pre-analysis plan, it introduced an unexpected complication. For baseline, this recall period (November to June) captures both brinjal planted in October, but also brinjal planted earlier in the year. As a result, for some baseline farmers, their baseline data captures two harvests on the same plot of land rather than one. This is seen, most notably, in the number of farmers reporting harvesting in November, December, and January. At baseline, 494, 597, and 689 households, respectively, reported harvesting in these months. At endline (remembering that transplanting of seedlings took place largely in November), the number of farmers harvesting were 7, 29, and 340 in November, December, and January, respectively.

discarded for any other reason, including damage due to pests or other diseases) were calculated. The net yield variable is the primary outcome defined in the analysis plan.

Table 7.1 provides descriptive statistics on endline brinjal production by treatment status. Comparing the unconditional endline means, farmers growing Bt brinjal produced, on average, 113.2 kg more brinjal (600 kg versus 487 kg for control farmers) between November 2017 to June 2018, which amounts to a 23.3 percent increase for treatment farmers. Bt brinjal farmers discarded less (40 kg) brinjal. Gross and net yields per ha were, on average, higher for Bt brinjal farmers. Consequently, after accounting for amounts paid out and retained for home consumption or seed stock, Bt brinjal farmers sold more brinjal. They did so on slightly smaller (0.033 ha versus 0.040 ha) planted areas (remember, Bt brinjal farmers were supposed to plant a border around their fields, so the average net area planted under Bt brinjal is 21 percent smaller than the average total plot area). However, the total plot size with border is used for Bt brinjal yield calculations because the farmers need to utilize the entire area with a refuge border for Bt brinjal cultivation.

Table 7.1 Mean levels of endline brinjal production and yield, by treatment status

Mean levels of endline brinjal production and yield	Treatment	Control	Difference
	(n=593)	(n=583)	
Quantity harvested (kg)	599.9	486.7	113.2
Quantity discarded (kg)	33.0	73.3	-40.3
Quantity paid out (kg)	38.1	31.9	6.2
Quantity retained for home consumption and/or seed stock (kg)	29.1	22.1	7.0
Quantity sold (kg)	499.7	359.4	140.3
Plot area with border (ha)	0.042	0.040	0.002
Net plot area without border (ha)	0.033	0.040	-0.007
Gross yield (kg per ha)	14,700.3	12,456.1	2,244.2
Net yield (kg per ha)	13,914.3	10,483.1	3,431.2

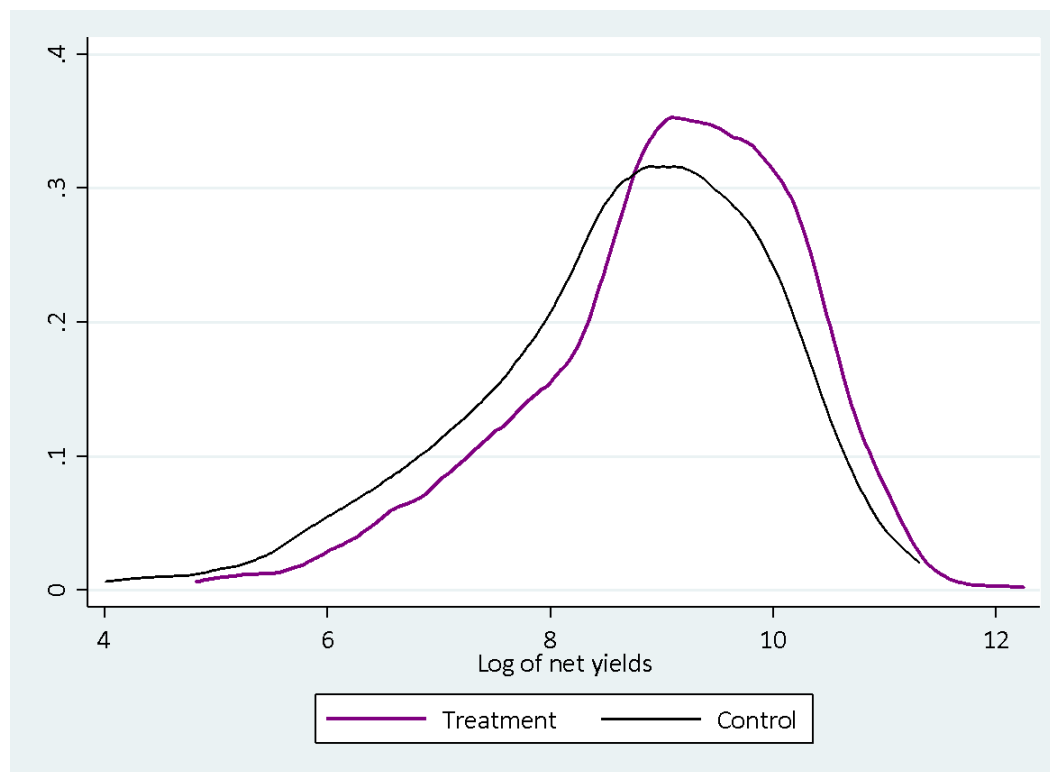
Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: Maintaining a refuge border area is required only for Bt plots. Therefore, the total area and net area for treatment farmers are different, but these areas are the same for among control farmers.

The distribution of yields across Bt brinjal and control households and log net yields were calculated. Density functions were plotted. The null hypothesis, which is that these distributions are equal, was tested.

Figure 7.1 shows that, relative to control households, the distribution of (log) net Bt brinjal yields per ha is shifted to the right. This suggests that mean differences between treatment and control households is not driven by a small number of households but rather that Bt brinjal yields are generally higher than the non-Bt brinjal variety (ISD-006).

Figure 7.1 Kernel density functions for net yields per ha, by treatment status



Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

7.3 Basic Impact Results

An ANCOVA specification and the same household controls (years of education, age and years worked as a farmer or person with primary responsibility for brinjal production, wealth index, and land operated (acres) at baseline) was used to assess impacts on outcomes. Standard errors account for clustering at the level of randomization, the village.

Table 7.2 shows that on a per ha basis, net yields (one of the primary outcomes) are approximately 3,600 kg higher when farmers grow Bt brinjal. These results are robust to expressing the outcome variable as gross or net yields, including or excluding control

variables apart from baseline values, winsorizing the data to account for outliers,¹⁵ or expressing the dependent variable in logs (all these specification tests were pre-specified in the pre-analysis plan). The log results indicate that net yields are 42 percent higher for Bt brinjal farmers.

Table 7.2 Impact of Bt brinjal on yields

Outcome	(1) Gross yield per ha	(2) Gross yield per ha	(3) Net yield per ha	(4) Net yield per ha
Treatment: Bt brinjal	2,420.1* (1,319.9)	2,355.6* (1,318.4)	3,624.1*** (1,241.8)	3,622.1*** (1,234.6)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes
Observations	1,166	1,166	1,166	1,166

Table 7.2 Impact of Bt brinjal on yields (continued)

Outcome	(5) Net yield per ha winsorized	(6) Net yield per ha winsorized	(7) Log Net yield per ha	(8) Log Net yield per ha
Treatment: Bt brinjal	3,367.2*** (1,129.6)	3,372.9*** (1,129.7)	0.417*** (0.117)	0.420*** (0.119)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes
Observations	1,166	1,166	1,114	1,114

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level.

* significant at the 10% level; *** significant at the 1% level. Columns (1), (3), (5), and (7) do not control for household characteristics. Columns (2), (4), (6), and (8) do account for these household controls.

¹⁵ Winsorizing is a method of addressing outliers in data. When winsorizing, one converts the values of data points that are considered to be outlying high (low) to the highest (lowest) value not considered to be an outlier (Reifman and Keyton 2010). As noted in section 2.3, we winsorize by setting the values of the bottom two percentiles equal to the second percentile and by setting the values of the top two percentiles equal to the 98th percentile.

During focus group discussions, most Bt brinjal farmers asserted that they achieved higher yields and higher fruit weight compared to non-Bt brinjal. Treatment farmers in Gobindaganj Upazila, Gaibandha District, indicated that their 10-decimal plots each yielded between 40 to 55 *maunds*—that is, 1,600 to 2,200 kg each, which is about 15 to 20 *maunds* (600 to 800 kg) greater than previous yields from conventional brinjal. In Gaibanda Sadar Upazila, Gaibanda District, treatment farmers noted that local brinjal yield was approximately 1 kg per plant, whereas Bt brinjal yields were three-fold, with up to 3 kg per plant.

7.4 Mechanisms and Extensions

Table 7.3 explores the mechanisms underlying these results. Relative to the control farmers growing ISD-006, Bt brinjal farmers produced 113.6 kg more brinjal (column 2) per farmer. After harvesting, they discarded 42.9 kg less than control farmers (column 6). Bt brinjal farmers sold 146 kg more brinjal. All impacts are statistically significant at the 5 percent level.

Limited exploration of sample disaggregations by median farmer age, education, and total land holdings produced no evidence of differential impact related to net yields.

Table 7.3 Impact of Bt brinjal on harvest, plot area, quantity discarded, paid out, retained for consumption and sold

Outcome	(1) Harvest kg	(2) Harvest kg	(3) Area planted ha	(4) Area planted ha	(5) Qty discarded kg	(6) Qty discarded kg
Treatment: Bt brinjal	117.7** (54.0)	113.6 ** (54.0)	.002** (.001)	.002** (.001)	-40.54*** (9.88)	-42.92*** (10.36)
Controls						
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes	No	Yes
Observations	1,166	1,166	1,166	1,166	1,166	1,166

Table 7.3 Impact of Bt brinjal on harvest, plot area, quantity discarded, paid out, retained for consumption and sold (*continued*)

Outcome	(7) Qty paid out kg	(8) Qty paid out kg	(9) Qty retained for home consumption kg	(10) Qty retained for home consumption kg	(11) Qty sold kg	(12) Qty sold kg
Treatment: Bt brinjal	5.54 (4.91)	5.67 (4.94)	6.85*** (2.19)	6.46*** (2.09)	145.1*** (49.3)	143.8*** (49.3)
Controls						
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes	No	Yes
Observations	1,166	1,166	1,166	1,166	1,166	1,166

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. ** significant at the 5% level; *** significant at the 1% level. Columns (1), (3), (5), (7), (9), and (11) do not control for household characteristics. Columns (2), (4), (6), (8), (10), and (12) do account for these household controls.

7.5 Summary

Bt brinjal raised yields (defined as quantity of fruits harvested in kg minus fruit discarded for any other reason, including damage due to pests or other diseases, all divided by area cultivated in ha), and the magnitude of this impact is large—net yields are approximately 40 percent higher for Bt brinjal farmers. This result is robust to model specification for yields in gross or net terms and remains after accounting for outliers. The descriptive distributional work suggests that these yield gains are widespread.

Differences in net yields are driven by two outcomes: average quantity harvested is higher on Bt brinjal fields, by 113 kg per farmer; and after harvesting, fewer fruits were discarded because of damage due to diseases, by 43 kg. Consequently, Bt brinjal farmers sold, on average, 143 kg more brinjal. These impacts are statistically significant at the 1 percent level. There are no statistical differences when disaggregated by age, education, or land area operated.

Qualitative findings from treatment farmers and SAAOs coincide with our impact results, noting higher yields and less wastage due to Bt brinjal cultivation.

8. IMPACTS OF BT BRINJAL: MARKETING, COSTS, AND REVENUES

8.1 Marketing of Brinjal

The study sought to develop an understanding of how marketing of Bt brinjal compares with non-Bt brinjal varieties, whether Bt brinjal was sold at different prices, and the profitability of growing Bt brinjal.

8.1.1 Type of Buyer

Approximately two-thirds of brinjal farmers (65.4 percent of treatment and 61.5 percent of control farmers) sold some portion of their brinjal output to wholesalers.

Table 8.1 shows that about 13 percent of the farmers did not sell any of their brinjal at all, with slightly more control farmers not selling their output compared with treatment farmers. It is unclear why farmers withheld their brinjal from the market. Our qualitative findings point to several possible explanations. One possibility is seasonal price variation. One farmer in Gobindapur Village, Naogaon District, noted that sometimes the market price in winter falls so low that farmers do not take their produce to the market. A second explanation is that farm households kept some of their brinjal for home consumption.

Being paid a high or fair price is the prevailing factor explaining how farmers select buyers (38.3 percent), followed by receiving immediate payment (30.3 percent), and bulk purchases (19.6 percent).

A treatment farmer in Gopalpur Village, Mohadevpur Upazila, Naogaon District, explained that market traders' preferences for brinjal vary by region, but brinjal's color and shape typically matter for receiving a good price per unit. In his area, traders want to buy the *Tal begun* variety, a large purple brinjal (not round), at Tk 600 to 700 per *maund* (40 kg). He noted that the *Tal begun* variety is not consumed locally but enjoys high demand in Dhaka. On the other hand, he said that Bt brinjal-4, which is green and round, is typically not chosen by traders, and fetches only 220 per *maund*.

Table 8.1 Marketing of brinjal at endline

	Treatment (n=595)	Control (n=594)	All (n=1189)
	(percent)		
<i>Main buyer of brinjal</i>			
Wholesaler	65.4	61.5	63.4
Retailer	10.9	10.6	10.8
Consumer	9.2	8.9	9.1
Village collector	2.4	4.7	3.5
Others	0.5	0.0	0.3
Did not sell	11.6	14.3	13.0
<i>Major reason for the choice of buyer</i>			
Pays high/fair price	39.7	36.7	38.3
Makes immediate payment	31.8	28.9	30.3
Buys in bulk	18.8	20.4	19.6
Buys limited quantity	5.5	8.1	6.8
Lives nearby	2.1	3.0	2.5
Makes advance payment	0.2	0.8	0.5
No other option	1.9	2.2	2.0
<i>Location of sales</i>			
District wholesale market	44.3	44.4	44.4
Local retail market	43.4	42.8	43.1
Farmer's field / own property	10.5	10.6	10.5
Another district wholesale market	1.3	1.6	1.5
Other wholesale market	0.0	0.6	0.3
Others	0.6	0.0	0.3
<i>Price was agreed upon over phone</i>	39.0	33.3	36.6
<i>Means of transportation</i>			
Tricycle	57.0	57.2	57.1
Motorized van	18.3	17.9	18.1
Headload	9.5	10.8	10.1
Bicycle	8.9	7.7	8.3
Motorbike	1.0	1.0	1.0
Rickshaw	0.2	0.6	0.4
Push cart	0.2	0.0	0.1
Truck/pickup	0.0	0.6	0.3
Others	0.6	0.0	0.3
Sold at home	4.4	4.3	4.4

Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

8.1.2 Location of Sale

Treatment farmers noted that traders visit farmers when market prices are high. But when demand is low, farmers typically transport their crops to the market. About 44 percent of all study farmers sold their brinjal at the district wholesale market, while the local retail market was the second preference at 43.1 percent. As the sale locations are consistent between treatment and control farmers, these findings suggest that treatment farmers were not compelled to change where they sell their output in order to sell the new variety.

8.2 Cost of Production

The study collected plot-level data on the input costs for treatment and control farmers. The average prices are multiplied by respective input coefficients to calculate per ha costs of these inputs. Costs of irrigation, seedling raising, pesticide use, and mechanical power per plot are obtained directly from the survey and converted into per ha costs.

Most farmers in Bangladesh rely heavily on family labor for crop cultivation. If family members cannot find other jobs, or if family labor will not be offered to the market when the crop in question is not produced, then the opportunity cost of family labor is likely to be much lower than prevailing labor wage rates. However, when labor must be hired to supplement family labor, the use of a market wage rate to value family labor may be appropriate (Ahmed 1994). Although the surveys for this study collected information on the use of both hired and family labor, only the cost of hired labor is used in this analysis as the opportunity cost of family labor is unknown. Hired labor coefficients for different activities are multiplied by respective wages for these activities to obtain labor costs.

Table 8.2 Input costs per hectare for Bt brinjal and non-Bt brinjal (ISD-006) cultivation at endline

Cost	Treatment	Control
	(Tk per ha)	
Seed/seedling	5,461	5,539
Fertilizer	30,326	32,026
Irrigation	11,241	11,867
Pesticide	14,852	22,145
Machinery	7,600	8,097
Total hired labor	2,505	2,227
Total cash cost	72,109	81,902

Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

Table 8.2 features a breakdown of costs of inputs per ha for treatment farmers cultivating Bt brinjal and control farmers growing non-Bt brinjal. The total costs of production for Bt brinjal per ha are lower than for ISD-006 at endline (Tk 72,109 for treatment versus Tk 81,902 for control farmers), mainly because Bt brinjal farmers spent considerably less on pesticides than did control farmers.

The qualitative research validated the quantitative findings on lower input costs for Bt farmers. For example, one SAAO in Pargacha Upazila, Rangpur District, indicated that Bt brinjal required less pesticide:

In brinjal cultivation, the main cost is pesticides, but in Bt brinjal cultivation, there was less pesticide required than the regular varieties. Spraying once in a week was enough for Bt [brinjal], whereas other varieties required as often as three times a week. This is a financial savings for farmers.

Another SAAO in Gaibandha Sadar Upazila, Gaibandha District, attempted to quantify farmers' savings from lower pesticide use due to Bt brinjal's resistance to FSB:

Normal brinjal requires spraying [pesticide] every five days for majra poka [fruit and shoot borer], but since Bt brinjal deters majra poka, no spraying is required for that pest each month. One time's spraying costs about Tk 300, amounting to Tk 1,200 each month if farmers need to spray four times.

8.3 Labor Use

Labor is one of the most critical inputs in agricultural production and has significant ramifications for the costs and benefits of growing crops. The survey collected information on hours of work in brinjal fields, disaggregated by male and female labor and by activities, from preparing land to harvesting to uprooting brinjal plants. These figures were then converted to labor days based on the standard eight-hour-per-day norm. Labor days were then expressed in per ha terms.

Table 8.3 presents descriptive statistics on labor use (days per ha) from the endline survey. Patterns of the labor use are very similar for the treatment and control groups by cultivation activity. The total labor use among the treatment group is 6 percent less than the control group (percentage difference between total treatment labor and total control labor). The major difference in labor use is in pesticide application, which is 30 percent less among the treatment group than the control group at endline (percentage difference between total treatment labor and total control labor for pesticide application). Among the various activities, weeding requires the most labor input (37.2

percent of the total labor days per ha), followed by harvesting (19.2 percent of the total labor days per ha).

The labor use patterns also show that participation of female workers in brinjal cultivation is significantly lower than male workers' participation. Overall, total female labor days per ha in brinjal cultivation activity is 82 percent lower than total male labor days per ha. Female labor participation is highest for harvesting and post-harvesting operations, like sorting and packing; and male labor participation is highest for weeding and harvesting. Scarcely any female labor was used for pesticide application.

In general, mainly family labor is used for brinjal cultivation among the surveyed farmers. Hired labor is mostly used for weeding, which accounts for 68 percent of total hired labor days per ha.

Table 8.3 Labor use for Bt brinjal cultivation: Days per hectare by cultivation activities: Study plot (endline)

Activity	Family labor						Hired labor						Total labor				
	Treatment			Control			Treatment			Control			Total male labor	Total female labor	Total labor (Treatment)	Total labor (Control)	Total labor (Treatment + Control)
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total					
	(Labor days)						(Labor days)						(Labor days)				
Land preparation	18.8	0.9	19.7	19.2	1.4	20.7	6.8	0.2	7.0	7.7	0.2	7.8	52.5	2.7	26.7	28.5	55.2
Transplanting	20.2	2.6	22.8	21.0	2.2	23.3	12.5	1.0	13.5	11.9	0.1	12.0	65.7	5.9	36.3	35.3	71.6
Fertilizer application	10.9	0.1	11.0	13.3	0.3	13.6	0.6	0.0	0.6	0.6	0.0	0.6	25.3	0.4	11.5	14.2	25.7
Pesticide application	23.1	0.3	23.4	35.4	0.5	35.9	3.6	0.0	3.6	2.7	0.0	2.7	64.8	0.8	27.0	38.5	65.5
Weeding	59.1	5.8	64.9	63.6	5.2	68.8	61.4	10.8	72.2	59.6	6.8	66.5	243.7	28.6	137.0	135.3	272.3
Irrigation	4.2	0.1	4.3	4.2	0.1	4.3	0.6	0.0	0.6	0.4	0.0	0.4	9.4	0.2	4.9	4.7	9.6
Harvesting	45.5	19.9	65.4	48.3	21.9	70.2	0.9	0.7	1.6	2.2	1.6	3.7	96.9	44.1	67.1	73.9	141.0
Sorting and packing	13.5	11.3	24.9	13.6	12.1	25.6	0.3	0.2	0.6	0.1	0.1	0.2	27.6	23.7	25.5	25.9	51.3
Plant uprooting	13.2	1.2	14.3	15.4	1.2	16.6	4.3	0.2	4.4	4.5	0.2	4.7	37.3	2.8	18.8	21.3	40.1
Total	208.4	42.4	250.7	234.1	44.8	278.9	91.0	13.1	104.1	89.7	9.0	98.7	623.1	109.2	354.8	377.6	732.3

Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

8.4 Impact Results

An ANCOVA specification for estimating impacts is employed and controls for age, years of education, wealth, number of years working as a farmer, and the size of operated land at baseline are used. Standard errors account for clustering at the village level.

Table 8.4 presents the impact of Bt brinjal on cost. Bt brinjal cost of production per ha was Tk 9,261 lower than non-Bt brinjal production cost (column 1). When the data are winsorized to reduce outlier bias, the cost of Bt brinjal production is Tk 8,266 lower per ha than local brinjal production cost (column 4). Overall, the cost of Bt brinjal production per ha dropped by about 11 percent (column 6) and cost per kg reduced by 31 percent (column 10), which are statistically significant at the 1 percent level.

Table 8.4 Impact of Bt brinjal on input costs

Outcome	(1) Cost per ha	(2) Cost per ha	(3) Cost per ha winsorized	(4) Cost per ha winsorized	(5) Log cost per ha	(6) Log cost per ha
Treatment: Bt brinjal	-9,260.5*** (2131.8)	-9,260.4*** (2129.5)	-8,214.6*** (1995.0)	-8,265.5*** (1996.8)	-0.105*** (.028)	-0.105*** (.028)
Controls						
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes	No	Yes
Size of operated land at baseline	No	Yes	No	Yes	No	Yes
Observations	1,174	1,174	1,174	1,174	1,174	1,174

Table 8.4 Impact of Bt brinjal on input costs (continued)

Outcome	(7) Cost per kg	(8) Cost per kg	(9) Log cost per kg	(10) Log cost per kg
Treatment: Bt brinjal	-8.17 ** (4.04)	-8.31 ** (4.06)	-0.309*** (0.102)	-0.310*** (0.103)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land at baseline	No	Yes	No	Yes
Observations	1,122	1,122	1,122	1,122

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. ** significant at the 5% level; *** significant at the 1% level. Columns (1), (3), (5), (7), and (9) do not control for household characteristics. Columns (2), (4), (6), (8), and (10) do account for these household controls.

Table 8.5 shows the impact of Bt brinjal on the cost of pesticide use (including costs of pesticides and hired labor cost for pesticide application), with identical household controls applied. Treatment farmers' cost of pesticide per ha was reduced by Tk 6,715 (column 2), translating to a 42 percent reduced cost compared to control farmers (column 4). The cost of pesticide per kg of brinjal for treatment farmers growing Bt brinjal was 62 percent less than for control farmers (column 8). Results across the board are statistically significant at the 1 percent level.

Table 8.5 Impact of Bt brinjal on cost of pesticide use

Outcome	(1) Cost of pesticide per ha	(2) Cost of pesticide per ha	(3) Log cost of pesticide per ha	(4) Log cost of pesticide per ha
Treatment: Bt brinjal	-6,652.2*** (1,120.3)	-6,714.7*** (1,118.6)	-0.418*** (.057)	-0.423*** (.057)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes
Observations	1,174	1,174	1,147	1,147

Table 8.5 Impact of Bt brinjal on cost of pesticide use (continued)

Outcome	(5) Cost of pesticide per kg	(6) Cost of pesticide per kg	(7) Log cost of pesticide per kg	(8) Log cost of pesticide per kg
Treatment: Bt brinjal	-3.53*** (1.01)	-3.57*** (1.03)	-0.615*** (.109)	-0.618*** (.110)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land at baseline	No	Yes	No	Yes
Observations	1,122	1,122	1,102	1,102

Source: 2017 Baseline and endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. *** significant at the 1% level. Columns (1), (3), (5), and (7) do not control for household characteristics. Columns (2), (4), (6), and (8) do account for these household controls.

Table 8.6 illustrates descriptive statistics of total sales revenue per farmer, unit value of sales, and total value of sales per ha. The results show that Bt brinjal farmers received higher revenues than conventional brinjal (ISD-006) farmers at endline.

Table 8.6 Mean sales revenue at endline, by treatment status

	Treatment (n=593)	Control (n=583)	All (n=1176)
Total value of sales (revenue) per farmer (Tk)	4,342	2,448	3,403
Selling price (Tk per kg)	8.6	7.6	8.1
Total value of sales (revenue) per ha (Tk)	1,22,865	96,138	1,09,501

Source: 2018 Endline survey for Bt Brinjal Impact Evaluation, IFPRI.

Focus group discussions with treatment farmers revealed that although brinjal prices fluctuated with market demand, farmers more often sold Bt brinjal to market traders at higher prices than conventional brinjal. One farmer from Gabindoganj Upazila, Gaibandha District, shared that he sold Bt brinjal at Tk 1,200 per *maund* initially, whereas local brinjal sold at Tk 500 to 700 per *maund*. Later, when he sold Bt brinjal for Tk 750 per *maund*, the local variety selling price was Tk 200 to 300 per *maund*. Market traders tend to buy Bt brinjal at higher prices, but also sell at higher prices in the market. According to a farmer from Gangachara Upazila, Rangpur District, the market price for Bt brinjal is higher than conventional brinjal.

The qualitative fieldwork suggests that some market traders experienced difficulties in marketing Bt brinjal. One market trader spoke about his experience managing low consumer demand for Bt brinjal:

At the beginning, I could not sell this brinjal in this market; I forced them to take it, especially those who are known to me and come every day. I told them no problem if you do not pay money. Then, when they took the brinjal home and ate it, they told me to give them more brinjal. Since then, demand is increasing. In fact, it was not sold for two or three days at the beginning. After that, I enticed all of them to buy. Since then, I do not have any problems.

During IFPRI's monitoring field visits for the study, treatment farmers and DAE monitoring officials frequently reported that farmers received higher prices for Bt brinjal compared to other brinjal because Bt brinjal looked better and had no marks of infestation or holes. Therefore, buyers preferred Bt brinjal and paid higher prices.

Table 8.7 describes the impact of Bt brinjal cultivation on sales revenue. Bt brinjal increased sales revenue by Tk 29,005, controlling for household characteristics (column 2). This increase in sales revenue resulted from higher yields and the higher selling price of Bt brinjal compared with ISD-006. This increase translates to a 27.3 percent increase in revenue per ha (column 4). All results presented are statistically significant at the 1 percent level.

Table 8.7 Impact of Bt brinjal on total sales revenue

Outcome	(1) Value of sales Tk per ha	(2) Value of sales Tk per ha	(3) Log value of sales Tk per ha	(4) Log value of sales Tk per ha
Treatment: Bt brinjal	29894.4*** (475.7)	29005.6*** (465.7)	.276** (0.115)	.273** (0.116)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land at baseline	No	Yes	No	Yes
Observations	1,174	1,174	1,122	1,122

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. ** significant at the 5% level; *** significant at the 1% level. Columns (1) and (3) do not control for household characteristics. Columns (2) and (4) do account for these household controls.

Bt brinjal had positive impacts on sales revenue for treatment farmers, with a 27.3 percent increase in sales revenue per ha and a 10.9 percent increase in sales revenue per kg.

Table 8.8 provides the impact of Bt brinjal on price for those who sold in the market. The unit price increased by 10 percent (around Tk 1 per kg) as a result of selling Bt brinjal (column 4).

Qualitative findings suggest that treatment farmers were satisfied with certain aspects of Bt brinjal but not others. For example, although some farmers reported that they were satisfied with the Bt brinjal fruit color, texture, and size, others were disappointed with the late bearing of flowers and fruit. However, it is worth noting that the late bearing of flowers and fruit, a consequence of the adverse weather, affected both treatment farmers growing Bt brinjal *and* control farmers growing conventional brinjal (ISD-006).

Nevertheless, the delay in bearing of flowers and fruit was concerning to many farmers as they perceived that this contributed to lower market prices due to delayed harvest and the higher supply of brinjal in the market. Farmers and agriculture extension officials suggested that shifting brinjal production to times when there is lower supply of brinjal in the market may increase demand and profits for Bt brinjal.

Table 8.8 Impact of Bt brinjal on price for those who sold

Outcome	(1) Unit price Tk per kg	(2) Unit price Tk per kg	(3) Log unit price Tk per kg	(4) Log unit price Tk per kg
Treatment: Bt brinjal	0.78* (0.418)	0.74* (0.416)	0.113** (0.053)	0.109** (0.053)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes
Observations	1,122	1,122	1,122	1,122

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. * significant at the 10% level; ** significant at the 5% level. Columns (1) and (3) do not control for household characteristics. Columns (2) and (4) do account for these household controls.

Next, Table 8.9 shows the impact of Bt brinjal on profits (Table 8.8). Treatment farmers increased profits by Tk 38,063 per ha (column 2). When the data are winsorized to account for any potential outliers, the profits per ha change to an increase by Tk 33,827 (column 4). Similarly, profits per kg increase to Tk 9.11 (column 6), controlling for household characteristics and size of operated land at baseline.

Table 8.9 Impact of Bt brinjal on net profit

Outcome	(1) Profit per ha	(2) Profit per ha	(3) Profit per ha winsorized	(4) Profit per ha winsorized	(5) Profit per kg	(6) Profit per kg
Treatment: Bt brinjal	38,967.6*** (10,806.5)	38,063.4*** (10,815.0)	34,359.0*** (9,156.3)	33,827.0*** (9,216.9)	9.00** (4.04)	9.11** (4.06)
Controls						
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	Yes	No	Yes	No	Yes
Size of operated land in baseline	No	Yes	No	Yes	No	Yes
Observations	1,174	1,174	1,174	1,174	1,122	1,122

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Controls are age and education of household head; wealth; number of years working as a farmer and size of the operated land in baseline. Standard errors (in parentheses) clustered at the village level. **

significant at the 5% level; *** significant at the 1% level. Columns (1), (3), and (5) do not control for household characteristics. Columns (2), (4), and (6) do account for these household controls.

8.5 Summary

This section examined the changes in costs of production and revenues as a result of cultivating Bt brinjal.

Bt brinjal production costs per ha were significantly less than cultivating the local conventional brinjal (Tk 72,109 for treatment farmers versus Tk 81,902 for control farmers), amounting to an 11 percent reduction in production costs per ha and 30 percent reduction per kg—both statistically significant at the 1 percent level. Differences in production costs are primarily explained by treatment farmers' lower pesticide use. The difference in production costs per ha amounts to a Tk 9,793 savings for treatment farmers cultivating Bt brinjal.

Bt brinjal cultivation increases gross revenues from brinjal production (total production \times price received) by 27.3 percent, resulting in an increase in values by Tk 29,005 per ha. The impact of Bt brinjal on net profits amounts to Tk 33,827 per ha (which is 13.9 percent higher for Bt brinjal), or Tk 9.1 per kg.

Overall, the results are mutually supportive—cost of production drops, particularly driven down by reduced pesticide costs, and revenues increase, mainly because of higher yields of Bt brinjal and higher price. The lower cost of production and higher gross revenues result in a substantial increase in profits from cultivating Bt brinjal for treatment farmers compared to non-Bt brinjal produced by control farmers. This savings of Tk 9,261 per ha reflects a savings of Tk 245 per brinjal farmer, given that average cultivated land for Bt brinjal is 0.042 ha (Table 7.1).

9. IMPACTS OF BT BRINJAL: HEALTH

9.1 Introduction

As discussed in Section 6, Bt brinjal reduces the use of pesticides, including those that are particularly hazardous to human health. This section assesses potential health outcomes of this reduced use and reductions in the self-reporting of symptoms and illness consistent with pesticide exposure.

9.2 Data and Descriptive Statistics

In this section, unlike the previous section, the unit of observation is the individual, not the household. In both the baseline and endline surveys, individuals in the household who reported undertaking work on any field crops were asked if they had experienced eye irritation, headaches, dizziness, nausea or vomiting, diarrhea, fever, convulsions, shortness of breath, wheezing or coughing, skin disease, or joint pain (stiffness, swelling).¹⁶ The reference period for the baseline survey was the previous brinjal growing season; the reference period for the endline survey was the period from November 2017 to June 2018. This yields a dataset containing information on 2,531 individuals who were also asked how many days these symptoms persisted, the number of days during the agricultural season that these symptoms prevented the individual from working, and cash medical expenses associated with treating these symptoms.

Table 9.1 shows that at baseline, the average age of the respondent was 41. Somewhat more than half of the sample were male (62 percent) and 38 percent were female.¹⁷ Just under half (46 percent) were household heads. About a third of the respondents (31 percent) were spouses of the head, with 18 percent were children, sons- or daughters-in-law, or grandchildren of the head, and 5 percent were other relatives of the household head.

¹⁶ The surveys were designed to collect basic information on all household members in Module B, followed by information on illness in Module C to facilitate continuity between questionnaire sections. Module C1 collected general health information on all household members, whereas Module C2 focused only on household members who worked in any crop fields during the last brinjal season, whether it was brinjal or non-brinjal, which are discussed here.

¹⁷ At baseline, at least one household member from 1,185 households worked in (any) crop fields during the last brinjal season. There were 3,090 individuals total who worked in crop fields at baseline. The average number of members that worked in crop fields per household is 2.6. At endline, at least one household member from 1,190 households worked in (any) crop fields between November 2017 and June 2018. The total number of individuals who worked in crop fields at baseline was 3,245. The average number of members that worked in crop fields per household is 2.7.

Most (69 percent) reported at least one symptom consistent with pesticide exposure and, on average, respondents reported experiencing 1.9 such symptoms in the past year. A third (34 percent) reported that they missed at least a day's work because of these symptoms; days of work missed averaged 1.9 days. Just under half (42 percent) reported that they sought medical attention to address these symptoms and 58 percent stated that they had incurred cash expenses to deal with these. On average, individuals spent Tk 675 on fees, tests, transport, and medicines when treating these symptoms. Note that the variation in these expenses (standard deviation is 3,457) is high relative to the mean. The final set of results disaggregates these outcomes by treatment status; there are no meaningful differences between individual self-reports in treatment and control villages.

Table 9.1 Descriptive statistics for analysis of self-reported health status, baseline

	Mean	Standard Deviation
Demographic characteristics		
Age	40.8	14.2
Female	0.38	0.49
Head of household	0.46	0.50
Spouse of head	0.31	0.46
Child, son/daughter-in-law or grandchild of head	0.18	0.39
Other relation	0.05	0.22
Self-reported health status		
Any symptom consistent with pesticide exposure	0.69	0.46
Number of symptoms	1.85	1.78
Any work days lost because of symptoms	0.34	0.47
Number of days lost because of symptoms	1.89	4.53
Sought treatment for symptoms	0.42	0.49
Incurred expenses to address symptoms	0.58	0.49
Medical expenses incurred to address symptoms (Taka)	675	3,457
Self-reported health status by treatment status		
	Control	Treatment
Any symptom consistent with pesticide exposure	0.66	0.72
Number of symptoms	1.77	1.93
Any work days lost because of symptoms	0.30	0.38
Number of days lost because of symptoms	1.47	2.28
Sought treatment for symptoms	0.39	0.45
Incurred expenses to address symptoms	0.55	0.61
Medical expenses incurred to address symptoms (Taka)	519	827

Source: 2017 Baseline survey for Bt Brinjal Impact Evaluation, IFPRI.

Note: Sample size is 2,531.

9.3 Results

An ANCOVA specification was used and the same household controls (years of education, age, and years worked as a farmer or person with primary responsibility for brinjal production, wealth index, and land operated (acres) at baseline) were used, consistent with previous sections, to assess outcomes in other domains. Because illness is reported at an individual level, individual characteristics (age, sex, relationship to household head) were also controlled for. As self-reported illness data are only available for individuals who engaged in crop cultivation, the sample was restricted to the 2,531 individuals who were involved in cultivating crops at both baseline and endline. Linear probability models were used when the outcome is dichotomous, Tobit and Poisson estimators for count outcomes, and Tobit estimators when the outcome is continuous but censored at zero. Standard errors account for clustering at the level of randomization, the village.

Table 9.2 shows the impact of Bt brinjal cultivation on self-reported symptoms consistent with pesticide exposure. Of all individuals in the control group engaged in brinjal cultivation at endline, 62.5 percent reported at least one symptom consistent with pesticide exposure. Treatment farmer households, with individuals in the treatment group growing Bt brinjal from November 2017 to June 2018, were 6.2 to 7.5 percentage points less likely to report symptoms consistent with pesticide exposure (columns 1 and 2) than individuals in control households. This is equivalent to a 10 percent reduction in the likelihood of reporting symptoms consistent with pesticide exposure. Table 9.2 also considers whether Bt brinjal cultivation reduces the *number* of reported symptoms. Assessing this is complicated by the fact that this outcome is (1) bounded (or censored) at zero, and (2) is a count, not a continuous outcome. Econometrically, this can be addressed in two different ways: (1) by estimating a Tobit regression, and (2) by estimating a Poisson regression. Both estimators report a negative coefficient. However, some but not all estimates show a statistically significant reduction; these impacts are sensitive to model specification and the estimator chosen.

Three checks on model specification were estimated. (1) For the core results, the reduction in reported symptoms and the seeking of medical care was re-estimated using a probit and calculate marginal effects. This produces almost the same results as those generated by the linear probability model. (2) the number of days lost because of these symptoms and the cash costs associated with treatment were winsorized. Re-estimating with the winsorized data does not produce statistically significant impacts. (3) For days lost and cash costs, Powell's (1984) censored least absolute deviations estimator (CLAD) was run; this does not produce statistically significant impacts either. Results should be interpreted with caution as individual self-report can be subject to bias.

Table 9.2 Impact of Bt brinjal cultivation on self-report of symptoms consistent with pesticide exposure

Outcome	(1) Any symptom of pesticide exposure	(2) Any symptom of pesticide exposure	(3) # symptoms of pesticide exposure	(4) # symptoms of pesticide exposure	(5) # symptoms of pesticide exposure	(6) # symptoms of pesticide exposure
Estimator	LPM	LPM	Tobit	Tobit	Poisson	Poisson
Treatment: Bt brinjal	-0.075** (0.032)	-0.062** (0.032)	-0.304** (0.149)	-0.268* (0.148)	-0.117* (0.068)	-0.103 (0.068)
Controls						
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	No	Yes	No	Yes	No	Yes
Household characteristics	No	Yes	No	Yes	No	Yes
Observations	2,531	2,531	2,531	2,531	2,531	2,531

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: Individual characteristics are age, sex and relationship to household head. Household characteristics include characteristics of the individual responsible for brinjal production (age, education, years working as a farmer), land operated by the household and household wealth index derived from principal components (using number of rooms in the dwelling; whether the dwelling has electricity; physical states of the dwelling and ownership of the following consumer durables: wrist watch, color tv, bicycle, tri van, motorcycle and solar panels). Standard errors (in parentheses) clustered at the village level. ** significant at the 5% level; * significant at the 10% level. Columns (1), (3), and (5) do not control for individual and household characteristics. Columns (2), (4), and (6) do account for individual and household controls.

Individuals in households growing Bt brinjal were 6.5 to 7.7 percentage points less likely than control farmers at endline to report that they needed to seek medical care for these symptoms (Table 9.3). When the impact of Bt brinjal cultivation on the level of medical expenses associated with treating these symptoms is considered, there is a negative impact (that is, cash expenses are lower) but these estimates are not statistically significant (Table 9.3).

Table 9.3 Impact of Bt brinjal cultivation on consequences of symptoms consistent with pesticide exposure compared to control households

Outcome	(1) Symptoms prevented person from working	(2) Symptoms prevented person from working	(3) Sought medical treatment for any of these symptoms?	(4) Sought medical treatment for any of these symptoms?	(5) Incurred cash expenses associated with treating symptoms?	(6) Incurred cash expenses associated with treating symptoms?	(7) Cash expenses associated with treating symptoms	(8) Cash expenses associated with treating symptoms
Estimator	LPM	LPM	LPM	LPM	LPM	LPM	Tobit	Tobit
Treatment: Bt brinjal	-0.034 (0.026)	-0.024 (0.025)	-0.077** (0.035)	-0.065* (0.034)	-0.061* (0.032)	-0.048 (0.031)	-220.8 (224.6)	-172.7 (219.6)
Controls								
Baseline outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Household characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2,531	2,531	2,531	2,531	2,531	2,531	2,531	2,531

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: See Table 9.2. ** significant at the 5% level; * significant at the 10% level. Columns (1), (3), (5), and (7) do not control for individual and household characteristics. Columns (2), (4), (6), and (8) do account for individual and household controls. Standard errors (in parentheses) clustered at the village level.

Table 9.4 disaggregates key findings by sex; there is no statistically significant difference in impacts between men and women, but with smaller sample sizes, there is a slight loss of precision. Disaggregating other outcomes by sex does not reveal any other differences in these outcomes. These impact models were also estimated, disaggregated by age and, separately, by relationship to household head. These disaggregations show similar coefficients across different groups but again, with smaller sample sizes and in some instances, loss of precision.

Table 9.4 Selected impacts on self-reported health outcomes, by sex

Outcome	(1) Any symptom of pesticide exposure	(2) Any symptom of pesticide exposure	(3) Sought medical treatment for any of these symptoms?	(4) Sought medical treatment for any of these symptoms?
	Women	Men	Women	Men
Estimator	LPM	LPM	LPM	LPM
Treatment: Bt brinjal	-0.072* (0.038)	-0.058* (0.033)	-0.083** (0.040)	-0.051 (0.036)
Controls				
Baseline outcome	Yes	Yes	Yes	Yes
Individual characteristics	No	Yes	No	Yes
Household characteristics	No	Yes	No	Yes
Observations	970	1,561	970	1,561

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: See Table 9.2. ** significant at the 5% level; * significant at the 10% level. Columns (1) and (3) do not control for individual and household characteristics. Columns (2) and (4) do account for individual and household controls. Standard errors (in parentheses) clustered at the village level.

Many individuals in the sample have worked as farmers for decades, have been exposed to pesticides for a very long time, and consequently may have developed chronic conditions consistent with pesticide exposure. To assess whether the presence of pre-existing chronic conditions might affect these results, the sample was disaggregated into two groups: those who reported suffering from either persistent respiratory problems or persistent skin disease at baseline belonged to one group (approximately 20 percent of the sample, 522/2,531), and the other group representing those not suffering from these chronic conditions at baseline.

Results are reported in Table 9.5. Individuals who had a pre-existing chronic condition consistent with pesticide exposure, and who lived in villages randomly selected to grow Bt brinjal were 11 percentage points less likely to report a symptom of pesticide exposure, reported 0.2 fewer such symptoms, were 12 percentage points less likely to seek medical care for these symptoms, and were 11 percentage points less likely to incur cash medical expenses to treat these symptoms. All impacts are statistically significant at the 5 percent level.¹⁸ Impacts for individuals who did not have these pre-existing chronic conditions are smaller in magnitude. For this group, only one outcome is statistically significant (any symptom consistent with pesticide exposure). However, we cannot reject the null hypothesis that symptoms of pesticide exposure impacts are equal across individuals with or without pre-existing conditions.

¹⁸ There were no statistically significant impacts for either group for symptoms that prevented a person from working or level of cash expenses associated with treating symptoms.

Table 9.5 Selected impacts on self-reported health outcomes, by chronic disease status

Outcome	(1) Any symptom of pesticide exposure	(2) Any symptom of pesticide exposure	(3) # symptoms of pesticide exposure	(4) # symptoms of pesticide exposure	(5) Sought medical treatment for any of these symptoms?	(6) Sought medical treatment for any of these symptoms?	(7) Incurred cash expenses associated with treating symptoms?	(8) Incurred cash expenses associated with treating symptoms?
Estimator	Chronic respiratory or skin disease LPM	No chronic respiratory or skin disease LPM	Chronic respiratory or skin disease Poisson	No chronic respiratory or skin disease Poisson	Chronic respiratory or skin disease LPM	No chronic respiratory or skin disease LPM	Chronic respiratory or skin disease LPM	No chronic respiratory or skin disease LPM
Treatment: Bt brinjal	-0.115*** (0.038)	-0.050** (0.021)	-0.215** (0.093)	-0.068 (0.073)	-0.122** (0.050)	-0.050 (0.036)	-0.109** (0.044)	-0.033 (0.034)
P value on equality of coefficients	0.14		0.10*		0.15		0.10*	
Observations	522	2,012	522	2,012	522	2,012	522	2,012

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

Note: See Table 9.2 *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Standard errors (in parentheses) clustered at the village level.

9.4 Pesticide Handling

Both treatment and control households received training on the safe handling of pesticides. In the event that adoption of good pesticide handling practices differed between treatment households and control households for any reason, then the differences in symptoms associated with pesticide exposure could be a consequence of pesticide handling practices, not Bt brinjal. To assess this possibility, farmers were asked how they handled pesticides while cultivating brinjal at baseline and endline. Results are reported in Table 9.6. The following patterns emerge:

- There are some proper practices that the vast majority of farmers, irrespective of treatment status, undertook at both baseline and endline. These include washing after spraying, changing clothes, wearing long-sleeved clothing, and wearing trousers.
- There were some practices that more farmers undertook at endline compared to baseline, which suggest that the training was effective in getting farmers to apply improved agricultural practices. These included reading and following instructions, not using bare hands when mixing pesticides, and checking for wind direction before spraying. These improvements were observed in both treatment and control households.
- There were some practices that few farmers undertook at baseline and for which there was little change at endline. These included mixing pesticides with a stick and wearing gloves, and wearing eye protection, gloves, or sandals/shoes while spraying. There is little evidence of change in either treatment or control households.

Crucially, looking across these practices, there are similarities across treatment and control households at baseline and endline, with similar changes observed for both groups. This suggests that differences in pesticide handling practices do not account for the reduction in the self-reported symptoms previously described for the treatment group.

Table 9.6 Pesticide handling practices by treatment status and survey round

Pesticide handling practices	Baseline		Endline	
	Treatment	Control	Treatment	Control
Do you read the labels on pesticide bottles/packs? (percent)				
Yes	62.8	62.2	69.0	68.3
Cannot read, have someone else read it	8.8	12.4	19.7	20.9
No	23.1	21.0	10.8	9.2
Cannot read, do not have someone else read it	5.3	4.4	0.5	1.5
Do you follow the instructions on the label?				
Yes	36.8	38.5	67.3	67.7
Yes, sometimes	34.1	34.8	21.8	22.9
No	5.9	5.8	0.2	0.2
No, do not read label	23.1	21.0	10.8	9.3
How do you prepare pesticide?				
With bare hands	71.1	74.2	59.9	61.7
Wearing gloves	11.4	9.3	7.1	11.1
With a stick (but bare hands)	85.1	80.7	81.8	83.5
With a stick wearing gloves	12.7	9.5	9.1	14.1
Spraying practices				
Wears long sleeves	92.5	93.2	95.8	97.1
Wears long trousers	91.7	92.7	96.0	97.1
Shields face	67.9	63.7	67.8	69.2
Covers head	58.5	54.0	61.2	68.8
Wears eye protection	13.7	12.2	8.9	10.6
Wears gloves	12.2	8.0	8.8	11.2
Wears sandal/shoes	11.5	10.0	16.2	19.9
Do you determine the wind direction before spraying?				
Yes	89.5	89.5	95.8	97.5
Do you spray when it is windy?				
Yes	5.4	7.3	4.7	4.9
After applying pesticides				
Wash hands after spraying	97.5	98.1	96.3	97.1
Wash face after spraying	96.6	96.7	95.6	97.1
Take bath/shower after spraying	95.1	96.4	96.1	97.3
Change clothes after spraying	96.1	97.4	95.8	97.6

Source: 2017 Baseline and 2018 endline surveys for Bt Brinjal Impact Evaluation, IFPRI.

9.5 Summary

Changes in the reporting of symptoms and illness consistent with pesticide exposure were assessed. At baseline, most brinjal farmers (69 percent) reported at least one symptom consistent with pesticide exposure and, on average, respondents reported experiencing an average of 1.8 symptoms in the previous year. Just under half (42 percent) reported that they sought medical attention to address these symptoms, and 58 percent stated that they had incurred cash expenses to deal with these.

Individuals growing Bt brinjal were 6.2 percentage points less likely to report symptoms consistent with pesticide exposure from November 2017 to June 2018. There is some evidence that cultivation of Bt brinjal reduces the number of symptoms reported, though this impact is sensitive to model specification and the estimator chosen. Individuals in households growing Bt brinjal were 6.5 percentage points less likely to report that they needed to seek medical care for these symptoms (Table 9.3). While Bt brinjal cultivation reduces the number of days lost because of these symptoms and the level of medical expenses associated with treating these symptoms, these estimates are not statistically significant. Impacts are robust to model specification and estimation.

Impacts do not differ by sex or age. Individuals who had a pre-existing chronic condition consistent with pesticide exposure and who lived in villages randomly selected to grow Bt brinjal were 11 percentage points less likely to report a symptom of pesticide exposure, reported 0.2 fewer such symptoms, were 12 percentage points less likely to seek medical care for these symptoms, and were 11 percentage points less likely to incur cash medical expenses to treat these symptoms. All impacts are statistically significant at the 5 percent level.

10. CONCLUSIONS

10.1 Background

This study has examined the impact of genetically modified (GM) eggplant in Bangladesh. Eggplant, called brinjal in Bangladesh, is a high-value crop that is widely grown and consumed. Brinjal is highly vulnerable to fruit and shoot borer (FSB) pest infestation. Over a 10-year period, public sector Bangladeshi agricultural researchers, with support from researchers based in the United States, developed a series of GM varieties, called Bt brinjal, that are resistant to FSB. Extensive biosafety work has demonstrated that there are no significant differences between Bt brinjal and its non-GM counterparts and, following regulatory review, Bangladesh has approved Bt brinjal for human consumption (APAARI 2018).

Despite these findings, the introduction of GM crops remains controversial both in Bangladesh and globally. Criticisms include claims that they are harmful to the environment, damaging to human health, and inaccessible to small farmers for reasons of cost or intellectual property rights. It is also claimed that GM crops (including Bt brinjal) have no yield benefits, although much of the work critics cite on economic benefits was based on observational data rather than randomized control trials (RCTs). Further, research on GM crops is perceived to be industry-influenced or biased in some way.

This study was designed to provide independent rigorous scientific information that could address some of the key criticisms of Bt brinjal. Specifically:

- (1) The treatment crop studied, BARI Bt brinjal-4, is an open pollinated variety.
- (2) Bt brinjal, like conventional brinjal varieties, can be grown on small plots, making its cultivation accessible to farmers with only limited access to land.
- (3) The study is implemented as an RCT with pre-intervention baseline and post-intervention endline surveys. The comparison crop, ISD-006, is genetically identical to Bt brinjal-4 except for the introduction of a genetic construct containing a crystal protein gene (*Cry 1 Ac*), which produces an insecticidal protein that is toxic to FSB. Under the study, 1,200 farmers living in 200 villages were randomized to receive either seedlings for Bt brinjal-4 or ISD-006. The study does not suffer from attrition bias or imbalance between treatment and control groups.
- (4) Implementation of the intervention was undertaken by the the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE) under the Ministry of Agriculture. Both treatment and comparison groups received near-identical access to agricultural extension services. The only meaningful

difference is that treatment farmers were informed that pesticides are not needed against FSB as Bt brinjal is resistant to this pest. Both treatment and comparison farmers received extensive training in the use of non-pesticide methods to control for pests.

(5) The intervention was evaluated by an independent, external group of researchers, based both inside and outside of Bangladesh. These researchers have no financial stake or other conflicts of interest associated with Bt brinjal.

10.2 Key Findings

A randomized design, together with an analysis of covariance (ANCOVA) estimator, was used to assess the impacts of growing Bt brinjal. The results described below are robust to the inclusion (or not) of control variables and alternative methods for addressing outliers in these data. Unless noted, results do not differ across disaggregations based on age and education of the household head or size of land holdings. Impacts are:

(1) On pesticide use:

- 47 percent reduction in the cost of applying pesticides, equivalent to a reduction of Bangladeshi taka (Tk) 7,196 per hectare (ha).
- 51 percent reduction in the number of pesticide applications.
- 39 percent reduction in the quantity of pesticides applied.
- 41 percent reduction in the toxicity of pesticides applied, as measured by the Pesticide Use Toxicity Score (PUTS).
- 56 percent reduction in environmental toxicity, as measured by the Field Use Environmental Impact Quotient (EIQ-FUR).

(2) On reduction in fruit and shoot borer (FSB) infestation:

- At baseline, 34.9 percent of all brinjal plants were infested by FSB for the treatment group and 36.0 percent of all brinjal plants were infested by FSB for the control group.
- At endline, only 1.8 percent of all Bt brinjal plants grown by the treatment farmers were infested by FSB. In contrast, 33.9 percent of all ISD-006 brinjal plants grown by the control farmers were infested by FSB. This shows that Bt brinjal has been successful in repelling infestation by the FSB pest.

(3) On yields, revenues, costs, and profits:

- Net yields (kilograms (kg) produced per ha of brinjal cultivated) were 42 percent higher, equivalent to a 3,622 kg per ha increase. Distributional statistics show that these increases were widespread. This increase occurs both because production is higher and because fewer fruits are discarded after harvest.
- 31 percent reduction (per kg) in the cost of growing brinjal. On a per ha basis, the cost of growing brinjal is reduced by Tk 9,620. This cost reduction is mostly attributed to lower pesticide use.
- 27.3 percent increase in gross revenues per ha.
- An increase of Tk 33,827 (approximately US\$400) per ha in net profits. This profit per hectare is 13.9 percent higher for Bt brinjal.

(4) On self-reported health impacts:

- Individuals in households growing Bt brinjal were 10 percentage points less likely to report symptoms consistent with pesticide exposure.
- Individuals in households growing Bt brinjal were 6.5 percentage points less likely to report that they needed to seek medical care for these symptoms.
- Both men and women in households growing Bt brinjal reported reductions in the likelihood of reporting symptoms consistent with pesticide exposure.
- Reductions in reported symptoms were larger for individuals who, at baseline, reported symptoms consistent with chronic respiratory illnesses or skin disease.

These results suggest that there are considerable gains from encouraging the cultivation of Bt brinjal. In doing so, it is worth noting the following:

- Bt brinjal is designed to reduce, but not eliminate, overall pesticide use. Pesticide use as part of an integrated pest management (IPM) strategy to handle multiple pests would still be appropriate since Bt brinjal has been developed to manage FSB.
- While not central to the objectives of this study, data collected indicate that the pesticide handling practices of many farmers remain poor. Additional efforts to improve these practices, alongside efforts to ensure that existing pesticide regulations (including labelling) are enforced, would likely be beneficial.

10.3 Sustainability of Bt Brinjal Technology in Bangladesh

Since the Bangladesh Government introduced Bt brinjal in 2014, adoption has increased tremendously—from 20 farmers growing Bt brinjal on a trial basis in 2014 to over 27,000 farmers in 2018 (Shelton et al. 2018). Looking forward, scaling up Bt brinjal production will require addressing several challenges.

Increasing seed production and availability

In the seed production system in Bangladesh, research organizations (in this case, BARI) produce breeder seeds, which are then multiplied by the Bangladesh Agricultural Development Corporation (BADC), which is a government parastatal, and the private seed sector to produce foundation seeds. These foundation seeds are then further multiplied by BADC and the private sector to sell to farmers as truthfully labelled seeds.

Moving forward, it will be important to design and implement standard operating procedures to provide concrete, clear guidance on seed testing, packaging and labeling, and recordkeeping in compliance with audit requirements for Bt brinjal (Shelton et al. 2018).

Developing new varieties to expand Bt brinjal cultivation

An important consideration for Bt brinjal's sustainability is expanding its production geographically to scale up its benefits. Various studies in Bangladesh have been conducted in the north (Islam and Norton 2007; Prodhan et al. 2018), in part because winter cultivation of Bt brinjal is relatively more prominent there and because BARI's Bt brinjal varieties were developed for winter cultivation.

BARI has developed four varieties of Bt brinjal. It plans to develop more varieties that will be suitable for cultivation in different regions of the country and during the summer season, as the current varieties can only be grown in the winter. For example, the *Chaga* variety, which is grown during summer and is very popular in the south, has not yet been officially released by the Government of Bangladesh. As Bt brinjal becomes popular, BARI should continue to develop new varieties that are suitable for markets in different regions to respond to increasing demand from farmers and consumers in those regions.

Strengthening agricultural extension services to facilitate Bt brinjal cultivation

Bt brinjal is a relatively new technology; therefore, it will require improved agricultural extension services to help farmers adopt the most efficient techniques for Bt brinjal production and marketing. For example, farmers' refuge border compliance for Bt brinjal

is critical to maximize its benefits (that is, to reduce pest infestation and increase crop yields) and to avoid the variety developing resistance to the *Cry 1 Ac* protein it produces.

One practical approach for promoting adoption of the Bt brinjal technology is to organize on-farm demonstrations for Bt brinjal varieties. Another approach is through the development and use of a clear, consistent training manual for agricultural extension officials and brinjal farmers on the proper agronomic practices for cultivating Bt brinjal. Under this study, DAE, with technical guidance from BARI, printed two manuals—one for treatment farmers and one for control farmers. These manuals were used to train agricultural extension officials, who then used them to train farmers in the study. DAE conducted the same IPM trainings for treatment and control farmers; however, the manual for Bt brinjal contains some unique aspects of cultivating Bt brinjal, such as refuge border management.

Lastly, Shelton et al. (2018) suggest developing a prepared mixture of Bt and non-Bt seed, meant specifically for refuge border development and maintenance. This approach might assist when training on Bt brinjal cultivation ramps up and as farmers and extension officials familiarize themselves with the unique agronomic aspects of cultivating this new biotech variety.

Strengthening value chains and markets

Agricultural value chains refer to the whole range of goods and services necessary for an agricultural product to move from the farm to the final consumer. Value chain development involves finding ways of linking producers to agribusiness, and hence into the value chains (Shepherd 2007). For the brinjal crop in Bangladesh, value chain actors include seed and associate input suppliers, producers, graders and packers, *farias* (petty traders), wholesalers, brokers, transporters, retailers, and consumers.

In Bangladesh, agricultural value chains are in the early stage of development. Marketing inefficiency, seasonality, poor transportation, underdeveloped infrastructure, and insufficient post-harvest handling and storage facilities intensify the price volatility for fruits and vegetables (SAC 2014). Non-rice crops such as brinjal face special problems of perishability. Year-to-year price fluctuations are much larger for non-rice crops than for rice, indicating relatively high levels of market-induced risks for production of non-rice crops. High-value crops, especially fruits and vegetables, have thin domestic markets owing to relatively low levels of demand for them due to widespread poverty and inadequate purchasing power. An increase in production causes a sharp decline in market prices (Ahmed and Ghostlaw 2019).

An option to reduce farmers' risk is through contract farming, an arrangement where farmers supply agreed upon quantities of an agricultural product to a firm, usually at a price negotiated in advance. Additionally, staggered planting of Bt brinjal may help avoid seasonal supply gluts in the market. The release of additional varieties of Bt brinjal suitable for different seasons may address this issue.

Further, strengthening the capacity of market traders is key. Market traders may face challenges with low consumer demand for Bt brinjal as the variety gradually gains recognition. Currently, they may not be prepared to communicate Bt brinjal's advantages—for example, that it is less contaminated by toxic pesticides compared with conventional brinjal varieties. Therefore, training market traders on marketing Bt brinjal is an area where the Department of Agricultural Marketing (DAM) and the private sector could provide support. Moreover, providing accurate market information, improving farmers' access to credit, and facilitating the formation of growers' associations could strengthen Bt brinjal value chains.

Strategic, evidence-based communication

As GM crops are a contentious issue in the media, the sustainability of Bt brinjal in Bangladesh requires the deft, tactful navigation of a complex media environment. In Bangladesh and globally, media messaging on Bt brinjal has been polarized between research-based evidence supporting the benefits of Bt brinjal and smear campaigns launched by the anti-GMO lobby. Although there are no qualitative findings from this study to suggest that consumers were concerned that Bt brinjal is unsafe for human consumption, divisive media messaging may contribute to confusion on whether Bt brinjal is safe. In view of this, careful attention must be given to promoting consumer education on Bt brinjal, stressing that there is no evidence of harmful impacts on food safety for human consumption.

Further, despite mounting evidence on the advantages of Bt brinjal for producers and consumers in Bangladesh, it is as important as ever to publish objective, science-based information on the impacts of Bt brinjal so relevant stakeholders—from policymakers to farmers to consumers—can make informed decisions about the future of Bt brinjal in Bangladesh. For this study, this may mean publishing press releases, blogs, and other materials to ensure the findings are effectively communicated to diverse audiences.

10.4 Projected Impacts at the National-Level

Annually, Bangladesh produces around 450,000 tons of brinjal on about 50,000 ha of land. According to the *2017 Yearbook of Agriculture Statistics* (BBS 2018), the total area of brinjal cultivated in Bangladesh was 31,703 ha in the winter season and 18,531 ha in the summer season from 2015 to 2017 (three-year average). Since this study only evaluates the impacts of the Bt brinjal-4 variety developed by BARI for winter season cultivation, the projections are presented for the winter season.

According to the impact estimates, the average pesticide cost for Bt brinjal farmers was Tk 7,196 per ha lower than the average pesticide cost for control farmers. If Bt brinjal is adopted nationally, then the potential total cost savings on pesticide use could be Tk 228 million (US\$2.7 million).

Impact estimates revealed that total cost of production per ha for treatment farmers was Tk 9,620 lower than for control farmers. Thus, potential total cost savings on production for nationwide Bt brinjal adoption is projected to be Tk 305 million (US\$3.6 million).

Bt brinjal's net yield was 3,622 kg per ha higher than conventional brinjal. This means that nationwide adoption of Bt brinjal could increase brinjal production by 114,828 tons per year.

Net profits for farmers cultivating Bt brinjal increased by Tk 38,063 per ha. Therefore, nationwide adoption of Bt brinjal could increase farmers' profits by a total of Tk 1,207 million (US\$14.3 million).

In sum, promoting the sustainability of Bt brinjal technology in Bangladesh will require collective efforts to strengthen the capacity of government agencies, enhance private sector involvement, and tackle obstacles that may hinder commercialization if the Ministry of Agriculture decides to roll out this technology.

REFERENCES

- Ahmed, A.U. 1994. *Input-Output Coefficients for Estimating Rice Production Costs and Returns in Bangladesh*. Bangladesh Food Policy Project Manuscript 61. Washington, DC: International Food Policy Research Institute.
- . 2013. Bangladesh Integrated Household Survey (BIHS) 2011-2012. Washington, DC: International Food Policy Research Institute (datasets).
<http://hdl.handle.net/1902.1/21266>
- . 2016. *Description of the Bangladesh Integrated Household Survey*. Dhaka, Bangladesh: International Food Policy Research Institute. Available at:
<https://dataverse.harvard.edu/file.xhtml?persistentId=doi:10.7910/DVN/BXSYEL/Z0CJD3&version=3.0>
- Ahmed, A.U., and J. Ghostlaw. 2019. “Diversifying rice-centric agriculture and diets: The Bangladesh experience.” In *Agriculture for improved nutrition: Seizing the momentum*. Edited by S. Fan, S. Yosef, and R. Pandya-Lorch. Chapter 15. Wallingford, UK: International Food Policy Research Institute and CABI.
<http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/133088>
- Ahsanuzzaman, and D. Zilberman. 2018. “Bt Eggplant in Bangladesh Increases Yields and Farmers’ Incomes, and Reduces Pesticide Use.” ARE Update 22(2): 5–8. University of California Giannini Foundation of Agricultural Economics. Available at:
https://s.giannini.ucop.edu/uploads/giannini_public/34/0f/340f8c28-cf2d-4246-9f87-84fe661568cb/v22n2_4.pdf
- Ali, M.I., M.S. Ali, and M. S. Rahman. 1980. “Field evaluation of wilt disease and shoot and fruit borer attack of different cultivars of brinjal.” *Bangladesh Journal of Agricultural Science* 7: 193–194.
- APAARI (Asia-Pacific Association of Agricultural Research Institutions). 2018 *Success Story on Bt Brinjal in Bangladesh*. Asia-Pacific Association of Agricultural Research Institutions, Bangkok, Thailand. <http://www.apaari.org/web/wp-content/uploads/downloads/2018/Bt%20Brinjal%20in%20Bangladesh%20final.pdf>
- BBS (Bangladesh Bureau of Statistics). 2011. *Report of the Household Income and Expenditure Survey 2010*. Statistics Division, Ministry of Planning, Government of the People’s Republic of Bangladesh.

<http://203.112.218.65:8008/WebTestApplication/userfiles/Image/LatestReports/HIES-10.pdf>

- . 2018. *2017 Yearbook of Agriculture Statistics*. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- Bruhn, M., and D. McKenzie. 2009. "In Pursuit of Balance: Randomization in Practice in Development Field Experiments." *American Economic Journal: Applied Economics*, 1(4), 200–232. doi: 10.1257/app.1.4.200
- DAE (Department of Agricultural Extension of Ministry of Agriculture), Government of the People's Republic of Bangladesh. 2016. *List of Registered Agricultural Biopesticides and Public Health Pesticides in Bangladesh Approved up to 65th Technical Advisory Committee Meeting*. <http://www.dae.gov.bd>
- Dey, N.C. 2010. "Use of Pesticides in Vegetable Farms and its Impact on Health of Farmers and Environment." *Environmental Science & Technology* (II): 134–140.
- Eshenaur, B., J. Grant, J. Kovach, C. Petzoldt, J. Degni, and J. Tette. 1992–2015. www.nysipm.cornell.edu/publications/EIQ. Environmental Impact Quotient: "A Method to Measure the Environmental Impact of Pesticides." New York State Integrated Pest Management Program, Cornell Cooperative Extension, Cornell University.
- Fitzgerald, J., P. Gottschalk, and R.A. Moffitt. 1998. "An Analysis of Sample Attrition in Panel Data: The Michigan Panel Study of Income Dynamics." *Journal of Human Resources*, 33(2): 300–344. doi: 10.3386/t0220
- Goertz, G., and J. Mahoney. 2012. "Concepts and Measurement: Ontology and Epistemology." *Social Science Information*, 51(2): 205–216. <https://doi.org/10.1177%2F0539018412437108>
- Hidrobo, M., J. Hoddinott, A. Peterman, A. Margolies, and V. Moreira. 2014. "Cash, Food or Vouchers? Evidence from a Randomized Experiment in Northern Ecuador." *Journal of Development Economics* 107: 144–156. <https://doi.org/10.1016/j.jdeveco.2013.11.009>
- Islam, S.F., and G.W. Norton. 2007. "Bt Eggplant for Fruit and Shoot Borer Resistant in Bangladesh." In *Economic and Environmental Benefits and Costs of Transgenic Crops: Ex-Ante assessment*. Edited by C. Ramasamy, K. N. Selvaraj, G.W. Norton, and K. Vijayaraghavan. Coimbatore, India: Tamil Nadu Agricultural University.
- Kniss, A.R., and C.W. Coburn. 2015. "Quantitative Evaluation of the Environmental Impact Quotient (EIQ) for Comparing Herbicides." *PLOS ONE*, 10(6), p.e0131200. <https://doi.org/10.1371/journal.pone.0131200>

- Kovach, J., C. Petzoldt, J. Degni, and J. Tette. 1992. "A Method to Measure the Environmental Impact of Pesticides." *New York's Food and Life Sciences Bulletin* 139: 1–8.
<https://hdl.handle.net/1813/55750>
- McKenzie, D. 2012. "Beyond Baseline and Follow-Up: The Case for More T in Experiments." *Journal of Development Economics*, 99(2): 210–221. doi: 10.1016/j.jdeveco.2012.01.002
- . 2015. Tools of the Trade: A Joint Test of Orthogonality When Testing for Balance. Development Impact Blog. Available at:
<https://blogs.worldbank.org/impactevaluations/tools-trade-joint-test-orthogonality-when-testing-balance>.
- Norton, G. W., and D.M. Hautea (Eds.). 2009. *Projected Impacts of Agricultural Biotechnologies for Fruits & Vegetables in the Philippines & Indonesia*. International Service for the Acquisition of Agri-biotech Applications and the SEAMEO, Southeast Asian Regional Center for Graduate Study and Research in Agriculture.
- Powell, J.L. 1984. "Least Absolute Deviations Estimation for the Censored Regression Model." *Journal of Econometrics*, 25(3): 303–325. [https://doi.org/10.1016/0304-4076\(84\)90004-6](https://doi.org/10.1016/0304-4076(84)90004-6)
- Prodhan, M.Z.H., M.T. Hasan, M.M.I. Chowdhury, M.S. Alam, M.L. Rahman, A.K. Azad, M.J. Hossain, S.E. Naranjo, and A.M. Shelton. 2018. "Bt Eggplant (*Solanum melongena* L.) in Bangladesh: Fruit Production and Control of Eggplant Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee), Effects on Non-Target Arthropods and Economic Returns." *PLOS ONE* 13(11): e0205713. <https://doi.org/10.1371/journal.pone.0205713>
- Rashid, M.H., M. Mohiuddin, and M.A. Mannan. 2008. "Survey and Identification of Major Insect Pest and Pest Management Practices of Brinjal During Winter at Chittagong District." *International Journal of Sustainable Crop Production*, 3(2): 27–32.
- Rashid, M.A., M.K. Hasan, and M.A. Matin. 2018. "Socio-economic Performance of Bt Eggplant Cultivation in Bangladesh." *Bangladesh Journal of Agricultural Research*, 43(2): 187–203. <https://doi.org/10.3329/bjar.v43i2.37313>
- Raza, M.S. 2018. "Present Status of Insecticides Use for the Cultivation Of Brinjal in Kushtia Region, Bangladesh." *International Journal of Engineering Science Invention*, 7(1): 44–51.
- Reifman, A., and K. Keyton. 2010. "Winsorize." In N. J. Salkind (Ed.), *Encyclopedia of Research Design* (pp. 1636–1638). Thousand Oaks, CA: Sage.
- Sabur, S.A., and A.R. Molla. 2001. "Pesticide Use, its Impact on Crop Production and Evaluation of IPM Technologies in Bangladesh." *Bangladesh Journal of Agricultural Economics*, 24 (1-2): 1–18.

SAC (SAARC Agriculture Centre). 2014. *Value Chain Analysis and Market Studies on Fruits and Vegetable in SAARC Member Countries*. N. Akter and A. K. Azad, eds. Dhaka: SAARC Agriculture Centre.

Shelton, A.M., M.J. Hossain, V. Paranjape, A.K. Azad, M.L. Rahman, A.S.M.M.R. Khan, M.Z.H. Prodhan, M.A. Rashid, R. Majumder, M.A. Hossain, S.S. Hussain, J.E. Huesing, and L. McCandless. 2018. "Bt Eggplant Project in Bangladesh: History, Present Status, and Future Direction." *Frontiers in Bioengineering and Biotechnology* 6:106. doi: 10.3389/fbioe.2018.00106

Shepherd, A. 2007. *Approaches to Linking Producers to Markets*. Agricultural Management, Marketing and Finance Occasional Paper 13. Rome: FAO.

United Nations. 2011. *Globally Harmonized System of Classification and Labelling of Chemicals (GHS)*. New York: United Nations.

WHO (World Health Organization). 2010. *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2009-10*. Geneva: World Health Organization.

APPENDIX A: SCOPE OF WORK FOR Bt BRINJAL IMPACT EVALUATION

The below scope of work for the Bt brinjal study is an excerpt from the study proposal.

1. Background

Upon request of the Ministry of Agriculture (MOA), the International Food Policy Research Institute (IFPRI) will evaluate the impact of the Bt brinjal technology on production systems, producer and consumer economics and welfare, and health outcomes. In collaboration with the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE), IFPRI will conduct the Bt brinjal impact evaluation in selected districts of north-western Bangladesh. IFPRI has outstanding capacity to conduct rigorous and state-of-the-art impact evaluations, and carried out numerous impact evaluations in Bangladesh and several countries in Asia, Africa, and Latin America.

IFPRI will conduct the study under the ongoing Bangladesh Policy Research and Strategy Support Program (PRSSP) for Food Security and Agricultural Development, funded by the U.S. Agency for International Development (USAID) and implemented by IFPRI. PRSSP conducts applied research to fill knowledge gaps on critical food security and agricultural development issues in Bangladesh, and thereby facilitates evidence-based policy formulation and policy reforms to achieve the goal of sustainably reducing poverty and hunger. Its main objectives are to provide policy options and advisory services to decision makers and stakeholders, collaborate with national institutions to strengthen analytical capacity within the country, and stimulate policy dialogue.

This document outlines the research design and the work plan for evaluating the impact of Bt brinjal.

2. Objectives of the Study

The Bt brinjal impact evaluation is designed to provide a thorough understanding of the impact of adoption of the Bt brinjal technology among Bangladeshi farmers, mimicking as much as possible the real-world context of a roll-out. In doing so, this evaluation may provide important insights of the efficacy of this new technology, based on which the Ministry of Agriculture may guide its future roll-out strategy. The results of the study will also be useful for various other stakeholders, such as scientists at the National Agricultural Research System (NARS), USAID, policymakers, the media, and the civil

society in Bangladesh and beyond. The study has the following specific objectives:

1. Estimate, using a rigorous impact evaluation, the impact of growing Bt brinjal by farmers on key outcomes:
 - a. Use of pesticide for brinjal cultivation
 - b. Brinjal yields
 - c. Cost of production
 - d. Net crop income
 - e. Human health outcomes
2. Document and disseminate results and lessons learned from the study.

3. Bt Brinjal Impact Evaluation Design

IFPRI will use a clustered randomized control trial (RCT) design for the Bt brinjal impact evaluation, using villages as clusters, to quantitatively measure the impact of the introduction of Bt brinjal. This will be complemented through the use of qualitative research methods. The evaluation will address the following research questions:

3.1 Research Questions

Production

1. Does the cultivation of Bt brinjal change the quantity of pesticides applied to brinjal? (Yes/No). How large is this change?
2. Does the cultivation of Bt brinjal change the frequency with which pesticides are applied to brinjal? (Yes/No). How large is this change?
3. Does the cultivation of Bt brinjal change the cost of applying pesticides to brinjal? (Yes/No). How large is this change?
4. Does the cultivation of Bt brinjal change the prevalence of secondary insect infestations? (Yes/No). How large is this change?
5. Does the cultivation of Bt brinjal change the amount of labor used to produce brinjal? (Yes/No). How large is this change? If this change occurs, does it reflect a change in the use of hired labor (Yes/No; how large is the change) or family labor (Yes/No; how large is the change)? If family labor changes, who in the family changes their labor supply and by how much?
6. Does the cultivation of Bt brinjal change other production practices? (Yes/No). If so, what are those changes?
7. Does the cultivation of Bt brinjal change other (i.e., not pesticides or labor) costs associated with brinjal production? (Yes/No). What costs change? How large is

this change?

8. Does the cultivation of Bt brinjal change the amount of brinjal produced? (Yes/No). How large is this change?
9. Does the cultivation of Bt brinjal change brinjal yields (i.e., production / area cultivated)? (Yes/No). How large is this change?
10. Why do these changes occur? Are they observed uniformly across the sample or are they associated with specific farmer or locational characteristics?

Marketing

11. Compared to conventional varieties, is Bt brinjal easier or more difficult to sell in local markets? Why?
12. Has the introduction of Bt brinjal brought in new traders into local markets for brinjal? If so, who are these individuals? Have other traders left these markets?
13. Is Bt brinjal sold at a different price compared to conventional brinjal? (Yes/No). Is this a higher or lower price? How large is the price differential? Is this a constant price differential or does it vary? If it varies, by how much and why?
14. How do farmers' experiences in marketing Bt brinjal compare to marketing conventional brinjal? What factors affect these experiences?

Income

15. Does the cultivation of Bt brinjal cause gross revenues from brinjal production (total production x price received) to change? How large is this change?
16. Does the cultivation of Bt brinjal cause net revenues from brinjal production (gross revenues minus all costs) to change? How large is this change?
17. If changes in gross or net revenues occurs, what accounts for these? Changes in revenues, in costs or some combination of these?

Health

18. Does the cultivation of Bt brinjal reduce household self-reports of symptoms consistent with pesticide poisoning? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?
19. Does the cultivation of Bt brinjal reduce the number of days that household members are too ill to work? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?
20. Does the cultivation of Bt brinjal change healthcare and expenditures related to health care? (Yes/No). How large is this change? Who in the household (by age/sex/relationship to household head) is affected by this change?

3.2 Sample size calculations for the Bt brinjal impact evaluation

The sample size needed for the Bt brinjal impact evaluation depends on several factors: (1) the outcomes that are of the greatest interest to researchers and program managers; (2) the minimum size of change in those outcomes that researchers would like to observe; (3) the degree of variability in those outcomes; (4) the extent to which there is correlation in outcomes within localities; (5) the desired level of statistical power; and (6) the level of desired statistical significance. Sample sizes increase with reductions in the size of change that the evaluation is attempting to uncover; greater variability in outcomes; increased correlation of outcomes; and higher statistical power.

In the context of the Bt brinjal impact evaluation, the calculations must also consider that treatment will be randomized at the village (cluster) level. In sample size calculations for cluster-randomized studies, not only the number of households and the number of clusters matter, but also the inherent similarity of households within a cluster. The measure that captures this similarity for each outcome is referred to as its "intra-cluster correlation"—that is, in the absence of any treatment, a measure of the extent to which the outcome varies across households within a cluster relative to how much it varies across clusters.

The value of the intra-cluster correlation for any outcome is likely to depend on the context of the data. Since it is necessary to conduct sample size calculations prior to collecting the data, the accepted approach to estimating intra-cluster correlations for sample size calculations is to use values calculated from existing comparable datasets.

For the Bt brinjal impact evaluation, parameters derived from a nationally representative IFPRI survey, the Bangladesh Integrated Household Survey (BIHS), conducted in 2011-2012 were used.¹⁹ Brinjal yields per ha and total cost of pesticide use per ha are the outcome indicators. During a meeting on April 7, 2015, the Director General, Bangladesh Agricultural Research Institute (BARI), and Member Director (Crops), Bangladesh Agricultural Research Council (BARC)—two key people involved in the Bt brinjal research work from the Government of Bangladesh—informed IFPRI that farmers spray pesticides on brinjal plants 60180 times during cultivation, yet they are unable to fully control pest infestation. Cost of pesticides is a major cost of brinjal production. They also reported that the fruit and shoot borer insect causes 30-50

¹⁹ Dataset: Ahmed, A.U., 2013. "Bangladesh Integrated Household Survey (BIHS) 2011-2012", <http://hdl.handle.net/1902.1/21266> UNF:5:p7oXR2unpeVoD/8a48PcVA== International Food Policy Research Institute [Distributor] V3 [Version]

percent loss in brinjal production, resulting in a significant reduction in brinjal yields.

We follow the standard practice of calculating the sample size that, given the expected change in the selected outcome indicators, would provide an 80 percent chance (the power of the test) of correctly rejecting the null hypothesis that no change occurred, with a 0.05 level of significance.

The estimated necessary minimum sample size is reported in Table 1. For example, to detect a minimum, statistically significant increase in brinjal yields per hectare of 30 percent between treatment and control groups, a minimum total sample size of 180 clusters (villages) and 1,046 farm households are required, with 523 farm households for the treatment group and 523 households for the control group. For reduction of pesticide cost per hectare as an outcome indicator, 187 clusters and 1,120 farm households (560 treatment and 560 control households) are required to detect a minimum of 40 percent reduction in pesticide costs. A large enough sample size is needed to assess both impacts (that is, at least 1,120 farm households) and account for the possibility that some households may drop out between baseline and endline. This implies that for the Bt brinjal impact evaluation, 200 clusters/villages (100 treatment and 100 control villages) and 1,200 farm households (600 treatment and 600 control households) will be used. Each cluster will include six farm households.

Table 1 Minimum sample size required for detecting changes in selected outcome indicators

		Required Number of clusters			
		Required number of farm households			
Indicators	Minimum impact		Treatment	Control	Total
Brinjal yield per hectare	An increase of 25%	281	701	701	1,402
Brinjal yield per hectare	An increase of 30%	180	523	523	1,046
Pesticide cost per hectare	A reduction of 35%	250	731	731	1,462
Pesticide cost per hectare	A reduction of 40%	187	560	560	1,120

Source: Calculated using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

3.3 Selecting Treatment and Control Groups

The sampling process for the treatment and the control groups will include the following steps:

- The Bt brinjal varieties currently released by BARI are best suited to winter cultivation. For this reason, the study will focus on localities where farmers predominantly cultivate brinjal in the winter (*Rabi*) season, with planting of seeds beginning in September/October (*Ashwin/Kartik* month of the Bangla calendar). Further, given our interest in understanding the marketing and sale of Bt brinjal, these localities must also be characterized by good physical infrastructure and well-functioning markets for brinjal. In consultation with officials from BARI and DAE, four districts that satisfy these criteria have been identified—Bogura, Gaibandha, Naogaon, and Rangpur. This selection balances the value of surveying a diverse set of localities with the practicalities of ensuring timely delivery of Bt brinjal seeds prior to planting season.
- DAE officials in the selected districts will provide IFPRI, by upazila, lists of villages where brinjal is cultivated predominantly in the winter season and the number of brinjal farmers in each village. Using these lists, upazilas with a high concentration of villages, defined as having at least 15 brinjal farmers per village, will be purposively selected.
- A list of villages within these upazilas will be compiled where there are at least 15 brinjal farmers.
- From this list, 100 villages will be assigned to the treatment group and 100 villages to the control group (200 villages to be selected).
- A 100 percent census of the 100 selected treatment villages and the 100 selected control villages will be conducted in August 2017 and all brinjal-growing farmers from the village census lists will be listed.
- From the census list of brinjal farmers of the selected treatment and control villages, farmers willing to grow ISD-006 variety of brinjal and Bt brinjal on 10 decimal plots during the planting season beginning in November 2017 will be identified. This selection criteria will ensure that farmers selected for the study will have similar attributes in terms of risk-taking behavior and preferences. Six farmers from each of the treatment and control villages will be randomly selected and confirm their participation in the study by September 2017 (1,200 farmers to be selected).

4. Input Package to be Provided to Treatment and Control Farmers

The Ministry of Agriculture will provide input packages to all 1,200 brinjal farmers under this study, with funding from the Government of Bangladesh. Table 2 shows the items and cost of an individual input package for a 10-decimal demonstration plot under this study. Please note that the input package will not include any pesticides.

Table 2 Individual input package and cost

Items	Quantity (kg)	Unit cost (Taka per kg)	Cost (Taka)
Urea	17	16	272
Triple Super Phosphate (TSP)	17	22	374
Muriate of Potash (MoP)	10	15	150
Gypsum	7	12	84
Zinc Sulphate	1	100	100
Boric acid	1	150	150
Irrigation			350
Netting to prevent bird attack and support for plants (posts)			350
Seed sorting			150
Seed treatment			50
Total cost for 10 decimal plot			2,030

Source: Department of Agricultural Extension (DAE)

5. Production and Distribution of Seedlings

The original concept note stated that BARI would raise Bt brinjal seedlings and distribute to 600 treatment farmers in the 100 treatment villages. But in subsequent meetings with stakeholders, BARI conveyed that they did not have the necessary logistics to undertake this task. Thus, the stakeholders decided to select one “lead farmer” from the selected six treatment farmers in each of the 100 treatment villages to grow seedlings for himself and the five other farmers in his village. The Department of Agricultural Extension (DAE) will provide full input and technical support to lead farmers to produce Bt brinjal seedlings. The other five treatment farmers in the village will later collect the seedlings from the lead farmer and transplant them on their 10 decimal plots. Sub-assistant agricultural officers (SAAOs) of the DAE will closely monitor the lead farmers.

For the control villages, DAE will collect enough ISD-006 variety of brinjal seeds from sources like BARI and BADC for distribution to the control farmers. A process similar to the one in the treatment village will be followed in selecting a “lead farmer” in each of the 100 control villages. SAAOs will closely monitor the lead farmers and provide all necessary input and technical support for raising the seedlings.

6. Collecting Data

Data collection will include quantitative surveys and qualitative semi-structured key informant interviews and focus group discussions. This mixed method of data collection is expected to provide a rich pool of data and analytical power that will be able to answer the relevant outcomes needed to answer the evaluation questions, while also providing enough contextual information to determine why some of these outcomes may or may not be happening. Gender-disaggregated information will be collected for all person level data. Focus groups and key informant interviews may also be disaggregated by gender when it is meaningful and relevant to the evaluation questions.

6.1 Baseline and endline farm household surveys for impact evaluation

The quantitative impact evaluation involves two rounds of farm household surveys of 600 treatment farmers in 100 villages (clusters) and 600 control farmers in 100 villages. The first survey will be designed as a baseline, to be conducted in November–December 2017, after transplanting of Bt and conventional brinjal seedlings. The second (endline) survey will be conducted in June 2018, after farmers have harvested all brinjals produced in the selected plots.²⁰

There are several reasons why a baseline and an endline survey will be used.

- To implement the double-difference methodology described above in the “Evaluation Methods” section.
- There may be heterogeneity in impacts. For example, farmers who previously used low levels of pesticides could see only small effects on cost of production and large effects on yields, whereas farmers who previously used high levels of pesticides could see big effects on cost of production and smaller effects on yields. In order to understand these heterogeneous impacts, an understanding of past use of inputs, production and yields is key.
- To answer the following questions related to distributional effects of these changes: Who gains most? Richer farmers? Poorer farmers? Better educated or

²⁰ Brinjal harvesting starts about three months after planting, and the crop is periodically harvested for 4 to 5 months.

less educated farmers?

- To know the prevalence of attrition from the trial—that is, the extent to which treatment and control households drop out of the study and whether this is systematically linked to particular household characteristics.

The baseline farm household survey questionnaire will cover the following topics:

- Brinjal production in the previous 12 months, including area planted, pesticide use, labor input (disaggregated by family versus hired labor and family labor further disaggregated by relation to household head), use and cost of other inputs, credit used to purchase inputs associated with brinjal production, amount produced, income generated. Because this would be recall data, this module will be designed carefully and piloted.
- Pesticide-related illness (incidence, duration, severity) and the costs associated with these
- Background information on key household characteristics, including:
 - Household composition and education (relation to household, age, marital status, occupation, literacy, level of education)
 - Household assets, farming and consumer durables (ownership and value), housing characteristics
 - Loans and debt
 - Land ownership and tenure (plot-level data on homestead land, cultivable land, other land, soil type, current value of land, gender-disaggregated information on land ownership and decision-making regarding use of land)
 - Access to agriculture extension services
 - Access to other agriculture-related services

The endline survey will collect data on the following:

- Brinjal production since the baseline survey, including area planted, pesticide use, labor input (disaggregated by family versus hired labor, and family labor further disaggregated by relation to household head), use and cost of other inputs, credit used to purchase inputs associated with brinjal production, amount produced, and income generated.
- Pesticide-related illness (incidence, duration, severity) and the costs associated with these.
- Limited data on changes in assets, loans and debt, and land ownership.

IFPRI researchers will prepare draft survey questionnaires, which will be pilot tested, peer-reviewed, and revised to address comments and suggestions of stakeholders. Data Analysis and Technical Assistance (DATA) will implement the farm household surveys, a Bangladeshi consulting firm with expertise in conducting complex surveys and data analysis. DATA will work under the supervision and guidance of IFPRI researchers. DATA's capacity to conduct surveys to collect high-quality data was largely built by IFPRI over the past two decades.²¹

For the baseline farm household survey, DATA will provide experienced survey enumerators and supervisors to administer the survey on sample treatment and control households. IFPRI researchers and DATA experts will provide additional training to survey enumerators and supervisors. The training of the survey enumerators will consist of a formal classroom component, as well as closely monitored practice fieldwork. The questionnaire will be field tested in one of the selected survey districts in north-western Bangladesh. The questionnaire will be finalized after pretesting.

The enumerators will conduct the interviews one-by-one and face-to-face. During interviews, survey responses will be recorded using computer-assisted personal interviews (CAPI) on tablets. IFPRI's substantial experience with CAPI indicates that it sharply improves data quality and identification of households and individuals in multiple-round data collection exercises compared to paper questionnaires. DATA have both male and female enumerators on staff; where we have female farmers in our sample, they will be interviewed by female enumerators.

IFPRI and DATA will take much care to ensure the quality of the farm household survey data. Each survey team will have one supervisor and four to five enumerators. In the field, survey supervisors will oversee all interviews conducted by enumerators. If inconsistencies in responses are detected in completed questionnaires, supervisors will visit the related respondents to find out the reasons and correct the responses as needed. Since the survey will be conducted using computer-assisted personal interviewing (CAPI), enumerators will submit completed interviews online to a central server at the DATA office in Dhaka daily. The field-based supervisors, who will be connected to the server online, will perform consistency checks of all data collected daily. If inconsistencies in responses are detected in completed interviews, the

²¹ DATA carried out all IFPRI surveys in Bangladesh, including over 50 household surveys and several market, school, and other institutional surveys. Besides IFPRI, DATA conducted numerous surveys for various international organizations such as the World Food Programme (WFP)-Bangladesh, the World Bank, European Union, U.S. Department of Agriculture (USDA), CARE-Bangladesh, World Vision-Bangladesh, Population Council-New York, Save the Children (USA), Tufts University School of Nutrition Science and Policy, and IRIS Center at the University of Maryland.

supervisor, together with the enumerator, will re-visit the sample farm household the next day to resolve the problem. In addition, DATA survey coordinators will periodically make field visits during the survey to supervise the survey teams. Further, at the DATA headquarters, system analysts will check online data inputs from field daily, and the survey manager will regularly communicate with field teams and survey coordinators to ensure high quality data and smooth functioning of the survey. IFPRI researchers will make field visits to supervise the fieldwork.

The endline survey will be administered on all treatment and control farm households included in the baseline survey sample, which will create a two-round panel survey, and will adhere to the same data quality assurance processes as the baseline data collection.

6.2 Qualitative interviews and monitoring

The IFPRI-PRSSP office in Dhaka has a well-trained and experienced qualitative research team that will conduct the qualitative research. There will be two rounds of qualitative fieldwork. The first round will occur in March 2018, after Bt brinjal has been planted and farmers have several months experience cultivating it. Focus Group Discussions (FGDs) in nine treatment villages (three villages per district x three districts) will be conducted. In each, all farmers growing Bt brinjal will be invited to participate. While the discussions in these FGDs will center on the 10 research questions about production of Bt brinjal, particular attention will be given to question #10 to better understand in farmers' own words why these changes have occurred and why they might vary with specific farmer or locational characteristics. In addition, Key Informant Interviews (KIIs) with concerned officials of the Department of Agricultural Extension will be undertaken to get their perspectives on the cultivation of Bt brinjal, again with a particular focus on research question #10.

A second round of qualitative work will take place in June 2018. FGDs in nine treatment villages (three villages per district x three districts) will be conducted again, inviting all farmers growing Bt brinjal to participate. These discussions will center on the four research questions about the marketing of Bt brinjal, with particular attention to question #14, seeking to understand farmers' experiences marketing Bt brinjal. This will be complemented with KIIs with market traders operating in these villages, understanding from their perspective the challenges and opportunities that Bt brinjal brings.

7. Estimating Impacts

IFPRI's impact estimation strategy for the Bt brinjal impact evaluation study relies on the RCT design of the evaluation. Random assignment of clusters (villages) assures that, on

average, farm households will have similar baseline characteristics across treatment and control groups. Such a design eliminates systematic differences between treatment and control households and minimizes the risk of bias in the impact estimates due to “selection effects” (Hidrobo et al. 2014).

Analysis of Covariance (ANCOVA) regression will be used to estimate impacts of the Bt brinjal technology using the longitudinal data on treatment and control households. The ANCOVA specification allows a household’s outcome at follow-up to depend on the same household’s outcome at baseline as well as on the household’s treatment status and an error term (accounting for any omitted observable or unobservable factors). In case of high variability and low autocorrelation of the data at baseline and follow-up, ANCOVA estimates are preferred over difference-in-difference estimates (McKenzie 2012). Intuitively, if autocorrelation is low, then difference-in-difference estimates will over-correct for baseline imbalances. ANCOVA estimates, on the other hand, will adjust for baseline imbalances according to the degree of correlation between baseline and follow-up, as the specification allows estimating autocorrelation rather than imposing it to be unity. The ANCOVA model that will be estimated is below:

$$Y_h = \alpha + \beta T_h + \gamma Y_{h,base} + \varepsilon_h ,$$

where α is a scalar, Y_h is the outcome of interest (for example, Bt brinjal yields) for farm household h at follow-up, and $Y_{h,base}$ is the outcome of interest at baseline. T is an indicator for whether household h is in the treatment group (treatment = 1, control = 0), β is the ANCOVA impact estimator, and ε_h is an error term. In other words, β represents the amount of change in outcome, Y , which is due to household h being assigned to the treatment group. To test whether the ANCOVA impact estimator is statistically different for the treatment group, Wald tests of equality are conducted and p-values are reported.

The randomization of treatment status, the selection of farmers based on their willingness to grow Bt brinjal, and the use of the ANCOVA estimator collectively provide us the means of ensuring that changes in outcome variables can be ascribed to the adoption of Bt brinjal. Despite these considerable strengths, there may be residual concerns regarding self-selection into treatment. This may be addressed in multiple ways.

As always, the control and treatment groups using observable characteristics collected in the surveys will be balanced. In particular, balancing will be checked by comparing (i) those individuals assigned to the treatment group against those assigned to the control group at baseline, and (ii) those individuals in the treatment group who ultimately complied with (or dropped out of or from) the treatment through to endline against

those assigned to the control group at baseline. Where observable characteristics differ within these groups, the data will be analyzed to determine the magnitude and nature of the (selection or attrition) bias, if present.

8. Project Partners and Their Scope of Work

The key research partners have agreed upon the following scope of work:

8.1 Bangladesh Agricultural Research Institute (BARI)

- Transfer funds earmarked for the study to DAE during the first week of August 2017.
- Certify Bt brinjal seeds supplied to DAE.
- Package and supply enough Bari Bt Begun 4 (ISD-006) seeds to DAE for 600 treatment farmers each cultivating a 10-decimal plot.
- Provide conventional brinjal seeds for the refuge border to abide by biosafety rules and guidelines set by BARI.
- Conduct training of trainers (ToT) for DAE officials of each of the districts of the study. Provide detailed protocol on Bt brinjal cultivation.
- Monitor Bt brinjal seedling production and cultivation by treatment farmers.

8.2 Department of Agricultural Extension (DAE)

- Mobilize DAE officials to attend ToT sessions to be conducted by BARI scientists.
- Identify and assign SAAOs to each of the villages selected for the study.
- Mobilize SAAOs to attend ToT sessions to be conducted by DAE officials trained by BARI scientists.
- Organize farmers' training by trained SAAOs at the upazila-level.
- Conduct training for 600 treatment farmers selected on growing Bt brinjal.
- Conduct training for 600 selected control farmers on growing conventional brinjal.
- Identify 1 lead farmer among 6 treatment farmers in each treatment village (100 lead farmers).
- Collect Bt brinjal seeds from BARI and distribute to lead farmers in each treatment village. The lead farmers will then raise the seedlings, which will later be collected by the other 5 treatment farmers.
- Collect conventional brinjal seeds (ISD-006) to be distributed to 600 control farmers.
- Provide input support to 1,200 farmers (600 treatment and 600 control farmers). In addition, lead farmers from the treatment group will receive Bt brinjal seeds and other inputs to raise seedlings for treatment farmers.

- Coordinate and monitor seedling distribution to all selected treatment farmers in each of the 100 treatment villages.
- Monitor Bt brinjal cultivation by treatment farmers as well as conventional brinjal cultivation by control farmers throughout implementation.
 - During growth period of the brinjal (first three and a half months), frequency of monitoring will be monthly; during harvesting period, frequency of monitoring will be every 15 days.
 - Bear costs of travel and daily allowance (TA/DA) of SAAOs during training and monitoring visits.

8.3 International Food Policy Research Institute (IFPRI)

- Coordinate various activities between partners.
- Prepare village census questionnaire.
- Train DATA enumerators to conduct census of the 200 selected villages (100 treatment and 100 control villages).
- Guide DATA on the selection of treatment and control farmers from the village census lists.
- Prepare and pilot baseline and endline survey questionnaires.
- Train DATA enumerators to conduct baseline and endline surveys.
- Observe ToT provided by BARI to DAE officials.
- Observe farmers' training by SAAOs.
- Monitor baseline and endline farm household surveys for 600 treatment and 600 control farmers.
- Monitor treatment and control farmers to ensure they properly fill in the registry provided.
- Analyze baseline survey data, prepare baseline report, and present survey findings to MOA and USAID for review and comment and other stakeholders.
- Analyze endline survey data to estimate impacts of Bt brinjal and costs and benefits of Bt brinjal production.
- Conduct qualitative fieldwork, analyze collected information, and incorporate findings in the final report.
- Prepare final report, present evaluation results to MOA, USAID, and other stakeholders for feedback, incorporate inputs, and distribute final report.
- Prepare and disseminate policy briefs from the evaluation study.

8.4 Data Analysis and Technical Assistance (DATA)

The scope of work for DATA is presented in Section 6 of this report.

9. Schedule of Activities

The study's activities are scheduled to start in May 2017 and end in September 2018. Four partners will collaborate on this evaluation – (1) BARI, (2) DAE, (3) IFPRI, and (4) DATA. Table 3 features the timeline of activities of the study.

Table 3 Schedule of activities

Activities	Responsible partners	Timeline 2017-2018
2017		
Complete census questionnaire and prepare draft baseline survey questionnaire for comments by partners	IFPRI, DATA	20 June 2017
Finalize full village list and randomly select 100 treatment and 100 control villages. Provide final village lists to DAE and BARI	IFPRI, DATA	20 July
Share training modules, technology fact-sheet and demo guideline for preparation of training manual with DAE and IFPRI	BARI	20 July
Finalize training manual	DAE	23-25 July
Prepare tender/quotation for printing material	DAE	25 July
Send requisition letter to BARI for supplying certified Bt brinjal seeds to DAE	DAE	25 July
Update budget and send request to BARI to transfer earmarked funds to DAE	DAE, BARI	31 July
Print 750 copies of “ <i>Bt begun utpadon koushol o prodorshoni bastobayon nirdeshika</i> ” for trainers and farmers in the treatment category, and 750 copies of “ <i>Begun utpadon koushol o prodorshoni bastobayon nirdeshika</i> ” for trainers and farmers in the control category.	DAE	31 July
Supply enough Bt brinjal seeds to DAE	BARI	31 July
BARI to impart training of trainers (ToT) to DAE officials at BARI-Gazipur on Bt brinjal (treatment) and conventional brinjal (control) cultivation	BARI	1-3 August
Conduct census in 100 treatment and 100 control villages	DATA, IFPRI	1-14 August
Randomly select 600 treatment and 600 control farmers and provide list to DAE and BARI	IFPRI, DATA	20 August
Confirm farmers' participation in study cultivation by SAAO and finalize treatment and control farmers' list	DAE	21 – 31 August
Ensure and procure enough non-bt/conventional (ISD-006) brinjal seeds of the same variety as BARI Bt Begun 4 for control farmers by DAE local authority	DAE	31 August
Develop monitoring form for DAE and BARI	IFPRI	31 August
Impart treatment and control farmers' training by DAE officials and supply non-seed inputs to farmers	DAE	10-14 September
Supply sufficient Bt brinjal seeds to lead farmers for raising seedlings for treatment farmers	DAE	10-14 September
Lead farmer (one of the treatment farmers) in each treatment village sows Bt brinjal seeds to produce seedlings	DAE	16 September
Conduct training of survey enumerators on how to administer the baseline questionnaire, pretest the questionnaire and finalize it	IFPRI, DATA	11-20 October
Treatment farmers prepare 10 decimal plot for Bt brinjal cultivation	DAE	13-20 October
Collect Bt brinjal seedlings from lead farmer and transplant seedlings on	DAE	21-30 October

10 decimal plot by treatment farmers		
Administer baseline survey on treatment and control farmers	IFPRI, DATA	10-30 November
Clean and document baseline survey data, then deliver dataset to IFPRI	DATA	1-31 December
2018		
Analyze baseline survey data	IFPRI	1 January – 15 February
Present baseline survey findings to relevant stakeholders	IFPRI	28 February
First round of qualitative fieldwork on production practices	IFPRI	March
Prepare and disseminate baseline report	IFPRI	31 March
Monitor lead farmers producing seedlings and monitor 600 treatment farmers' Bt brinjal cultivation practices. Ensure that the registry provided to the farmer is filled in properly.	BARI, DAE, IFPRI, APSU	20 September 2017- 31 May 2018
Monitor 600 control farmers. Ensure that the registry provided to the farmer is filled in properly.	BARI, DAE, IFPRI, APSU	11 November 2017- 31 May 2018
Prepare draft endline survey questionnaire for testing	IFPRI	15 May
Train survey enumerators on how to administer the endline questionnaire, followed by pretesting and finalizing the questionnaire	IFPRI, DATA	16-31 May
SAAOs collect registry from 600 treatment and 600 control farmers and send to IFPRI for analysis	DAE	1-10 June
Second round of qualitative fieldwork on marketing practices	IFPRI	June
Enter data from farmers' registry	DATA	11-25 June
Conduct endline survey on treatment and control farmers	DATA, IFPRI	1-30 June
Clean and document endline survey data, then deliver dataset set to IFPRI	DATA	1-15 July
Analyze endline survey data to estimate impacts and costs and benefits of Bt brinjal production	IFPRI	16 July-15 August
Present evaluation findings to stakeholders and receive feedback	IFPRI	30 August
Prepare and disseminate final evaluation report	IFPRI	20 September 2018

References

Ahmed, A. U., K. Ahmad, V. Chou, R. Hernandez, P. Menon, F. Naeem, F. Naher, W. Quabili, E. Sraboni, and B. Yu. 2013. *The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Project report submitted to the U.S. Agency for International Development. International Food Policy Research Institute, Dhaka.

Dataset: Ahmed, Akhter, 2013, "Bangladesh Integrated Household Survey (BIHS) 2011-2012", <http://hdl.handle.net/1902.1/21266>
UNF:5:p7oXR2unpeVoD/8a48PcVA== International Food Policy Research Institute [Distributor] V3 [Version]

Hidrobo, H., J. Hoddinott, A. Peterman, A. Margolies, and V. Moreira. 2014. Cash, food, or vouchers? Evidence from a randomized experiment in northern Ecuador. *Journal of Development Economics* 107 (2014): 144–156.

McKenzie, David. 2010. *Beyond Baseline and Follow-Up: The Case for More T in Experiments*. Policy Research Working Paper 5639. Washington, DC: The World Bank.

APPENDIX B: COMBINED BASELINE AND ENDLINE SURVEY QUESTIONNAIRE

**Ministry of Agriculture
Government of the People's Republic of Bangladesh**

**Assessing the Impact of Bt Brinjal Technology in Bangladesh
Baseline Survey (November – December 2017) & Endline Survey (July-August 2018)**

**Survey designed and supervised by: Bangladesh Policy Research and Strategy Support Program (PRSSP)
International Food Policy Research Institute (IFPRI)**

Survey administered by: Data Analysis and Technical Assistance Limited (DATA)

Farm Household Questionnaire

Sample type:

☐

Bt Brinjal Farmer.....1

Control Farmer.....2

Module A: Sample Household and Identification (Baseline and Endline)

Q. No.	Household Identification	Response	Q. No.	Household Identification	Response						
A01	Household Identification Number: :.....	<div><div></div><div></div><div></div><div></div></div>	A11	Mobile phone number:	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>						
A02	Census number	<div><div></div><div></div><div></div></div>	A12	Name and Member ID of the Primary Respondent (Household Head / primary male) (from Module B1): :.....	<div><div></div><div></div></div>						
X	Household location/landmark: :.....		A13	Name of the Household Head and Member ID: :.....	<div><div></div><div></div></div>						
XI	Is this household located in the same location (i.e. village, union, upazilla)?	<div><div></div>yes.....1 No.....2</div>	A14	Name and Member ID of Household Head's father (if Household Head is female report for Household Head's husband)::.....	<div><div></div>..... 98 e but not HH member 99</div>						
A03	Village (name and code): :.....	<div><div></div><div></div></div>	A15	Household Head's religion	Muslim1 Hindu2 Christian3 Buddhist4 Other(specify)5						
A04	Mouza (name and code): :.....	<div><div></div><div></div><div></div></div>									
A05	Agricultural Block (name and code):.....	<div><div></div><div></div><div></div></div>	A16	Date of the First visit (dd/mm/yy)::	<table><tr><th>Day</th><th>Month</th><th>Year</th></tr><tr><td><div></div></td><td><div></div></td><td><div></div></td></tr></table>	Day	Month	Year	<div></div>	<div></div>	<div></div>
Day	Month	Year									
<div></div>	<div></div>	<div></div>									
A06	Union (name and code): :.....	<div><div></div><div></div></div>	A17	Date of the second visit (dd/mm/yy):	<table><tr><th>Day</th><th>Month</th><th>Year</th></tr><tr><td><div></div></td><td><div></div></td><td><div></div></td></tr></table>	Day	Month	Year	<div></div>	<div></div>	<div></div>
Day	Month	Year									
<div></div>	<div></div>	<div></div>									
A07	Thana/ Upazilla (name and code): :.....	<div><div></div><div></div></div>	A18	Name of Interviewer and code: :.....	<div><div></div><div></div></div>						
A08	District (name and code): :.....	<div><div></div><div></div></div>	A19	Name of Supervisor and code: :.....	<div><div></div><div></div></div>						
A09	Division (name and code): :.....	<div><div></div><div></div></div>	A20	Date of Data Verification (dd/mm/yy):	<table><tr><th>Day</th><th>Month</th><th>Year</th></tr><tr><td><div></div></td><td><div></div></td><td><div></div></td></tr></table>	Day	Month	Year	<div></div>	<div></div>	<div></div>
Day	Month	Year									
<div></div>	<div></div>	<div></div>									
A10	GPS Coordinates: [Report degree, minute and second]	North: <div><div></div></div> East: <div><div></div></div>	A21	Signature of supervisor:							

Informed Consent for Assessing the Impact of Bt Brinjal Technology in Bangladesh

Informed Consent: *Before beginning the interview, it is necessary to introduce the household to the survey and obtain their consent to participate. Make it clear to them that their participation in the survey is voluntary. Please read the following statement in the language of interview:*

Good morning/afternoon. I am _____ from the Data Analysis and Technical Assistance Limited (DATA), a Bangladeshi research organization based in Dhaka. Together with the International Food Policy Research Institute (IFPRI), we are conducting a survey to learn about agriculture production and practices, and the health of households in this area. You have been selected to participate in an interview which includes questions on topics such as your family background, asset ownership, income earning activities, and health status of household members. The interview will be done in private and are confidential from each respondent in the household. We value your opinion and there are no wrong answers to the questions we will be asking in the interview. We will use approximately 2 hours of time in total to collect all the information. There will be no cost to you other than your time. Your participation in this interview is completely voluntary. You are free to withdraw your consent and discontinue participation in this study at any time. You are free to skip any questions that you do not wish to respond, as well. However, your responses may help us to carry out research that is designed to help promote the welfare of Bangladeshis.

This study is conducted in a way that you will be only identified through code numbers. Your identity will not be stored with other information we collect about you. Your responses will be assigned a code number, and the list connecting your name with this number will be kept in an encrypted file that will be destroyed once all the data has been collected and analyzed. Any information we obtain from you during the research will be kept strictly confidential. This research study has been reviewed and approved by the Institutional Review Board (IRB) of IFPRI. We will leave a copy of this consent form with you.

Your participation will be highly appreciated. We will also interview other households in your community and in other parts of Bangladesh. After we collect all the information we will use the data to make a study about how various programs can be most helpful to the people in this area. Do you understand everything we explained to you? Do you have any questions before agreeing to be a part of the study? If you have questions about your rights as a research participant, you may contact the following key persons involved in this study.

Contact Person:

Dr. Akhter Ahmed
Principal Investigator, PRSSP/IFPRI
Tel: 989-8686
Email: a.ahmed@cgiar.org

Dr. Eduardo Maruyama
2033 K Street, N.W.
Washington, DC 20006
E-mail: ifpri-irb@cgiar.org

Md. Zobair,
Director, DATA
Tel: +88 02 912 0091;
Email: m.zobair@databd.org

Please ask the participants (male and female) if they consent to the participation in the study (check one box):

Participant 1:	YES <input type="checkbox"/>	NO <input type="checkbox"/>	Participant 2:	YES <input type="checkbox"/>	NO <input type="checkbox"/>
----------------	------------------------------	-----------------------------	----------------	------------------------------	-----------------------------

I _____, the enumerator responsible for the interview taking place on _____, 2017 certify that I have read the above statement to the participant and they have consented to the interview. I pledge to conduct this interview as indicated on instructions and inform my supervisor of any problems encountered during the interview process.

If the household does not give consent to all of the data collection, stop the interview and inform your team leader. Team leaders will discuss the reason for this refusal and decide whether a partial data collection is possible for this household.

DEFINITION OF HOUSEHOLD

A household is a group of people who live together and take food from the “same pot.” In our survey, a household member is someone who has lived in the household at least 6 months, and at least half of the week in each week in those months. Even those persons who are not blood relations (such as servants, lodgers, or agricultural laborers) are members of the household if they have stayed in the household at least 3 months of the past 6 months and take food from the “same pot.” If someone stays in the same household but does not bear any costs for food or does not take food from the same pot, they are not considered household members. For example, if two brothers stay in the same house with their families but they do not share food costs and they cook separately, then they are considered two separate households.

Generally, if one person stays more than 3 months out of the last 6 months outside the household, they are not considered household members. We do not include them even if other household members consider them as household members.

Exceptions to these rules should be made for:

Consider as household member

- A newborn child less than 3 months old.
- Someone who has joined the household through marriage less than 3 months ago.
- Servants, lodgers, and agricultural laborers currently in the household and will be staying in the household for a longer period but arrived less than 3 months ago.

Do not consider as household member

- A person who died very recently though stayed more than 3 months in last 6 months.
- Someone who has left the household through marriage less than 3 months ago.
- Servants, lodgers, and agricultural laborers who stayed more than 3 months in last 6 months but left permanently.

This definition of the household is very important. The criteria could be different from other studies you may be familiar with, but you should keep in mind that you should not include those people who do not meet these criteria. Please discuss any questions with your supervisor.

Module B: Household Composition and Education (Respondent: Household head) (Baseline and Endline)

Note: **Write complete years. For example, if age is 18 years and 9 months, write only 18 years.

Member ID	Name	Sex Male .....1 Female..2	Age* (complete years)	Relation to Household Head	Marital Status	Education (Highest class passed)	Main Source of income Note: please keep it in mind that here we are not asking about the profession
		Code ↑	Year	Code 1	Code 2	Code 4	Code 5
MID	Name	B01	B02	B03	B04	B05	B06

Code list for Module B:

Code 1: Relationship Relationship to household head	Code 4: Education (Highest class passed)	Code 5: Occupation Wage Labor	Self-employment	Trader
Household head...1	Never attended school...99	Agricultural day labor..... 1	Rickshaw/van pulling.....22	Small trader (roadside stand or stall).....50
Spouse of household head...2	Reads in class I....0	Earth work (govt program)..... 2	Driver of motor vehicle.....23	Medium trader (shop or small store).....51
Son/daughter....3	Completed class I....1	Earth work (other)..... 3	Tailor/seamstress.....24	Large trader (large shop or whole sale).....52
Son/ Daughter-in-law....4	Completed class II....2	Sweeper..... 4	Blacksmith.....25	Fish Trader.....53
Grandson/daughter....5	Completed class III....3	Scavenger..... 5	Potter.....26	Contractor.....54
Father/mother....6	Completed class IV....4	Tea garden worker..... 6	Cobbler.....27	
Father/mother-in-law....7	Completed class V....5	Construction labor..... 7	Hair cutter.....28	Production
Brother/sister....8	Completed class VI....6	Factory worker..... 8	Clothes washer.....29	Food Processing.....55
Brother/sister-in-law....9	Completed class VII....7	Transport worker (bus/truck helper)..... 9	Porter.....30	Small industry.....56
Niece/Nephew ....10	Completed class VIII....8	Apprentice.....10	Goldsmith/silversmith.....31	Handicrafts.....57
Household head's cousin.....11	Completed class IX....9	Other wage labor (specify).....11	Repairman (appliances).....32	
Other relative....12	Completed Secondary School/Dakhil...10	Salaried worker	Mechanic (vehicles).....33	Livestock Poultry related work/occupation
Permanent servant.....13	Completed Higher Secondary/Alim...12	Government/ parastatal.....12	Plumber.....34	Milk collector.....58
Other Non-relative/friends....14	BA/BSC/Fazil (pass course)....14	Service (private sector).....13	Electrician.....35	Livestock Vet medicine seller.....59
	BA/BSC /Fazil (honors)....15	NGO worker.....14	Carpenter.....36	Livestock Feed supplier.....60
	MA/MSK/Kamil and above....16	House maid.....15	Mason/Construction Rod Welder.....37	Commercially feed producer.....61
	SSC Candidate.....22	Teacher (GoB-Primary school).....16	Doctor.....38	Animal Breeder.....62
	HSC Candidate.....33	Teacher (Non-GoB Primary school).....17	Rural physician.....39	Veterinary/paravet doctor.....63
	Preschool class (general)....66	Teacher (GoB High school).....18	Midwife.....40	
	Preschool (mosque based)....67	Teacher (Non-GoB High school)....19	Self-employment (continued)	Farming
	Nurani/kiratia/hafizia.....68	Teacher (college, university).....20	Herbal doctor/Kabiraj.....41	Working own farm (crop).....64
	Other (specify).....69	Other salaried worker(specify).....21	Engineer.....42	Share cropper/tenant.....65
			Lawyer/deed writer/Moktar.....43	Homestead farming.....66
			Religious leader (Imam/Muazzem/ Khadem/Purohit).....44	Fisherman (using non owned/not leased water body).....67
			Lodging master.....45	Raising fish / fish pond.....68
			Private tutor/house tutor.....46	Raising poultry.....69
			Beggar.....47	Raising livestock.....70
				Dairy production/ dairy farming.....71
				Other self-employed (specify).....72
				Remittance.....91
				Income from Safety net program.....92
				Income from asset (house/shop rent, etc.).....93
				Non-earning occupation
				Student.....81
				Housewife.....82
				Retired.....83
				Child(age <12 no study/ work).....84
				Physically/ mentally challenged.....85
				Jobless.....86
				Don't know.....98
Code 2: Marital status				
Unmarried (never married)...1				
Married (currently married).....2				
Widow/widower....3				
Divorced....4				
Separated/Deserted....5				

Module C: Health (Baseline and Endline)

C1: General health questions

We would like to begin with some general questions about the health and health behaviors of household members

[illegible]

Code 1: 1 Excellent/ Very good 2 Good 3 Fair 4 Poor 5 Very poor	Code 2: 1 Easily/no problem 2 Yes but with a little difficulty 3 Yes, but with a lot of difficulty 4 Cannot do this task
---	---

C2: Health status during the last brinjal growing season

		Did this person have this symptom during this agricultural season (November 2017 to June 2018)?									
Did this person work in any field of brinjal farming during this period? If yes, ask the following questions		Eye irritation	How long did this symptom last?	Headache	How long did this symptom last?	Dizziness	How long did this symptom last?	Nausea or Vomiting	How long did this symptom last?	Diarrhea	How long did this symptom last?
MID	Yes/no	Yes/No	Days	Yes/No	Days	Yes/No	Days	Yes/No	Days	Yes/No	Days
	C2_01a	C2_02a	C2_02b	C2_03a	C2_03b	C2_04a	C2_04b	C2_05a	C2_05b	C2_06a	C2_06b

	Did this person have this symptom during this agricultural season?									
	Fever	How long did this symptom last?	Convulsion	How long did this symptom last?	Shortness of breath, wheezing, coughing	How long did this symptom last?	Skin disease	How long did this symptom last?	Joint pain (e.g. stiffness, swollen)	How long did this symptom last?
	Yes/No	Days	Yes/No	Days	Yes/No	Days	Yes/No	Days	Yes/No	Days
MID	C2_07a	C2_07b	C2_08a	C2_08b	C2_09a	C2_09b	C2_10a	C2_10b	C2_11a	C2_11b

	How many days during this agricultural season did all these symptoms prevent you from working?	Did you seek medical treatment for any of these symptoms?	Did you incur any cash expenses associated with treating these symptoms? If “no” skip to next member	Consultation fee	Medicines	Lab tests	Hospital/clinic fees/ expenses	Transport cost to seek treatment
	Days	Yes/No	Yes/No	Tk	Tk	Tk	Tk	Tk
MID	C2_12	C2_13	C2_14	C2_15	C2_16	C2_17	C2_18	C2_19

Module D: Assets (Respondent: Household head) (Baseline Only)

Module D1: Current Household Assets

Description of asset	Asset code	Does your household own the item? Yes...1 No....2>>Next item	Quantity	ID of owner Report three primary owners If household member, write MID All members jointly .....71 If not household member, then use following codes: Male outside household .....72 Female outside household. 73			Current value/ if asset sold today how much will you receive? (report total value for all items owned)
			No.	MID			(Tk)
D1_01	D1_02	D1_03	D1_04	D1_05a	D1_05b	D1_05c	D1_06
Trunk /Suitcase	1						
Buckets / Pots	2						
Stove / Gas burner	3						
Metal cooking pots	4						
Bed / Khat / Chowki	5						
Armoire/Cabinet/ Alna	6						
Table / chair	7						
Electric fan	8						
Electric iron	9						
Radio	10						
Audio cassette/CD player	11						
Wall clock /watch	12						
Wristwatch	13						
Television (B/W)	14						
Television (Color)	15						
Camera/ Video Camera	16						
Jewelry (gold)	17						

Description of asset	Asset code	Does your household own the item? Yes...1 No....2>>Next item	Quantity	ID of owner Report three primary owners If household member, write MID All members jointly 71 If not household member, then use following codes: Male outside household 72 Female outside household. 73			Current value/ if asset sold today how much will you receive? (report total value for all items owned)
			No.	MID			(Tk)
D1_01	D1_02	D1_03	D1_04	D1_05a	D1_05b	D1_05c	D1_06
Jewelry (silver)	18						
Sewing machine	19						
Bicycle	20						
Rickshaw	21						
Van (tricycle van)	22						
Boat	23						
Engine boat	24						
Motorcycle	25						
Mobile phone set	26						
Dheki	27						
Jata	28						
Randa	29						
Saw	30						
Hammer	31						
Fishing net	32						
Spade (Kodal)	33						
Axe (Kural)	34						
Shovel (belcha)	35						
Shabol	36						
Daa	37						

Description of asset	Asset code	Does your household own the item? Yes...1 No....2>>Next item	Quantity	ID of owner Report three primary owners If household member, write MID All members jointly 71 If not household member, then use following codes: Male outside household 72 Female outside household. 73			Current value/ if asset sold today how much will you receive? (report total value for all items owned)
			No.	MID			(Tk)
D1_01	D1_02	D1_03	D1_04	D1_05a	D1_05b	D1_05c	D1_06
Mule	38						
Donkey	39						
Cow	40						
Buffalo	41						
Horse	42						
Goat/ Sheep	43						
Duck/ Hen	44						
Other Animal (specify)	45						
Cash in hand	46						
Solar energy panel	47						
Electricity Generator	48						
IPS	49						
Computer/ Laptop	50						
Tab	51						

Module D2: Agricultural Implements and Other Productive assets (Respondent: Household head)

Description of asset	Asset code	Does your household own the item? Yes...1 No....2>> next item	Quantity	ID of owner Report three primary owners If household member, write MID If not household member, then use following codes: All members jointly 71 Male outside household..... 72 Female outside household.. 73			Current value/ if asset sold today how much will you receive? (report total value for all items owned)
	Code		No.	MID			(Tk)
D2_01	D2_02	D2_03	D2_04	D2_05a	D2_05b	D2_05c	D2_06
Farming tools:							
Manual Reaper/Sickle	60						
Weeding tool	61						
Harrow	62						
Rake	63						
Plough/ yoke	64						
Winnowing Machine	65						
Pesticide sprayer manual	66						
Pesticide sprayer motorized	67						
Equipment for showering plant (Jhorna)/ Jhajhara	68						
Net for covering field/ seedbed	69						
Insect trap (Pheromone trap)	70						
Jerry can (Container) for mixing pesticide	71						
Wheelbarrow	72						
Bullock cart	73						
Push cart	74						
Other Light Machinery (Specify)	75						
Machinery:							
Tractor	76						
Power Tiller	77						
Trolley/Trailers	78						

Description of asset	Asset code	Does your household own the item? Yes...1 No....2>> next item	Quantity	ID of owner Report three primary owners If household member, write MID If not household member, then use following codes: All members jointly 71 Male outside household..... 72 Female outside household.. 73			Current value/ if asset sold today how much will you receive? (report total value for all items owned)
	Code		No.	MID			(Tk)
D2_01	D2_02	D2_03	D2_04	D2_05a	D2_05b	D2_05c	D2_06
Thresher	79						
Fodder cutting machine	80						
Swing basket	81						
<i>Don</i>	82						
Hand tube well	83						
Treadle pump	84						
Rower pump	85						
Jumbo Pump (Axial Flow pump)	86						
Low lift pump (LLP) for irrigation	87						
Shallow tube well (STW)	88						
Deep tube well (DTW)	89						
Electric motor pump	90						
Diesel motor pump	91						
Spraying machines (chem./ fertilizer)	92						
Reaper	93						
Seeder Drills: till, plant, fertilize simultaneously	94						
Bed planter (forms fields into beds and furrows)	95						
Other Heavy Machinery	96						
<i>Other productive assets:</i>							
Briquette Urea Applicator (Injector)	98						
Briquette Urea Applicator (Push)	99						

Module D3: Housing, water and sanitation

Question number	Question	Response	Response option
D3_01	In what year was this house built? (structure of main dwelling)	<input type="text"/>	Years (if don't know.....9999)
D3_02	If this household shares space with another household, how many households live in this house?		Number (write 0 if no sharing)
D3_03	<u>OBSERVE</u> What type of dwelling does the household live in?	<input type="text"/>	No sign of damage..... 1 Slightly damaged..... 2 Somewhat damaged..... 3 Very damaged..... 4 In a very poor state..... 5
D3_04	<u>OBSERVE</u> The <u>outer walls</u> of the main dwelling of the household are predominantly made of what material?	<input type="text"/>	Concrete/Brick..... 1 Tin/CI Sheet..... 2 Wood..... 3 Mud..... 4 Bamboo..... 5 Jute straw..... 6 Plastic /Polythene..... 7 Cardboard/paper..... 8 Golpata/Palm leaf..... 9 Grass/Straw..... 10 Other (specify)..... 11
D3_05	<u>OBSERVE</u> The <u>roof</u> of the main dwelling is predominantly made of what material?	<input type="text"/>	Concrete/Brick..... 1 Tin/CI Sheet..... 2 Wood..... 3 Mud..... 4 Bamboo..... 5 Jute straw..... 6 Plastic /Polythene..... 7 Cardboard/paper..... 8 Golpata/Palm leaf..... 9 Grass/Straw..... 10 Other (specify)..... 11

Question number	Question	Response	Response option
D3_06	<u>OBSERVE</u> The <u>floor</u> of the main dwelling is predominantly made of what material?	<input type="text"/>	Concrete/Brick..... 1 Tin/CI Sheet..... 2 Wood 3 Mud 4 Bamboo 5 Jute straw 6 Plastic /Polythene 7 Cardboard/paper..... 8 Golpata/Palm leaf 9 Grass/Straw 10 Other (specify)..... 11
D3_07	How many rooms does your household occupy?	<input type="text"/>	Number (Exclude rooms used for business)
D3_08	How many rooms are used for sleeping?	<input type="text"/>	Number
D3_09	Does this household have an electricity connection?	<input type="text"/>	Yes..... 1 No 2
D3_10	What is your main source of <u>lighting fuel</u> ?	<input type="text"/>	Electricity 1 Private Generator..... 2 Solar electricity 3 Kerosene 4 Candles..... 5 Torch/fire skewer 6
D3_11	Is cooking done inside or outside the main dwelling?		Inside .....1 Outside in the open .....2 In another building, <u>not</u> the main dwelling ....3
D3_12	Observation Most cooking done in which type of stove? Note: Improved cook stoves are available in various names by area. For example; “Bondhu Chula”, remember that through improved cook stoves more cooking can be done in less amount of fuel and the smoke of improved cook stoves are less too.		Food is cooked using a traditional cook stove 1 Food is cooked using an improved cook stove .....2 Food is cooked directly over a fire .....3

Question number	Question	Response	Response option
D3_13	What is your main source of <u>cooking fuel</u> ?	<input type="text"/>	Electricity 1 Supply gas 2 LPG 3 Kerosene 4 Firewood 5 Dried cow dung 6 Coal 7 Rice bran/saw dust 8 Dried leaves 9 Other (specify)..... 10
D3_14	What type of latrine do you use?	<input type="text"/>	None (open field)..... 1 Kutcha (fixed place)..... 2 Pucca (unsealed)..... 3 Sanitary without flush (water sealed)..... 4 Sanitary with flush (water sealed)..... 5 Community latrine..... 6 Other (specify)..... 7
D3_15	Does the household have own access to a water supply/source?	<input type="text"/>	Yes..... 1 No 2
D3_16	What is the source of water used for other purposes than drinking?	<input type="text"/>	Supply Water (pipd) inside house 1 Supply Water (pipd), outside 2 Own tube well..... 3 Community tubewell..... 4 Rain water 5 Ring Well/ Indara 6 Pond/River/ Canal 7 Bottled water..... 8 Shallow tubewell for irrigation..... 9 Deep tubewell for irrigation..... 10 Other tube well 11 Other (specify)..... 12
D3_17	Is the source of drinking water same as the source of water used for other purposes?	<input type="text"/>	Yes..... 1>>D3_19 No 2

Question number	Question	Response	Response option
D3_18	Source of drinking water		Supply Water (piped) inside house .....1 Supply Water (piped), outside.....2 Own tube well.....3 Community tubewell.....4 Rain water .....5 Ring Well/ Indara .....6 Pond/River/ Canal .....7 Bottled water.....8 Shallow tubewell for irrigation.....9 Deep tubewell for irrigation.....10 Other tube well .....11 Other (specify).....12
D3_19	In the past 24 hours, what steps have you taken to purify your water?		Filtered using cloth/ bolter .....1 Boiled .....2 Boiled and filtered using cloth/ bolter .....3 Chemically treated (iodine/chlorine).....4 Treated by Phitkari / lime .....5 UV treated.....6 Filtered using cloth and sand .....7 Filtered using purchased commercial filter .....8 Boiled and filtered using cloth and sand.....9 Boiled and filtered using purchased commercial filter 10 Not purified .....11 Straight from source .....12 Others (specify) .....13
D3_20	If tubewell is used for drinking water, has the water been tested for arsenic contamination?	<input type="text"/>	Yes.....1 No .....2>> D3_23 Don't know .....3>> D3_23
D3_21	If yes, what color has the tubewell been marked?	<input type="text"/>	Red .....1 Green .....2>> D3_23 None .....3>> D3_23 Don't know .....4>> D3_23
D3_22	If it has been colored red, do you still use it for drinking purposes?	<input type="text"/>	Yes.....1 No .....2
D3_23	Is the source of drinking water the same throughout the year?		Yes.....1>> Module End No .....2

Question number	Question	Response				Response option															
D3_24	<p>If no, where else do you get your water from and during which months?</p> <p>For months write January1, February.....2,December....12</p>	<table border="1"> <thead> <tr> <th>Other source</th> <th>Month 1</th> <th>Month 2</th> <th>Month 3</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Other source	Month 1	Month 2	Month 3													<p>Supply Water (piped) inside house 1</p> <p>Supply Water (piped), outside.....2</p> <p>Own tube well.....3</p> <p>Community tubewell.....4</p> <p>Rain water5</p> <p>Ring Well/ Indara6</p> <p>Pond/River/ Canal7</p> <p>Bottled water.....8</p> <p>Shallow tubewell for irrigation.....9</p> <p>Deep tubewell for irrigation.....10</p> <p>Other tube well11</p> <p>Other (specify).....12</p>		
Other source	Month 1	Month 2	Month 3																		

Module E: Savings (Respondent: Household head) (Baseline Only)

Ask only for all members who are 15 years or older.

E01. Does any adult in the household currently have any savings?

☐ Yes.....1

If no,

END MODULE

Ask how many accounts each individual currently has and list them all. Each “account” should have a separate row. If the individual has more than one “account”, put in separate rows.

Serial No.	Saver	Where do you save?	If the source is an NGO, write the code of that NGO	Total amount currently saved in this savings account?
		[Code 1]	[Code 2]	(Tk)
E02	MID	E03	E04	E05
		2	2	

Code 1: Where	Code 2: NGO
At home .....1	BRAC .....1
NGO (name of NGO) 2	ASA .....2
Shamity (other than NGO) .....3	PROSHIKA .....3
Bank (Excluding Grameen bank)..4	Karitas Bangladesh .....4
Shop .....5	Shwanirbhar Bangladesh .....5
Post office / government institution .....6	TMSS .....6
Employer's provident fund.....7	RDRS Bangladesh .....7
Insurance company.....8	Bureau Tangail .....8
Relative / friend / neighbor .....9	Jagoroni Chakra .....9
Savings collector .....10	Voluntary Organization for Social Development (VOSD).....10
Land leased in from other household.....11	Peoples Oriented Program Implementation (POPI) .....11
Other (specify).....12	Gono Kalyan Trust (GKT) .....12
	Bachte Shekha .....13
	PKSF .....14
	Bangladesh Rural Development Board(BRDB)15
	PodokhepManobik Unnyan Kendra..... 17
	Heed Bangladesh..... 18
	Bureau Bangladesh 19
	Community Development Center (CODEC) 20
	Gono Milon Foundation 21
	Shapla Ful 22
	Sheba Manob kolyan Kendra (SMKK) 23
	Society for Disadvantaged Origin (SDO)..... 24
	Akota Shomaj Unnyan Kendra (ASUK) 25
	Bangladesh Development Society 26
	Social Organization for Voluntary Advancement (SOVA) 27
	Society development Committee (SDC) 28
	Faridpur Development Agency (FDA) 29
	Ashar Alo Unnyan Shangstha 30
	Polli Progoti Sohayok Samity 31
	Samadhan 32
	Manob Seba Sangstha..... 33
	Nobolok Parishad..... 34
	Rural reconstruction Foundation (RRF) 35
	Christian Civil Society (CSS) 36
	Uddipon 37
	Daak diye jai..... 38
	Shushilon 39
	Uttaran 40
	Unnyan Procheshta 41
	Save Bangladesh 42
	Satkhira Unnyan Shangstha (SUK) 43
	Ideal 44
	Manob Sompod Unnyan Kendra..... 45
	Grameen bank 46
	HKI (Helen Keller International) 47
	Other NGOs (specify)..... 48

Module F: Loans (Baseline and Endline)

Report cash loans. Include both interest bearing and nonbearing cash loans.

F01. Has any member in the household ever had any loans?

☐ Yes 1

F02. Does any member in the household currently have a loan?
with any individual or institution?

☐ Yes 1 >>F03

F02_a Have you or any other member of the household applied for loans in the last 12 months

☐ Yes..... 1>>**F02_b**

F02_b If you applied for loans, what was the reason for your application being denied?

Did not have collateral.....1

Did not have enough savings to qualify for loan...2

Did not repay previous loans (loan defaulter)3

Don't know.....4

Applied for and received loan (repaid)5

Other (specify)...6

NEXT MODULE

F02_c If you did not apply for loans, why did you not apply?

Did not need loan, and so did not apply.....1

Needed loan but did not apply fearing rejection of application2

Needed loan but did not apply fearing not receiving the loan on time.....3

Needed loan but did not apply fearing high interest rates.....4

Could not apply for not having collateral.....5

Others (specify)6

NEXT MODULE

First ask how many loans each individual currently has and list them all. Each loan should have a separate row. If an individual has more than one loan, put in separate rows.

Serial No.	Who took the loan?	What was the source of the loan?	If the source is an NGO, write the code of that NGO	What was the loan mainly used for? Report primary 3 uses			Amount of loan	What was the interest rate? (Report 999 if respondent does not know the interest rate)	What is the outstanding amount of the loan?	Is the outstanding amount with or without interest? With interest 1 Without interest 2	What is the maximum that you can borrow from this source?	What amount of borrowings have you applied for from this source?
		[Code 1]	[Code 2]	[Code 3]			(Tk)	(percent)	(Tk)	Code ↑	(Tk)	(Tk)
F03	MID	F04	F05	F06_a	F06_b	F06_c	F07	F08	F09	F10	F11	F12

Code 1: Source of loan		Code 2: NGO		Code 3: Loan use	
Relative/friend/neighbor.....1	BRAC.....1	PodokhepManobik Unnyan Kendra	Ashar Alo Unnyan Shangstha 30	Business enterprise.....1	Purchase Land .....14
Bangladesh Krishi Bank (BKB) .....2	ASA.....2	.....17	Polli Progoti Sohayok Samity 31	To buy fertilizer.....2	To purchase cow/goat .....15
Rajshahi Krishi Bank (RAKUB) .....3	PROSHIKA .....3	Heed Bangladesh.....18	Samadhan.....32	To buy seeds.....3	For medical treatment .....16
Other Bank (Excluding Grameen bank).....4	Karitas Bangladesh.....4	Bureau Bangladesh .....19	Manob Seba Sangstha .....33	To buy pesticides.....4	To meet household consumption needs .....17
Other financial institution.....5	Shwanirbhar Bangladesh .....5	Community Development Center (CODEC).....20	Nobolok Parishad .....34	To buy irrigation equipment.....5	Rent/purchase/improve housing .....18
NGO (name of NGO).....6	TMSS .....6	Gono Milon Foundation .....21	Rural reconstruction Foundation (RRF) .....35	To buy other agricultural implements .....6	Educational expenses.....19
Employer.....7	RDRS Bangladesh.....7	Shapla Ful.....22	Christian Civil Society (CSS). 36	To buy water for irrigation .....7	Marriage expenditure.....20
Shop / Dealer / Trader .....8	Bureau Tangail .....8	Sheba Manob kolyan Kendra (SMKK).....23	Uddipon .....37	Costs of diesel/electricity for agriculture.....8	Dowry .....21
Money lender .....9	Jagoroni Chakra.....9	Society for Disadvantaged Origin (SDO).....24	Shushilon .....39	Labor wages for agriculture.....9	Funeral .....22
Shamity (other than NGO) . 10	Voluntary Organization for Social Development (VOSD) .....1	Akota Shomaj Unnyan Kendra (ASUK).....25	Uttaran .....40	Costs of hired machines/animals for agriculture .....10	To lend out at higher interest...23
Leased out land to other HH .....11	Peoples Oriented Program Implementation (POPI) .....1	Bangladesh Development Society (SUK) .....26	Unnyan Procheshta.....41	To buy productive assets for purposes other than agriculture .....11	To go abroad.....24
Other (specify) .....12	1	Social Organization for Voluntary Advancement (SOVA).....27	Save Bangladesh .....42	For lease of land for agriculture (cash only) .....12	For lease of land used for purpose other than agriculture (cash only) .....13
	2	Society development Committee (SDC) .....28	Satkaira Unnyan Shangstha (SUK) .....43		
	Bachte Shekha .....1	Faridpur Development Agency (FDA)29	Manob Sompod Unnyan Kendra.....45		
	3		Grameen bank.....46		
	PKSF .....1		HKI (Helen Keller International) .....47		
	4		Other NGOs (specify) .....48		
	Bangladesh Rural Development Board(BRDB) .....1				
	5				

Module G: Roster of land and pond/water bodies owned or under operation (Baseline and Endline)

(Respondent: Person most knowledgeable about farm production)

MID of person answering questions in this module	
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Baseline:

Note: List all land (all type of land & water bodies) owned or under operation in last 12 months [from October 2016 to September 2017].

Endline:

Note: List all land (all type of land & water bodies) owned or under operation in last eight months [from November 2017 to June 2018].

Note: Firstly, update the information of all the plots of the first round survey, then include the new plots that are currently owned or under operation by the household after the 1st round survey.

owned or under operation by the household after the 1st round survey.																		
Plot ID	Plot Description	Plot Type	What was the size/ area of plot (land) in baseline?	Current Size/ Area	Status of the plot in the current round If answer of column # G02 is “0” and answer of column # G12 is in between 1 to 5 then skip to next plot.	Distance from home if next to home “0”	Usual flood depth (during monsoon/ flood season) if not flooded report “0”	Soil type	Current operational status (last 8 months)	If the plot is rented/leased in/out for cash, report amount per month Report if response to G06 is 3 or 6	Who owns the plot? (member ID) Report 3 primary owners. If HH member, write MID. If outside household, use code 4.	Who owns the plot officially? Report 3 primary owners MID	Current market value of the land (amount expected to spend/ pay if you want to buy)	How was the plot utilized in this season (last 8 months)?				
Plot ID		Code 1	Decimal	Decimal	Code 6	Meter	Feet	Code 2	Code 3	Tk	MID/Code 4	MID/Code 4	Tk	Code 5				
Plot ID	Description	G01	G13	G02	G12	G03	G04	G05	G06a	G06b	G06c	G07	G08	G09	G10	G11a	G11b	G11c
									Kharif 1	Rabi	Kharif 2		A	B		C	A	B	C	Kharif 1	Rabi	Kharif 2
1	Homestead																	

Code 1: Plot type	Code 2: Soil type	Code 3: Operation status	Code 4: Type of ownership	Code 5: How was the plot utilized
Homestead 1 Cultivable/arable land 2 Pasture 3 Bush/forest 4 Waste/non-arable land 5 Land in riverbed 6 Other residential/ commercial plot 7 Cultivable Pond 8 Derelict pond 9 Garden (wood/Fruit trees) 10 Floating plot) 11 Only for seed bed) 12	Clay 1 Loam 2 Sandy..... 3 Clay-loam 4 Sandy-loam.. 5	Fallow 1 Own operated 2 Rented/leased in/ for cash 3 Rented/leased in/crop share 4 Mortgaged in 5 Rented/leased out/cash 6 Rented/leased out/crop share 7 Mortgage out 8 Group leased in with other farmer 9 Leased out to NGO 10 Taken from joint owner 11 Jointly with other owners 12 Rented in for certain amount of crops 13 Rented out for certain amount of crops 14 Free of cost 15	All members jointly 71 Male outside household 72 Female outside household 73 Govt / Khas land/other institutions 74	Brinjal cultivation 1 Agriculture (except Brinjal)) 2 Fisheries 3 Grazing for livestock..... 4 Homestead/ house plot 5 Bush..... 6 Commercial/non-ag enterprise 7 Fallow 8 Other (specify)..... 9 Was not with me 1 0

Module H: BRINJAL PRODUCTION (Respondent: Person most knowledgeable about brinjal production)

BASELINE:

THIS MODULE ONLY REFERS TO THE PERIOD OCTOBER 2016 – DECEMBER 2016 & MAY 2017 – JULY 2017

ENDLINE:

NOTE: THIS MODULE ONLY REFERS TO THE PERIOD NOVEMBER 2017 – JUNE 2018

SI	Question	Answer	Answer Code
RID	MID of person answering questions in this module?	<input type="text"/>	Write MID from the list of household member

Module H1: Seedling/seedbed production and planting (Baseline and Endline)

H1_02	Was the brinjal seeded directly? (ask for all the brinjal cultivated by farmer – if for all brinjal answer is YES go to Module H2. Otherwise>>H1_03)	<input type="text"/>	Yes..... 1 No .....2
H1_03	Did you produce your own seedlings/seed bed for the brinjal you grew during the last season? (IF NO, go to Module H2)	<input type="text"/>	Yes..... 1 No .....2>>Next Module

We would now like to ask you some questions about these seedlings/seed beds

Serial no.	Plot ID	Is this seedbed prepared for the study plot? Yes...1 No.....2	Brinjal Variety	What is the area of reference for the seedbeds ?	Quantity of seed used for seedbed to produce seedling	Main source of seed		Price t of used Seed? If seed source code is 1 or 2, bring approximate cost of seed	Did you sell any seedlings or give to others? Yes.....1 No.....2> H1_12a	If yes, what portion of seedling you sold or gave to other?	In your opinion, what are the most important characteristics in this seed?	Total value of other inputs used in the seed bed							
												Chemical fertilizers		Organic fertilizers		Pesticides	Hired labor	Other	
Sl no.	Plot ID	Code ↑	Code1	decimals	Grams	Code 2		Taka	Code ↑	%	Code 3		Kg	Tk	Kg	Tk	Total Tk	Tk	Tk
H1_04	H1_05	H1_05a	H1_06	H1_07	H1_08	H1_09a	H1_09b	H1_10	H1_11	H1_12	H1_13a	H1_13b	H1_14a	H1_14b	H1_14c	H1_14d	H1_14e	H1_14f	H1_14g

Code 1: Variety code				Code 2: Source of seed				Code 3: Significant characteristics of seed			
BT-1 1	Bijoy .....8	Islampuri BADC . 15	Marich begun S 22	Code 2: Source of seed	Market .....7	Yield	Market				
BT-2 2	Borka .....9	IRRI begun..... 16	Nayantara 23	Own/Saved seeds	Other farmer.....8	.....	demand/price.....6				
BT-3 3	Chega.....10	Kaikka N 17	Singnath..... 24	.....	Bought from farm .....9	1	Good taste				
BT-4 4	Dharola...11	Kajla 18	Tarapuri 25	1	Bought seedling 10	Size	.....7				
Amjuri .....5	Deem	Katabegun WS 19	Thamba..... 26	Gift from others	Produced seedling..... 11	.....	Nice				
BL-118.....6	begun .....12	Khatkhatia BAU . 20	Uttara 27	.....	Seed from BT-Brinjal project ..	2	color.....8				
Bholanath	Eye red ...13	Laffa	Other Variety specify	2	..... 12	Insect/disease resistant	Good as animal				
.....7	ISD	S.....21	.....77	BADC outlet (Govt.)		.....	feed.....9				
	006.....14			.....		3	Others				
				3		Low labor	(specify).....10				
				Bought from BRAC		required.....4					
				.....		Low input required					
				4		.....5					
				Bought from other NGO							
										
				5							
				personal shop/dealer							
										
				6							

Serial no.	Plot ID (This must be a plot listed in Module G)	Brinjal Variety grown on this plot	Date planted		Area for whole plot	Is this the study plot? Yes...1 No.....2>> H2_06							How many brinjal plants did you have in your plot ?	Which household member was primarily responsible for managing the production of brinjal on this plot?	Did you irrigate? IF NO, go to next brinjal plot	What was the primary means of irrigating	How many times did you irrigate?	What was the total cash cost of irrigation?	What was the value of other payments you made for this irrigation in addition to these cash costs?	Was the amount of irrigation water sufficient for this plot? 1 YES 2 NO	Have you uprooted the brinjal that you planted? 1 YES 2 NO If No, skip to next plot	When did you uproot the brinjal that you planted?			If you uprooted brinjal plants before full potential harvest, why did you uproot (main reason)?
			Week	Month			Decimals	Code ↑																MID		Yes/No	Code 3 ↓	No. of times	Tk	Tk	Code ↑	Code ↑	year	month	week	Code 4
H2_01	H2_02	H2_03	H2_04a	H2_04b	H2_05	H2_13	H2_05a	H2_05b	H2_05c	H2_05d	H2_05e	H2_05f	H2_06	H2_07	H2_08	H2_09	H2_10	H2_11	H2_12	H9_02	H9_03a	H9_03b	H9_03c	H9_04	

Module H2: Area planted and irrigation (Baseline and Endline)

Serial no.	Plot ID (This must be a plot listed in Module G)	ASK TO TREATMENT FARMERS ONLY (FARMERS CULTIVATING BT BRINJAL AS PART OF THE STUDY)			What is the shape of this plot? If =5 skip to H2_05_08 If =2, 3 or 4 skip to H2_05_02 If =0 skip to H2_06	Actual measurement NOTE: Plot to be measured by enumerators without refuge border (in feet)		What is the diameter of this plot (feet)	How many triangle you draw for this plot?	Measurement of first triangle			Measurement of second triangle			Measurement of third triangle			Measurement of fourth triangle			Measure ment of this plot in square feet (calculate by CAPI)
		Is there a non-bt refuge border ? Yes... 1 No.... 2> H2_05_1	How many sides do you have the non-bt refuge border (inch)	How wide is the non-bt refuge border ?		What is the measurement of A arm of 1st triangle in feet?	What is the measurement of B arm of 1st triangle in feet?			What is the measurement of C arm of 1st triangle in feet?	What is the measurement of A arm of 2nd triangle in feet?	What is the measurement of B arm of 2nd triangle in feet?	What is the measurement of C arm of 2nd triangle in feet?	What is the measurement of A arm of 3rd triangle in feet?	What is the measurement of B arm of 3rd triangle in feet?	What is the measurement of C arm of 3rd triangle in feet?	What is the measurement of A arm of 4th triangle in feet?	What is the measurement of B arm of 4th triangle in feet?	What is the measurement of C arm of 4th triangle in feet?			
S1 no.	Plot ID	Code ↑	No.	Width (Inch)	code	Length (feet)	Width (feet)	feet	code	feet	feet	feet	feet	feet	feet	feet	feet	feet	feet	feet	feet	feet
H2_01	H2_02	H2_05a	H2_05b	H2_05c	H2_05_1	H2_05d	H2_05e	H2_05_08	H2_05_02	H2_05_f1_1	H2_05_f1_2	H2_05_f1_3	H2_05_f2_1	H2_05_f2_2	H2_05_f2_3	H2_05_f3_1	H2_05_f3_2	H2_05_f3_3	H2_05_f4_1	H2_05_f4_2	H2_05_f4_3	H2_05_9

Code 1: Variety code				Code 3: Irrigation Method		Code 4: reason for uprooted brinjal plants
BT-1 .....1	Bijoy .....8	Islampuri BADC 15	Marich begun S 22	Swing basket 1	Rower pump .....6	Due to low rice.....1
BT-2 .....2	Borka .....9	IRRI begun 16	Nayantara 23	Don 2	Shallow tube well 7	Low yields.....2
BT-3 .....3	Chega .....10	Kaikka N 17	Singnath 24	Dugwell 3	Deep tube well 8	Most of the plants yied.....3
BT-4 .....4	Dharola ...11	Kajla 18	Tarapuri 25	Hand tubewell 4	Low lift pump 9	High cost of production.....4
Amjuri .....5	Deem begun	Katabegun WS ...19	Thamba 26	Treadle pump 5	Canal irrigation 10	Less demand in the market for brinjal.....5
BL-118 .....6	.....12	Khatkhatia BAU.20	Uttara 27		Axial Flow Pump 11	To plant other crop on the same plot.....6
Bholanath	Eye red ....13	Laffa	Other Variety specify 77		Other.....12	N/A, uprooted after full harvest.....7
.....7	ISD	S .....21				
	006 .....14					

Code: shape	Code: no of triangle
4 sided: shape (Square / Rectangle)..... 1	1 triangle 1
Other 4 sided: shape (Trapezoid) 2	2 triangle 2
3 sided shape (Triangle) 3	3 triangle 3
More than 4 sided shape 4	4 triangle 4
Circle..... 5	
Enter measurement after interview 0	

Instruction for taking measurement of plot:

Shape-1. If the shape is “4 sided: shape (Square / Rectangle)”:

Take length(feet) and width(feet) and record in “H2_05d” and “H2_05e” variables.

Shape-5. If the shape is “Circle”:

Take only diameter (feet) and record in “H2_05_08” variable.

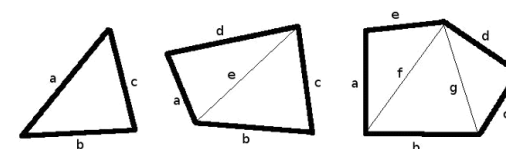
Shape-2-3-4. If the shape is “Other 4 sided: shape (Trapezoid)” OR “3 sided shape (Triangle)” OR “More than 4 sided shape”:

“3 sided shape (Triangle)”:

If the land shaped any type triangle take length(feet) of 3 (ABC) each arms and record in “H2_05_f1_1”, “H2_05_f1_2” and “H2_05_f1_3” variables.

“Other 4 sided: shape (Trapezoid)” OR “More than 4 sided shape”:

First of all, ask famer that what is the shape of the plot, draw the plot on a paper and ask the farmer to confirm the shape, correct the shape as the farmer said, then split the shape into a number of triangular-shaped plots as in image shown below and then mention



number of triangle in “H2_05_02” variable and take length(feet) of 3 (ABC) each arm(s) and record in “H2_05_f?_1”, “H2_05_f?_2” and “H2_05_f?_3” variables.

Module H3: Usage of Fertilizers (Baseline and Endline)

QNo	Question	Answer	Answer Code
H3_00	Did you use fertilizers on any of the plots of land on which you grew brinjal?	<input type="text"/>	Yes.....1 No 2>> MODULE H4

Sl.	Plot ID	Urea	Total value	TSP	Total value	DAP/MA P	Total value	MP	Total value	Other fertilizer	Total value	Manure/Compost (if own produced/not purchased ask what will be the cost if purchased)	Have you used vermicompost fertilizer? Yes..... 1 No 2 > H3_08	Vermicompost fertilizer was Produced 1 Purchased 2	what was the price? (if own produced /not purchased ask what will be the cost if purchased)	Vitamin / Hormone
		Amt (kg)	Taka	Amt (kg)	Taka	Amt (kg)	Taka	Amt (kg)	Taka	Amt (kg)	Taka	Total Value (Tk)	Code ↑	Code ↑	Total Value (Tk)	Total Value (Tk)
Sl.	Plot ID	H3_01a	H3_01b	H3_02a	H3_02b	H3_03a	H3_03b	H3_04a	H3_04b	H3_05a	H3_05b	H3_06	H3_07a	H3_07b	H3_07c	H3_08

Module H4: Pesticide usage (Baseline and Endline)

Plot	Did you use pesticides on this plot of land on which you grew brinjal? Yes..... 1 No 2>>> go to next plot	Please list all months in which you used pesticides on this plot of land	Name of pesticides used in this month	In this month for which pest/insect was this pesticide applied?	In this month for which disease this pesticide has been for applied?	In this month method of application	Number of sprays in this month	Quantity of pesticide	Unit	Total cost
		Code 1	Code 2	Code 3	??	Code 4			Code 5	Tk
Plot_id	H4_01	H4_02	H4_03	H4_04a	H4_04b	H4_05	H4_06	H4_07	H4_08	H4_09
First plot		First Month _	First Pesticide: _							
		First Month _	Second Pesticide: _							
		First Month _	Third Pesticide: _							
		Second Month _	First Pesticide: _							
		Second Month _	Second Pesticide: _							
		Second Month _	Third Pesticide: _							
		Third Month _	First Pesticide: _							
		Third Month _	Second Pesticide: _							
		Third Month _	Third Pesticide: _							
		Fourth Month _	First Pesticide: _							
		Fourth Month _	Second Pesticide: _							
		Fourth Month _	Third Pesticide: _							
		Fifth Month _	First Pesticide: _							
		Fifth Month _	Second Pesticide: _							
		Fifth Month _	Third Pesticide: _							
Second plot starts here		First Month _	First Pesticide: _							
		First Month _	Second Pesticide: _							
		First Month _	Third Pesticide: _							
		Second Month _	First Pesticide: _							
		Second Month _	Second Pesticide: _							
		Second Month _	Third Pesticide: _							
		Third Month _	First Pesticide: _							
		Third Month _	Second Pesticide: _							
		Third Month _	Third Pesticide: _							
		Fourth Month _	First Pesticide: _							
		Fourth Month _	Second Pesticide: _							
		Fourth Month _	Third Pesticide: _							
		Fifth Month _	First Pesticide: _							
		Fifth Month _	Second Pesticide: _							
		Fifth Month _	Third Pesticide: _							

QNo	Question	Answer	Answer Code
	How did you spray pesticide?	<input type="text"/>	Over the leaves/plants.....1 From under the leaves/plant.....2 Both.....3
H4_10	Did you use herbicides on any of the plots of land on which you grew brinjal? IF YES >> ____ IF NO >> Module H5.	<input type="text"/>	Yes..... 1 No..... 2>> Module H5.
H4_11	How much did you spend on herbicides?	<input type="text"/>	Tk

Code 1: Months	Code 2: Pesticide variety	Code 3: Pest/insect name	Code 4: Method of pesticide application	Code 5: Units
January.....1 February.....2 March..... 3 April.....4 May.....5 June.....6 July.....7 August.....8 September.....9 October.....10 November.....11 December.....12	open ended	open ended	Spray...1 Broadcast ...2	Gram.....1 Milliliter...2

Module H5: Pest infestation (Baseline and Endline)

SI No .	Plot ID	Was the brinjal in this plot affected by <u>shoot and fruit borer</u> ? Yes.....1 No.....2>>H5_05	In which month were the plants in this plot <u>most</u> affected by this pest?	What percent of plants were affected ?	Was the brinjal in this plot affected by <u>leaf eating beetles</u> ? Yes.....1 No.....2>>H5_08	In which month were the plants in this plot <u>most</u> affected by this pest?	What percent of plants were affected ?	Was the brinjal in this plot affected by <u>thrips, white fly, jassid or aphids</u> ? Yes.....1 No.....2>>H5_11	In which month were the plants in this plot <u>most</u> affected by this pest?	What percent of plants were affected ?	Was the brinjal in this plot affected by <u>mites, mealy or leaf wing bugs or leaf roller</u> ? Yes.....1 No.....2>>H5_14	In which month were the plants in this plot <u>most</u> affected by this pest?	What percent of plants were affected ?	Quantity discarded b/c of all pest infestation or other disease
		Code ↑	Month code	Percent	Code ↑	Month code	Percent	Code ↑	Month code	Percent	Code ↑	Month code	Percent	KG
Sl.	H5_01	H5_02	H5_03	H5_04	H5_05	H5_06	H5_07	H5_08	H5_09	H5_10	H5_11	H5_12	H5_13	H5_14

Module H6: Use of Tools, Machinery and Draft Animal for Brinjal (Baseline and Endline)

QNo	Question	Answer	Answer Code
H6_00	Did you use any tools, machinery or draft animals on any of the plots of land on which you grew brinjal?	<input type="text"/>	Yes.....1 No.....2 >> MODULE H7

Sl. No.	Plot ID	For land preparation							Tools/machinery used									
		Animal Used			Machinery Used				For planting		For fertilizer application		For pesticide application		For weeding		For harvesting	
		Have animals been used?	Total bullock days	Cost	Has machinery been used? If code2 = 3>> I4_06n	Power tiller.....1	Rental Cost	Fuel cost	Has machinery been used? If code2 = 3>>I4_07n	Cost	Has machinery been used? If code2 = 3>>I4_08n	Cost	Has machinery been used? If code2 = 3>>I4_09n	Cost	Has machinery been used? If code2 = 3>>I4_010n	Cost	Has machinery been used? code2 = >>Next row	Cost
						Tractor2													Plough .....3
		Code 2	days	(Tk/ day)	Code 2	Code	(Tk)	(Tk)	Code 2	(Tk)	Code 2	(Tk)	Code 2	(Tk)	Code 2	(Tk)	Code 2	(Tk)
Sl.	Plot ID	H6_01a	H6_01b	H6_01c	H6_02a	H6_02b	H6_02c	H6_02d	H6_03a	H6_03b	H6_04a	H6_04b	H6_05a	H6_05b	H6_06a	H6_06b	H6_07a	H6_08a

Code 2:

Yes, I used my own/ I used someone else's free of charge.....1
 Yes, I rented it and then used it.....2
 No, I have not used it3

Module H7: Household Labor Usage for Brinjal Production (Baseline and Endline)

QNo	Question	Answer	Answer Code
H7_00	Please tell us which household members worked on brinjal production during [this season] (November 2017 to June 2018).	<div></div> <div></div> <div></div> <div></div>	Write MID from the list of household member

We would now like you to tell us the number of hours each person worked on tasks associated with brinjal production during this season

S l. N o .	P l o t I D	M I D	Land preparation (Ploughing, Harrowing, Leveling etc.)	Planting (Seeding/Tran splanting)	Fertilizer (application)	Pesticide application	Weeding	Irrigation channel maintenance	Harvest	Sorting and packing	Uprooting of plants
			Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours
S l.	I D	M I D	H7_01	H7_02	H7_03	H7_04	H7_05 a	H7_06	H7_07	H7_08	H7_09

Module H8: Hired Labor Usage for Brinjal Production (Baseline and Endline)

QNo	Question	Answer	Answer Code
H8_00	Did you hire labor to work on any of the plots of land on which you grew brinjal?	<input type="text"/>	Yes..... 1 No .....2>> MODULE H9

We would now like you to tell us the number of hours worked by hired labor on tasks associated with brinjal production during this season

Please tell us how much you spent on hired labor for these tasks.

Sl. No.	Plot ID	Land preparation (Ploughing, Harrowing, Leveling etc.)				Planting (Seeding/Transplanting)				Fertilizer application				Pesticide application				Weeding			
		Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka
Sl.	ID	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female
Serial	Plot ID	H8_01a	H8_01b	H8_01c	H8_01d	H8_02a	H8_02b	H8_02c	H8_02d	H8_03a	H8_03b	H8_03c	H8_03d	H8_04a	H8_04b	H8_04c	H8_04d	H8_05a	H8_05b	H8_05c	H8_05d

Sl. No.	Plot ID	Irrigation channel maintenance				Harvest				Sorting and packing				Uprooting of plants			
		Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka	Hours	Taka
Sl.	ID	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female
Serial	Plot ID	H8_06a	H8_06b	H8_06c	H8_06d	H8_07a	H8_07b	H8_07c	H8_07d	H8_08a	H8_08b	H8_08c	H8_08d	H8_09a	H8_09b	H8_09c	H8_09d

Module H9: Harvesting and sales (Baseline and Endline)

Please tell us in which months did you harvest and/or sell brinjal that you produced during this season	Plot	Month							
		Repeat for each month of harvest as noted in H9_00							
		Quantity harvested Please exclude the amount of brinjal that discarded b/c of pest infestation or other disease mentioned in H5_14 column	Quantity retained for home consumption or seed stock	Quantity paid to owner of leased plot	Quantity paid to hired labor	Quantity given away as gift	Quantity lost for other reasons	Quantity Sold Kg	Value of sale
H9_00	H9_01	Kg H9_01a	Kg H9_01b	Kg H9_01c	Kg H9_01d	H9_01e	H9_01f	Kg H9_01g	Tk H9_01h

NOTE: For each plot and month: Quantity harvested must equal Quantity retained for home consumption or seed stock + Quantity paid to owner of leased plot + Quantity paid to hired labor + Quantity given away as gift + Quantity lost for other reasons + Quantity Sold

Module H10: Marketing of brinjal (Baseline and Endline)

We would now like to ask you some questions about the sale of your brinjal

Who was the main buyer of your brinjal?	In what months did you sell your brinjal to this buyer? (Allow for multiple responses)				Major reason for the choice of this buyer	Second reason for the choice of this buyer	How does this buyer pay you?	% paid in cash and immediately (if 100% go to H10_08)	If buyer paid later, then after how many days?	Did you contact buyer over cell phone before sale? Yes...1 No....2>> H10_10	If yes, to H10_09, was price agreed on cell phone? Yes...1 No....2	Sale location	Dist. and time taken usually to go to the place where you sold your produce?	Transport means	usually Transaction time on locate-on of sale	Does the buyer provide any input as advance to the farmer? Yes...1 No...2	Did you sell your crop to anyone else? Yes...1 No...2>>next module	Who was the second most important buyer of your crop?	
Code 1					Code 3	Code 3	Code 4	%	days			Code 5	hour	km	Code 6	Hour		Code 1	
H10_01	H10_02a	H10_02b	H10_02c	H10_02d	H10_03	H10_04	H10_05	H10_06	H10_07	H10_08	H10_09	H10_10	H10_11a	H10_11b	H10_12	H10_13	H10_14	H10_15	H10_16

Code list for Module H10:

Buyer code 1	Buyer's choice code 3	Payment code 4	Transportation code 6
Village collector 1	Pays high/fair price..... 1	Cash..... 1	Porter/ Self carrying
Wholesaler 2	Buys a bulk 2	Ingredients 2	.....
Cold storage owner 3	Buys limited quantity 3	Part cash & part goods 3	1
Cold storage wholesale 4	Makes advance	Cheque 4	Rickshaw
Collection center	Payment..... 4	Others (please specify)..... 5	.....
of company 5	Makes immediate		2
Processing farm..... 6	Payment..... 5		Van
Co-operative society 7	Lives nearby..... 6		.....
Farmer society 8	No other option..... 7		3
Retailer..... 9			Push van
Consumer..... 10			.....
Hotel/ restaurant 11			4
Others (please specify)..... 12			Tractor
		
			5
			Truck/pickup
		
			6
			Motorcar(Nosimon/korimon/tempoo/CNG/Easybike etc.
		
			7
			Bicycle
		
			8

			Motor bicycle 9 Horse cart 10 Bullock cart 11 Boat 12 Engine boat 13 From own home 14 Others (please specify) 15
--	--	--	--

Module H11: SHOCKS AFFECTING BRINJAL PRODUCTION (Endline Only)

Between November 2017 and June 2018 was your brinjal production affected by any of the following events?

Note: Period will be from sowing the seeds to uprooting the plants

Shocks (unexpected events)	Shock Code	Yes .....1 No2>>Next Row	What (main) consequence did you have to face because of the {SHOCK}? Code 1
	Code		H11_02
Flooding	01		
Heavy rainfall	02		
Drought	03		
Cold wave	04		
Excessive heat	05		
Sudden fall in market price of brinjal	06		
Illness or injury of household member most responsible for brinjal production	07		
Illness or injury of other household members	08		

Shocks (unexpected events)	Shock Code	Yes .....1 No2>>Next Row	What (main) consequence did you have to face because of the {SHOCK}?
			Code 1
	Code		H11_02
Medical expenses due to illness or injury	09		
Death of household member most responsible for brinjal production	10		
Death of other household member	11		
Contractual disputes regarding the purchase of inputs	12		
Disputes over ownership of land on which brinjal is grown	13		
Disputes over lease terms of land on which brinjal is grown	14		
Theft of inputs	15		
Theft of brinjal	16		
Other shocks not listed (1)	71		
Other shocks not listed (2)	72		

Code 1	
Delay in sowing of seeds to raise seedlings.....	1
Delay in transplanting seedlings to main plot.....	2
Stunted growth of brinjal plants	3
Sold with low price.....	4
Given away, consumed or used as animal feed.....	5
Production decreased / less yield.....	6
Plants damaged.....	7
Faced financial loss	8
Cultivate brinjal in less area (decimal) than expected	9
Other(please specify)	10

Module I: Knowledge, use and exposure to pesticides (Respondent: Person most knowledgeable about brinjal production and application of pesticides) (Baseline and Endline)

MID of person answering questions in this module (This should be the household member primarily responsible for preparing and applying pesticides).	<input type="text"/>
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We would like to ask you about knowledge, use and exposure to pesticides by household members aged 15 years and older

Member ID (Only list Member ID of members aged 15 years and older)	Name	Was this person involved in brinjal cultivation during last season [Nov'17 to June'18]? Yes..... 1 No.....2	Was this person involved in pesticide application e.g. application , mixing concentrated liquid or powder with water, putting into the sprayer? Yes..... 1 No.....2>> I1_01e	If yes, did s/he spray pesticide? Yes 1 No.....2>> I1_01e	How often did s/he spray pesticide? 1=Mostly; 2=Sometimes; 3=Rarely	Was this person involved in any other crop production? Yes..... 1 No.....2>> I1_01g	Did this person spray pesticides on other crops? Yes.....1 No.....2	Did this person come into contact with pesticides outside the family farm? (For example, while working as a laborer on other farms; in a factory etc.) Yes.....1 No.....2
		Code ↑	Code ↑	Code ↑	Code ↑		Code ↑	Code ↑
MID	Name	I1_01a	I1_01b	I1_01c	I1_01d	I1_01e	I1_01f	I1_01g

The next set of questions should be answered by the household member who is the primarily responsible for preparing and applying pesticides

Question Number	Questions	Response	Code
I2	Before using pesticides on brinjal, do you read the labels on the bottle/package?	<input type="text"/>	Yes 1>> I4 No 2 >>I5 Unable to read .....8 >>I3
I3	If you cannot read, do you get help from others who can read	<input type="text"/>	Yes 1 No .....2
I4	Do you follow the instructions on the label?	<input type="text"/>	Yes, all time 1 Yes, sometime .....2 No .....3
I5	Do you mix pesticides with:		
I5a	With bare hands	<input type="text"/>	Yes 1 No .....2

Question Number	Questions	Response	Code
I5b	With hands and wearing gloves	<input type="checkbox"/>	Yes 1 No 2
I5c	With a stick, but bare hands	<input type="checkbox"/>	Yes 1 No 2
I5d	With a stick and wearing gloves	<input type="checkbox"/>	Yes 1 No 2
I6	Before spraying, do you wear the following:		
I6a	Hand gloves	<input type="checkbox"/>	Yes 1 No 2
I6b	Head cover	<input type="checkbox"/>	Yes 1 No 2
I6c	Face shield	<input type="checkbox"/>	Yes 1 No 2
I6d	Eye protection	<input type="checkbox"/>	Yes 1 No 2
I6e	Full sleeve shirt/kurta	<input type="checkbox"/>	Yes 1 No 2
I6f	Full length trousers/lungi	<input type="checkbox"/>	Yes 1 No 2
I6g	Sandal /shoes	<input type="checkbox"/>	Yes 1 No 2
I7	Do you determine the wind direction first and then spray?	<input type="checkbox"/>	Yes 1 No 2
I8	Do you spray when it is windy?	<input type="checkbox"/>	Yes 1 No 2
I9	How do you clean the sprayer's nozzle	<input type="checkbox"/>	Blowing air on it with the mouth, without washing it off 1 Blowing air on it with the mouth, with washing it off 2 Cleaning it with an implement/thin wire, without washing it off 3 Cleaning it with an implement/thin wire, with washing it off 4 Spray using only water 5 Other method 6

Question Number	Questions	Response	Code
I10	Do you wash your hands after you have finished spraying?	<input type="checkbox"/>	Yes 1 No 2
I11	Do you wash your face after you have finished spraying?	<input type="checkbox"/>	Yes 1 No 2
I12	Do you take a bath/shower after you have finished spraying?	<input type="checkbox"/>	Yes 1 No 2
I13	Do you change your clothes after you have finished spraying?	<input type="checkbox"/>	Yes 1 No 2
I14	Do you keep medicine or food items in pesticide bottles after washing them out?	<input type="checkbox"/>	Yes 1 No 2
I15	Do you keep pesticide bottles in the same place where you keep medicine or food items	<input type="checkbox"/>	Yes 1 No 2

Module J: Agriculture (for all crops) EXCEPT FOR BRINJAL (Respondent: Person most knowledgeable about farm production)

MID of person answering questions in this module	
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Note:

- Do not include leased/rented out plots.
- If more than one crop is harvested on the same plot during the recall period, then use separate crop row for each crop.
- Collect plot level data in case of inter-cropping. For more than one crop report information using crop code.
- If plot is divided (at the same time) for different crop production (e.g. intercropping &/mixed cropping), then use decimal for divided plot/sub plot.[e.g. if plot no. 5 is divided into 3 sub plots then write 5.1, 5.2 and 5.3 as plot ID.].
- Write area in decimal of sub plot in J1_03, please note that summation of all sub plots will be less than or equal to the total area of original plot mentioned in Module G.

Module J1: CROP PRODUCTION (Baseline and Endline)

BASELINE:

Report for plot wise crop data for all Crop [EXCEPT FOR BRINJAL] cultivated during **in last 12 months [from October 2016 to September 2017].**

ENDLINE:

Report for plot wise crop data for all Crop [EXCEPT FOR BRINJAL] cultivated during **last season [from November 2017 to June 2018].**

PLOT ID in Module G and Module J must match.

Sl. No.	Season Kharif 1(Aus)..... 1 Rabi (Boro) 2 Kharif 2(Aman) 3 Annual..... 4	Plot ID	Crop name and code	Crop Code In case of Intercropping report Crop code for the second crop here	Area planted	Did you irrigate this crop? Yes.....1 No.....2	Did you use fertilizer on this crop? Yes.....1 No.....2	Did you use pesticides on this crop? Yes.....1 No.....2	Did you use herbicides on this crop? Yes.....1 No.....2	Total production/ quantity harvested	Quantity sold	Selling price per kg	Comment on this selling price. Was the price – higher than usual.....1 less than usual .....2 about the same.....3				
Season codes		Code 1	Code 1	Decimals	Code ↑	Code ↑	Code ↑	Code ↑	Code ↑	Kg	Kg	Tk.	Code ↑				
Sl.		Plot ID	J1_01	J1_02	J1_03	J1_04	J1_05	J1_06	J1_07	J1_08a	J1_08b	J1_09a	J1_09b	J1_10a	J1_10b	J1_11a	J1_11b
Code 1: Agriculture crop codes																	

Major Cereals	Pulses	Vegetables	Leafy vegetables	Fruits (continued)	Other crops (continued)
B Aus (local) 10	Lentil(Moshur) 51	Pumpkin 101	Pui Shak 201	Lemon..... 312	Tobacco 601
T. Aus (local) 11	Mung..... 52	Patal..... 103	Palang Shak (Spinach)..... 202	Shaddock (pomelo)..... 313	Bettlenut..... 602
T. Aus (HYV) 12	Black gram (Mashkalai) 53	Okra..... 104	Lal Shak 203	Black berry..... 314	Bettleleaf..... 603
T Aus (hybrid) 13	Chickling Vetch(Khesari) 54	Ridge gourd 105	Kalmi Shak 204	Other fruits (lemon like) 315	Other Tobacco like crop 604
B. Aman (local) 14	Chick pea (Chhola)..... 55	Bitter gourd 106	Danta Shak 205	Other fruits 316	Cut flower 605
T Aman(local) 15	Pigeon pea (Aarohor) 56	Arum 107	Kachu Shak 206	Boroi (Bitter Plum)..... 317	
T. Aman (HYV)..... 16	Field pea (Motor) 57	Ash gourd..... 108	Lau Shak 207	Rose Apple..... 318	
T. Aman (hybrid)..... 17	Soybean (Gori kalai/	Cucumber..... 109	Mula Shak 208	Wood Apple..... 319	
Boro (local) 18	Kali motor) 58	Carrot..... 110	Khesari Shak 209	Ambada/Hoq Plum..... 320	
Boro (HYV) 19	Other Pulses 59	Cow pea 111	Other green leafy vegetables 210	Pomegranate..... 321	
Boro (hybrid) 20		Snake gourd 112	Potato Leaves 211	Bilimbi..... 322	
Wheat (local)..... 21	Oil Seeds	Danta 113	Cabbage 212	Chalta 323	
Wheat (HYV)..... 22	Sesame..... 61	Green banana/plantain..... 114	Chinese cabbage 213	Tamarind(pulp)..... 324	
Maize 23	Linseed(tishi) 62	Cauliflower 115		Olive(wild)..... 325	
Barley 24	Mustard..... 63	Water gourd 116	Fruits	Coconut/Green Coconut..... 326	
Job..... 25	Ground nut/peanut..... 64	Sweet gourd 117	Banana 301		
Cheena..... 26	Soybean 65	Tomato 118	Mango..... 302	Other crops	
Kaun (Italian millet) 27	Castor (rerri)..... 66	Radish..... 119	Pineapple 303	Potato..... 411	
Joar (Great millet)..... 28	Other Oilseeds..... 67	Turnip..... 120	Jack fruit 304	Sweet potato..... 412	
Bajra (Pearl millet) 29		Green Papaya..... 121	Papaya..... 305	Mulberry(Tunt)..... 413	
Others 30	Spices	Kakrol..... 122	Water melon 306	Orange flesh sweet potato.. 414	
Fiber Crops	Chili 71	Yam Stem 123	Bangi/Phuti/Musk melon..... 307		
Dhonche 41	Onion 72	Other green Vegetables..... 124	Litchis 308	Sugurcan..... 501	
Jute..... 42	Garlic 73	Drumstick..... 125	Guava..... 309	Date 502	
Cotton 43	Turmeric 74	Bean..... 126	Ataa..... 310	Palm..... 503	
Bamboo 44	Ginger 75	Coriander leaf 127	Orange 311	Date Juice 504	
Other Fiber 45	Dhania/Coriander..... 76			Tea 505	
	Other spices 77				

Module J2: Access to agricultural extension for BRINJAL and other crops (Baseline and Endline)

Question Number	Questions	Response		Code
J2_01	Did any agricultural extension agent visit your farm during this season? (from November 2017 to June 2018)	<input type="text"/>		Yes 1 No 2>> J2_04
J2_02	If J2_01 is 1, then how many times did s/he come?	All Crops	BRINJAL	
J2_02a	From government extension service office	<input type="text"/>	<input type="text"/>	(Report frequency of visit. Report '0' if not visited)
J2_02b	From NGO (_____)	<input type="text"/>	<input type="text"/>	(Report frequency of visit. Report '0' if not visited)
J2_02c	From pesticide companies	<input type="text"/>	<input type="text"/>	(Report frequency of visit. Report '0' if not visited)
J2_03	Did you receive advice on the following?	All Crops	BRINJAL	
J2_03a	Fertilizer use	<input type="text"/>	<input type="text"/>	Yes 1 No 2
J2_03b	Pesticide use	<input type="text"/>	<input type="text"/>	Yes 1 No 2
J2_03c	Pest and Diseases	<input type="text"/>	<input type="text"/>	Yes 1 No 2
J2_04	Did you go to any extension agent or contacted over phone for any crop during this season? (from November 2017 to June 2018)	<input type="text"/>		Yes 1 No 2>>Next Module
J2_05	If J2_04 if 1, who went or who contacted over phone?	<input type="text"/>	<input type="text"/>	<input type="text"/> D
J2_6	How many times did you visit or contact the following?	All Crops	BRINJAL	
J2_06a	Government extension service office	<input type="text"/>	<input type="text"/>	(Report frequency of visit/Contact. Report '0' if not visited/Contacted)
J2_06b	NGO (_____)	<input type="text"/>	<input type="text"/>	(Report frequency of visit/Contact. Report '0' if not visited/Contacted)
J2_06c	From pesticide companies	<input type="text"/>	<input type="text"/>	(Report frequency of visit/Contact. Report '0' if not visited/Contacted)
J2_07	Did you receive advice on the following?	All Crops	BRINJAL	
J2_07a	Fertilizer use	<input type="text"/>	<input type="text"/>	Yes 1 No 2
J2_07b	Pesticide use	<input type="text"/>	<input type="text"/>	Yes 1 No 2
J2_07c	Pest and Diseases	<input type="text"/>	<input type="text"/>	Yes 1 No 2

Module K: Personal history, sense of agency (Respondent: Person most knowledgeable about brinjal production) (Baseline Only)

We would like to end this interview by asking a few questions about you.

Question Number	Questions	Response	Code
K01	How many years have you lived in this village?	<input type="text"/>	Years
K02	How many years have you been a farmer?	<input type="text"/>	Years
K03	Have you ever worked outside this village?	<input type="text"/>	Yes 1 No .....2
K04	Do you occasionally give up doing something because you don't think you have the ability?	<input type="text"/>	Yes 1 No .....2
K05	Do you occasionally feel like not listening to people even if you know they are right?	<input type="text"/>	Yes 1 No .....2
K06	Do you sometimes get irritated/annoyed (translate so understandable) by people who ask you to do something for them?	<input type="text"/>	Yes 1 No .....2
K07	Are you always courteous, even to people who are disagreeable/not pleasant?	<input type="text"/>	Yes 1 No .....2
K08	When you make a mistake, are you always willing to admit it?	<input type="text"/>	Yes 1 No .....2
K09	Which of the following propositions do you <i>most agree</i> with : 1. "Each person is primarily responsible for his/her own success or failure in life" OR 2. "One's success or failure is a matter of his/her destiny"	<input type="text"/>	1 "Each person is primarily responsible for his/her own success or failure in life" OR 2 "One's success or failure is a matter of his/her destiny"

MODULE L: Program Participation (Endline Only)

Question	Response	
Name of the participant farmer & member ID		
Type of participant		Treatment group.....1 Control group.....2
Type of farmer		Lead farmer.....1 Other farmer.....2

Q	Questions	Answer	Codes								
	TO ALL FARMERS (BT-Brinjal and ISD 006) (Questions L2 to L5 to be answered by the person who attended the farmer's training)										
L_01	Who attended the farmer's training on brinjal production?	<div style="display: flex; justify-content: space-around; width: 100%;"> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px;"></div> </div>	Use MID non-HH member...98>> skip to L_06 / L_09								
L_02	How were the contents of the training session?	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>	Very informative.....1 Moderately informative.....2 Most of the contents were already known.....3 Topics were difficult to understand.....4 Other (specify) 9 Don't know98 Refuse to answer.....99								
L_03	How satisfied you were with the training you received about how to grow bt-brinjal/ ISD 006?	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>	Very satisfied.....1 Satisfied.....2 Neither satisfied or dissatisfied.....3 Not satisfied.....4 Very dissatisfied.....5 Don't know98 Refuse to answer.....99								
L_04	What did you receive for attending the training?	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">Training materials (bag, notebook, pen, folder, etc.)</td> <td style="width: 40%;"></td> </tr> <tr> <td>Lunch</td> <td></td> </tr> <tr> <td>Refreshments</td> <td></td> </tr> <tr> <td>Allowance</td> <td></td> </tr> </table>	Training materials (bag, notebook, pen, folder, etc.)		Lunch		Refreshments		Allowance		Multiple response possible. Choose all that applies Yes.....1 No.....2
Training materials (bag, notebook, pen, folder, etc.)											
Lunch											
Refreshments											
Allowance											
L_05	What is the amount of allowance received for attending training?	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>	Taka								
	ONLY TO LEAD FARMER (BT-Brinjal and ISD 006) (Questions L6 to L8)										

Q	Questions	Answer	Codes																																								
L_06	Did you receive any inputs to raise seedlings?	<input type="text"/>	Yes.....1>>Q7 No.....2>>Q9																																								
L_07	If yes, what inputs did you receive?	<table border="1"> <thead> <tr> <th>Inputs</th> <th>Received ?</th> <th>Quantity</th> <th>was the input provided timely</th> </tr> </thead> <tbody> <tr> <td>Seed</td> <td></td> <td>gram</td> <td></td> </tr> <tr> <td>Organic fertilizer</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>Chemical fertilizer</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>Yellow/white traps</td> <td></td> <td>nos</td> <td></td> </tr> <tr> <td>Polythene</td> <td></td> <td>nos</td> <td></td> </tr> <tr> <td>Materials for shade</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Watering cane</td> <td></td> <td>nos</td> <td></td> </tr> <tr> <td>Others (please specify)</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Inputs	Received ?	Quantity	was the input provided timely	Seed		gram		Organic fertilizer		kg		Chemical fertilizer		kg		Yellow/white traps		nos		Polythene		nos		Materials for shade				Watering cane		nos		Others (please specify)				Yes.....1 No.....2 Multiple response possible. Choose all that applies.				
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TO ALL FARMERS (BT-Brinjal and ISD 006) (Questions L9 to L18 to be asked to both Bt and non-Bt farmers)																																											
L_08	Did you receive any inputs for brinjal cultivation?	<input type="text"/>	Yes.....1>>Q08 No.....2>>Q10																																								
L_09	If yes, what inputs did you receive?	<table border="1"> <thead> <tr> <th>Inputs</th> <th>received</th> <th>quantity</th> <th>was the input provided timely</th> </tr> </thead> <tbody> <tr> <td>Urea</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>TSP</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>MoP</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>Gypsum</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>Cash</td> <td></td> <td>Tk</td> <td></td> </tr> <tr> <td>Yellow/white traps</td> <td></td> <td>nos</td> <td></td> </tr> <tr> <td>Demo guide book</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Bleaching powder</td> <td></td> <td>kg</td> <td></td> </tr> <tr> <td>Others (please specify)</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Inputs	received	quantity	was the input provided timely	Urea		kg		TSP		kg		MoP		kg		Gypsum		kg		Cash		Tk		Yellow/white traps		nos		Demo guide book				Bleaching powder		kg		Others (please specify)				Multiple response possible. Choose all that applies Yes.....1 No.....2
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L_10	Were you able to plant brinjal when you wanted to?	<input type="text"/>	Yes.....1>>Q12 No.....2>>Q11																																								

Q	Questions	Answer	Codes
L_11	If no, why not?	Multiple response possible	Flood.....1 Heavy rain.....2 Cold wave.....3 Delay in receiving seedlings for transplanting ...4 Don't know .....98 Refuse to answer.....99
L_12	How many days old was the seedling when you transplanted it to the main plot?	<input type="text"/>	Days
L_13	Did anyone visit your plot from the agriculture extension office (from November 2017 to June 2018)?	<input type="text"/>	Yes.....1>>Q14 No.....2>>Q16
L_14	Who visited?	<input type="text"/>	UAO .....1 SAAO .....2 Both UAO and SAAO .....3
L_15	How many times did they visit?	UAO <input type="text"/> SAAO <input type="text"/>	Number of times
	ONLY FOR Bt FARMERS (Questions L19 to L30)		
L_16	Did anyone visit your plot from BARI office(from November 2017 to June 2018)?	<input type="text"/>	Yes.....1 No.....2>>Q18 Don't know.....98>>Q18
L_17	How many times did they visit?	<input type="text"/>	
L_18	Did you make refuge border around your plot?	<input type="text"/>	Yes.....1 No.....2

Q	Questions	Answer	Codes
L_19	Did you spray pesticide in the refuge border?	<input type="text"/>	Yes.....1 No.....2
L_20	What challenges did you face in cultivating, harvesting and marketing of bt brinjal? Rank main 3 of these problems according to importance.	1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/>	Low price.....1 Difficulty to market because of size and color...2 Flood.....3 Heavy rain.....4 Cold wave.....5 Pest infestation.....6 Low yield of brinjal.....7 Less flowering.....8 Bacterial attack (wilt, etc).....9 Leaf curl.....10 Lack of information from DAE/BARI on production practices.....11 Don't know .....98 Refuse to answer.....99
L_21	Compared to conventional brinjal varieties, did you use more, less, or about the same amount of pesticides when growing bt brinjal?	<input type="text"/>	More .....1 Less .....2 About the same.....3 Don't know .....98 Refuse to answer.....99
L_22	Compared to conventional brinjal varieties, did you use more, less, or about the same amount of family labor when growing bt brinjal?	<input type="text"/>	More .....1 Less .....2 About the same.....3 Don't know .....98 Refuse to answer.....99
L_23	Were you satisfied with the yield you obtained from growing bt brinjal?	<input type="text"/>	1 Very satisfied 2 Satisfied 3 Neither satisfied or dissatisfied 4 Not satisfied 5 Very dissatisfied Don't know .....98 Refuse to answer.....99

Q	Questions	Answer	Codes
L_24	Did you find it difficult to sell your harvest?	<input type="text"/>	1 Yes 2 No
L_25	Overall, were you satisfied with your experience growing bt brinjal?	<input type="text"/>	1 Very satisfied 2 Satisfied 3 Neither satisfied or dissatisfied 4 Not satisfied 5 Very dissatisfied Don't know .....98 Refuse to answer.....99
L_26	Would you like to grow bt brinjal in the future?	<input type="text"/>	1 Yes 2 No>> L_27_2
L_27_1	What is the main reason why you want to grow BT Brinjal in the future? Multiple response possible	<input type="text"/> <input type="text"/> <input type="text"/>	why you want to grow bt brinjal Good/high Yield 1 Low production cost 2 Insect/disease resistant (Insects do not bore the brinjal) 3 Less pesticide required 4 High market demand 5 Good market price 6 Good taste 7 Nice color 8 Low labor required 9 Less nursing required 10 Other (please specify) 77
L_27_2	What is the main reason why you do not want to grow BT Brinjal in the future? Multiple response possible	<input type="text"/> <input type="text"/> <input type="text"/>	why you do not want to grow bt brinjal Cannot get good/high yield 21 High production cost 22 Not so much insect/disease resistant 23 More pesticide required 24 Less market demand 25 Can not get good market price 26 Taste is not good 27 Color is not good 28 More labor required 29 More nursing required 30 BT seed/seedlings are not easily available 31 Less ideas about the cultivation of BT brinjal 32 Other (please specify) 77