Assessing the Impact of Bt Brinjal in Rural Bangladesh:
Pre-Analysis Plan

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Overview

Bangladesh is the first South Asian country to approve commercial cultivation of a genetically modified (GM) food crop: brinjal (eggplant) spliced with a gene from soil bacterium *Bacillus thuringiensis*. On October 28, 2013, Bangladesh's National Committee on Biosafety approved cultivation of four indigenous varieties of Bt brinjal, which is resistant to attacks by a common pest in South and Southeast Asia called the fruit and shoot borer. The National Committee on Biosafety approved Bt brinjal for use, stating that the GM crop would significantly reduce the need to use pesticides. While the reduced use of pesticides has been shown under controlled conditions, it is not known if farmers will follow this practice if provided with Bt brinjal. Further, farmers' willingness to grow Bt brinjal will be strongly affected by whether it provides higher yields relative to conventional varieties. These questions motivate this analysis: Whether the cultivation of bt brinjal reduces the costs associated with pesticide use on brinjal cultivation; and whether it increases brinjal yields.

Description of the sample to be used in the study

We begin with an explanation of our power calculations as these inform how our evaluation was designed. We also describe how we will test for randomization balance and for survey attrition.

Sample size calculations

As is well understood, sample size calculations need to account for: (1) the study's primary outcomes; (2) the minimum size of change in those outcomes; (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. For this impact evaluation, we used parameters derived from a nationally representative IFPRI survey, the Bangladesh Integrated Household Survey (BIHS), conducted in 2011-2012.[2] Our primary outcomes are brinjal yields per hectare and total cost of pesticide use per hectare. 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. Using these data and these parameters, 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 is 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

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[2] 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]

treatment and 560 control households) are required to detect a minimum of 40 percent reduction in pesticide costs. We need a sample size large enough to assess both impacts (i.e., at least 1,120 farm households) and we must allowing for the possibility that some households may drop out between baseline and endline. This implies that for the Bt brinjal impact evaluation, we will use 200 clusters/villages (100 treatment and 100 control villages) and 1,200 farm households (600 treatment and 600 control households). Each cluster will include six farm households.

How sample was obtained

To understand how our sample was obtained, we begin by noting that the Bt brinjal varieties released by BARI are best suited to winter cultivation with sowing of seeds beginning in September/October and transplanting seedlings in November. Given interest in assessing bt brinjal as a cash crop (rather than one simply for home consumption), we also needed to work in areas characterized by good physical infrastructure and well-functioning markets for brinjal. In consultation with officials from the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE), we purposively selected four districts in the northwestern region that satisfy these criteria: Bogra, Gaibandha, Naogaon, and Rangpur. Within these four districts, DAE officials provided us, by upazilas (sub-districts), lists of villages where brinjal is cultivated predominantly in the winter season and the number of brinjal farmers in each village. Using these lists, we purposively selected 10 upazilas with a high concentration of villages with substantial number of brinjal farmers. The selected upazilas are: Shahjahanpur, Gaibandha Sadar, Gobindoganj, Palashbari, Dhamoirhat, Manda, Gongachara, Mithapukur, Pirgacha and Pirganj. Within the 10 selected upazilas, we prepared a list of villages having at least 15 brinjal farmers per village. We then gave this list to the Bangladeshi survey firm who would undertake the data collection, Data Analysis and Technical Assistance Ltd (DATA). DATA randomly assigned 100 villages to the treatment group and 100 villages to the control group using the list of villages we provided to DATA. Specifically, DATA: (1) Used a random number generator to generate a number for each village; (2) Ordered villages from smallest to largest number; and (3) Allocated the first 100 villages to the control group and the remaining 100 villages to the treatment group. This approach meant that randomization was undertaken independently of both the program implementers and the evaluators.

Next, in August 2017, DATA conducted a village census that was administered in all 200 villages. This gave us a list of all farmers in the selected villages who grew brinjal in the preceding 24 months of the study period. From the census list of brinjal farmers in the 100 treatment villages, we identified and listed farmers willing to grow Bt brinjal on 10 decimal (one-tenth of an acre) plots during the planting season beginning November 2017. From the census list of brinjal farmers in the 100 control villages, we identified and listed farmers willing to grow conventional brinjal of the same variety used for Bt brinjal on 10 decimal plots during the planting season beginning November 2017. From the lists of farmers willing to grow Bt and conventional brinjal, randomly selected 10 farmers from each village, of whom 6 farmers belong to study group (total of 600 treatment and 600 control farmers), and 4 farmers belong reserve group. If a farmer in the study group is not available to participate in the study for any reason, then that farmer was to be replaced with one in the reserve group. We re-confirmed farmers' willingness to participate again in September and November 2017. (Out of 1,200 farmers in the original study group, 16 farmers declined to participate, so they were replaced by farmers in the reserve group.)

Tests of randomization

As the blog post by McKenzie (2017) notes, there are both beneficial and problematic aspects associated with testing for randomization. In our case, randomization was undertaken by an independent third party trained by us in how to implement randomized selection. Further, this was a straightforward randomization exercise; there are not multiple phases or stratification involved.

Given all this, we will follow the advice set out in McKenzie (2011): undertake an omnibus test of joint orthogonality; focus on the size of normalized differences; and consider the same set of variables that we will use for both tests of balance and for sample attrition. These are: age of household head; sex of household head (with the caveat that if more than 95% of households are male headed, we will drop this variable); education of household head; wealth status (based on a principal components analysis of ownership of consumer durables and housing quality); land operated during the winter cropping season, 2016-17 and number of years working as a farmer. In addition we will assess balance over baseline values for our two primary outcomes: brinjal yields (production per ha) and pesticide costs (Taka per ha).

Tests for sample attrition

We will estimate a probit regression where the dependent variable equals 1 if the household attrits, zero otherwise. Right hand side regressors will include baseline values that will tested for balance: age of household head; sex of household head (with the caveat that if more than 95% of households are male headed, we will drop this variable); education of household head; wealth status (based on a principal components analysis of ownership of consumer durables and housing quality); land operated during the winter cropping season, 2016-17 and number of years working as a farmer; brinjal yields (production per ha); pesticide costs (Taka per ha); and treatment status. If an omnibus test of joint orthogonality rejects the null that these baseline values are uncorrelated with attrition status and if attrition exceeds 10 percent, we will assess the robustness of our findings to the use of inverse-probability-of-attrition weights.

Data sources

Data for this impact evaluation will be taken from two surveys: A baseline survey fielded in November – December 2017; and an endline survey scheduled for June-July 2018. In addition, we have asked participating farmers to keep registries of input use, harvests, and sales. We do not know how carefully these registries will be kept; nor if all farmers will do so. For this reason, our impact evaluation will be based on the baseline and endline survey data; where available, we will use these registries to cross-check our survey data.

Hypotheses to be tested

We distinguish between our primary hypotheses and additional analysis designed to assess: secondary outcomes; mechanisms; and subgroup analysis.

We have two primary hypotheses:

(P1) Bt brinjal cultivation will reduce pesticide use (pesticide cost per ha of brinjal cultivated) compared to conventional brinjal. Pesticide use is taken from module I4 of the endline questionnaire.
(P2) Bt brinjal cultivation will increase brinjal yields (kg produced per ha of brinjal cultivated) compared to conventional brinjal cultivation. Production data are taken from module I9 of the endline questionnaire.

Analysis of secondary outcomes, mechanisms and subgroup analysis will include the following:

(S1) What mechanisms account for differences in pesticide use? Does the cultivation of Bt brinjal change the quantity of pesticides applied to brinjal? (Yes/No). How large is this change? Does the cultivation of Bt brinjal change the frequency with which pesticides are applied to brinjal? (Yes/No). How large is this change? Does the cultivation of Bt brinjal affect the prevalence of secondary insect infestations? (Yes/No). How large is this change? How does this affect the use of pesticides for insect infestations apart from fruit and shoot borers?

(S2) 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? Does the cultivation of Bt brinjal change other production practices? (Yes/No) If so, what are those changes? Does the cultivation of Bt brinjal change other (ie not pesticides or labor) costs associated with brinjal production? (Yes/No). What costs change? How large is this change?

(S3) Compared to conventional varieties, is Bt brinjal easier or more difficult to sell in local markets? Why? 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? How do farmers' experiences in marketing Bt brinjal compare to marketing conventional brinjal? What factors affect these experiences?

(S4) Does the cultivation of Bt brinjal cause gross revenues from brinjal production (total production *x* price received) to change? How large is this change? Does the cultivation of Bt brinjal cause net revenues from brinjal production (gross revenues minus all costs) to change? How large is this change? To what extent does this reflect results found under P1, P2, S2 and S3 above?

(S5) Do changes in cultivation practices and input use associated with Bt brinjal have spillover effects on crop practices, input use and (if available) production of non-brinjal crops during the winter season?

(S6) 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? 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? 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?

(S7) We will explore whether there are differential effects by subgroups based on farmer characteristics: age, sex of head, schooling, land cultivated. Note that because of the criteria for inclusion into the study, this sample of households may well be relatively homogeneous and thus there may be limited scope for heterogeneous effects.

Construction of primary outcome variables

Our primary outcomes are brinjal yields per hectare of and total cost of pesticide use per hectare. Data for both endline outcomes will be taken from the farm survey instrument to be fielded in June-July 2018. Where available, we will cross-check these data against registry information provided by farmers.

Pesticide use will be calculated as the cost of pesticides (in Taka) per ha (where area is defined as the area under brinjal cultivation). This is calculated over the period November 2017 – June 2018; see Module I4 of the endline questionnaire.

Brinjal yield will be calculated as brinjal production in kg (excluding fruit harvested but discarded because of pest infestation or damage) per ha (where area is defined as the area under brinjal cultivation). This is calculated over the period November 2017 – June 2018; see Module I9 of the endline questionnaire.

We will assess whether our results are robust to specifying these outcome variables in levels or in logs. We will also assess whether our results are robust to winsorizing at the 2nd and 98^{th} percentiles of the distributions of these outcome variables. No imputation for missing data at endline will be performed.

Treatment effect equation

Define:

Y_{i1} Baseline value of outcome variable for household i

Y_{i2} Endline value of outcome variable for household i

T_i Treatment status, =1 if household in village randomized to receive Bt brinjal

$\mathbf{X}_{i1}$ Vector of control variables (age of household head; sex of household head (with the caveat that if more than 95% of households are male headed, we will drop this variable); education of household head; wealth status (based on a principal components analysis of ownership of consumer durables and housing quality); land operated during the winter cropping season, 2016-17 and number of years working as a farmer).

β Parameters to be estimated

ε_I Disturbance term

We will estimate a basic and extended ANCOVA treatment effect equation.

The basic model is:

$$Y_{i2} = \beta \bullet Y_{i1} + \beta \bullet T_i + \varepsilon_I$$

The extended model is:

$$Y_{i2} = \beta \bullet Y_{i1} + \beta \bullet T_i + \beta \bullet \mathbf{X}_{i1} + \varepsilon_I$$

Standard errors will be corrected for clustering at the unit of randomization, the village.

Adjusting for multiple hypothesis testing

We have two domains of primary outcomes, pesticide use and yields. Within each domain, we defined a single outcome. For this reason, we will not adjust for multiple hypothesis testing.