AJAE appendix for The Impacts of GM Foods: Results from a Randomized Controlled Trial of Bt Eggplant in Bangladesh

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October 7, 2020

Note: The material contained herein is supplementary to the article named in the title and published in the American Journal of Agricultural Economics (AJAE).

Appendix S1: Pesticide Toxicity: EIQ and PUTS

Environment Impact Quotient (EIQ)

Kovach et al. (1992) developed the EIQ as a measure of the environmental effect of specific pesticides. They constructed a database showing the health, ecological, and environmental effects of pesticides on dermal toxicity, chronic toxicity, systemicity (the uptake and distribution of pesticides in the leaves and roots, Goertz and Mahoney (2012)), fish toxicity, leaching potential, surface loss potential, bird toxicity, soil half-life, bee toxicity, beneficial arthropod toxicity, and the plant surface half-life of specific pesticides. From this, they generate three components of 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

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). Each component is given equal weight. Across all pesticides in their data base, EIQ ranges from 6.7 to 226.7 (Kniss and Coburn 2015). To account for different formulations of the same active ingredient in various pesticides, and differences in rate of application, the EIQ Field Use Rating (EIQ-FUR) is calculated as:

EIQ-FUR = EIQ × % Active Ingredient × Rate of Application

Our calculation of EIQ-FUR is based on the pesticides most frequently used by farmers in our study to combat FSB. These are: 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 S1.1 describes the chemical name, percent of active ingredient, Field Use EIQ, and EIQ component scores of the selected pesticides.

Table S1.1 Pesticides Used to Calculate EIQ

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: Calculated from Eshenaur et al. (2015).

The EIQ values in table S1.1 are based on an application rate of 1,000 ml per ha. We adjusted the EIQ values according to the application rate (in ml/ha) on individual plots based on our survey data collected at baseline and endline. Table S1.2 presents descriptive statistics on EIQ values of pesticides used in treatment and control plots by survey round.

Table S1.2 Descriptive Statistics of EIQ-FUR and EIQ Components, by Round and Treatment Status

	Baseline				Endline			
	Treatment n=630		Control n=628		Treatment n=603		Control 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
EIQ Components								
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. *Note:* n = number of plots

Pesticide Use Toxicity Score (PUTS)

We constructed our PUTS (Pesticide Use Toxicity Score) measure in the following fashion.

Farmers were asked to name the pesticides used for different brinjal pests. We matched the trade names of these pesticides to the DAE List of Registered Agricultural Bio Pesticides and Public Health Pesticides in Bangladesh (DAE 2016) to obtain their respective chemical names. The toxicity levels of the chemicals in these pesticides were then checked against the Globally Harmonized System (GHS) Acute Toxicity Hazard Categories (United Nations 2011); see table S1.3. Combining information from these sources allows us to compile a list of pesticides commonly used against brinjal pests, the types of pests and crops they are appropriate for and their GHS toxicity classification (Table S1.4).

Table S1.3 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.

Table S1.4. Frequently Used Pesticides Used in Brinjal Production

Trade/ Brand Name	Generic/ Chemical Name	Name of Registration Holder	Recommended Pests	GHS Hazard Classification
Actara (25 WG)	Thiamethoxam	Syngenta Bangladesh Limited	BPH, Aphid, Jassid, Termite, Hopper, Beetle, Helopeltis	4 (Oral)
Alba (1.8 EC)	Abamectin	SAMP Limited	Brown Planthopper (BPH), Hispa	2 (Oral); 1 (Inhalation)
Basuden (10 GR)	Diazinon Organophosphate	Raven Agro Chemicals Limited	Aphid	4 (Oral)
Dursban (20 EC)	Chlorpyrifos Organophosphate	Auto Crop Care Limited	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	Stemborer, BPH, Ufra Nematode, White grub, Top and Early Shoot borer, Cutworm	2 (Oral); 2 (Inhalation)
Guilder (5 SG)	Emamectin Benzoate	Aama Gree Care	Pod borer, Termite	3 (Oral); 4 (Dermal)
Imitaf (20 SL)	Imidacloprid	Auto Crop Care Limited	BPH, Hispa, Aphid, Jassid, Whitefly, Bollworm, Termite	4 (Oral)
Licar (1.8 EC)	Abamectin	Corbel International Limited	BPH, Hispa	2 (Oral); 1 (Inhalation)
Pegasus (500 SC)	Diafenthiuron	Polo/Pegasus	Whitefly, mites, aphids, jassids	4 (Oral); 3 (Inhalation); 2 (Dermal)

Ripcord (10 EC)	Cypermethrin	BASF Bangladesh Limited	Bollworm, Hopper, Hairy caterpillar, Field cricket, Semilooper, Shoot and fruit borer	3 (Oral); 4 (Inhalation); 1 (Skin Sensitization)
Shobicron (425 EC)	Profenofos (40%) + Cypermthrin (2.5%)	Syngenta Bangladesh Limited	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)
Tundra (20 SP)	Acetamiprid	Auto Crop Care Limited	Aphid, Jassid, White fly	4 (Oral); 2 (Inhalation)
Vertimec (1.8 EC)	Abamectin	Syngenta Bangladesh Limited	Red spider mite, mite	2 (Oral); 1 (Inhalation)
Volium Flexi (300 SC)	Thiamethoxam (20%) + Chloraniliprole (20%)	Syngenta Bangladesh Limited	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	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; G: Granule.

We summarize pesticide use adjusting for toxicity by constructing a Pesticide Use Toxicity Score (PUTS). This is based on the GHS Oral Hazard category of the pesticides used as well as their frequency of use. In the GHS Hazard Classification scale, lower levels (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:

$$PUTS = Inversed\ GHS\ Oral\ Hazard\ Classification \times Number\ of\ times\ the\ respective\ pesticide\ was\ applied\ in\ a\ season$$

Summary statistics are shown in table S1.5.

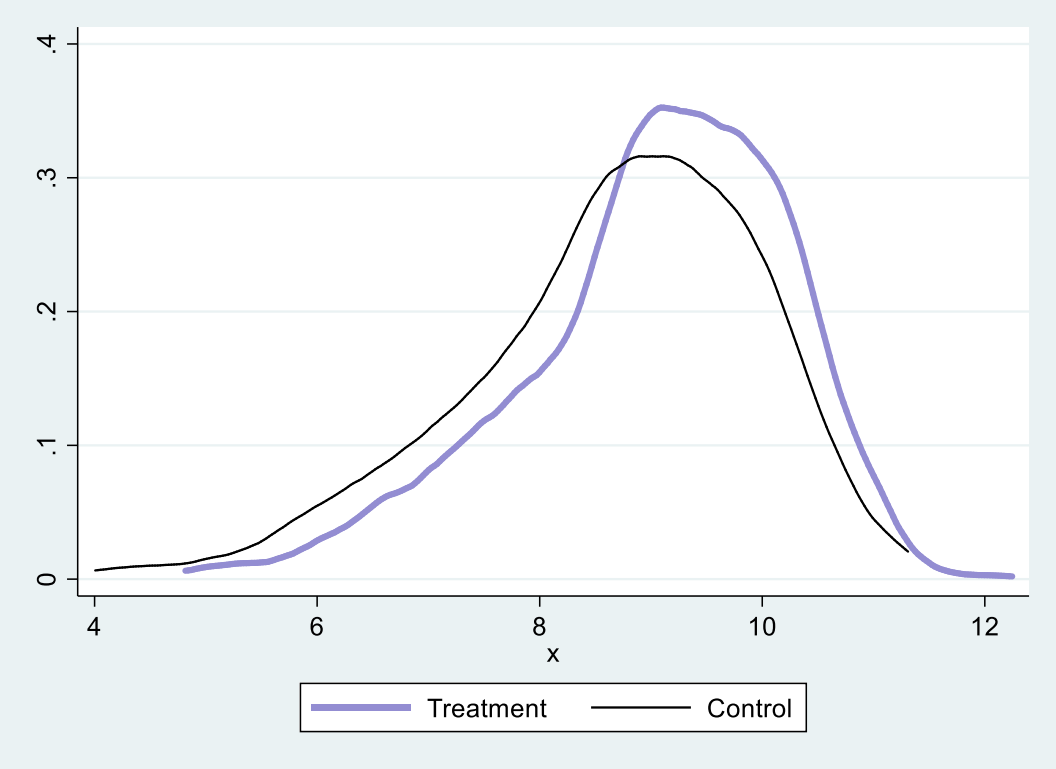
Table S1.5. Pesticide Use Toxicity Score (PUTS) Summary Statistics

	Baseline		Endline	
	Treatment	Control	Treatment	Control
Mean	22.3	24.5	9.5	17.0
St. Dev.	29.4	32.5	14.1	23.2
Min	0.0	0.0	0.0	0.0
Max	207.0	177.5	150.0	247.0

Source: 2017 baseline and 2018 endline surveys. *Note*: Range for PUTS: 0 to 438 (max. based on highest toxicity level times maximum number of sprays recorded in baseline).

Appendix S2: Additional Tables and Figures

Figure S2.1. Kernel density functions for net yields per ha, by treatment status



Source: 2018 endline survey

Table S2.1. Impact of Bt brinjal on production with Romano-Wolf p-values

	(1)	(2)	(3)	(4)
	Amount (kg)			
	Harvested	Discarded	Paid to labor	Retained for home consumption
Treatment: Bt brinjal	113.32	-42.97	5.61	6.45
Standard Error	(53.96)	(10.25)	(4.96)	(2.08)
Model p-value	0.037	0.000	0.259	0.002
Romano-Wolf p-value	0.064	0.003	0.258	0.007

Note: Standard errors clustered at the village level.

Table S2.2. Marketing of Brinjal at Endline

	Treatment	Control	All
		(percent)	
Main buyer of brinjal			
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
Main reason for the choice of buyer			
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
Location of sales			
District wholesale market	44.3	44.4	44.4
Local retail market	43.4	42.8	43.1
Farmer's field / own	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
Price agreed upon over phone	39.0	33.3	36.6

Source: 2017 endline survey.

Table S2.3. Input Costs per Hectare for Bt Brinjal and ISD-006 Cultivation at Endline

Cost	Treatment	Control
		(taka per hectare)
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.

Table S2.4. Endline Labor Use in Brinjal Cultivation: Days per Hectare by Cultivation Activities, Labor Type, and Treatment Status

Activity	All labor (male and female) (family and hired)		Family labor						Hired labor					
	Treatment	Control	Treatment			Control			Treatment			Control		
(Labor days)			Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Land preparation	26.7	28.5	18.8	0.9	19.7	19.2	1.4	20.7	6.8	0.2	7.0	7.7	0.2	7.8
Transplanting	36.3	35.3	20.2	2.6	22.8	21.0	2.2	23.3	12.5	1.0	13.5	11.9	0.1	12.0
Fertilizer application	11.6	14.2	10.9	0.1	11.0	13.3	0.3	13.6	0.6	0.0	0.6	0.6	0.0	0.6
Pesticide application	27	38.6	23.1	0.3	23.4	35.4	0.5	35.9	3.6	0.0	3.6	2.7	0.0	2.7
Weeding	137.1	135.3	59.1	5.8	64.9	63.6	5.2	68.8	61.4	10.8	72.2	59.6	6.8	66.5
Irrigation	4.9	4.7	4.2	0.1	4.3	4.2	0.1	4.3	0.6	0.0	0.6	0.4	0.0	0.4
Harvesting	67	73.9	45.5	19.9	65.4	48.3	21.9	70.2	0.9	0.7	1.6	2.2	1.6	3.7
Sorting and packing	25.5	25.8	13.5	11.3	24.9	13.6	12.1	25.6	0.3	0.2	0.6	0.1	0.1	0.2
Plant uprooting	18.7	21.3	13.2	1.2	14.3	15.4	1.2	16.6	4.3	0.2	4.4	4.5	0.2	4.7
Total	354.8	377.6	208.4	42.4	250.7	234.1	44.8	278.9	91.0	13.1	104.1	89.7	9.0	98.7

Source: 2018 endline survey.

Table S2.5. Impact of Bt brinjal on sales, revenues, and costs with Romano-Wolf p-values

	(1) Quantity sold	(2) Unit price	(3) Revenue	(4) Measured input costs	(5) Net revenue (Revenue less measured input costs)
Treatment: Bt brinjal	143.60***	0.96**	1325.87**	-318.54**	1635.94***
Standard Error	(49.29)	(0.42)	(647.13)	(147.70)	(585.57)
Model p-value	0.004	0.022	0.042	0.032	0.006
Romano-Wolf p-value	0.016	0.065	0.068	0.067	0.022

Note: Standard errors clustered at the village level.

Table S2.6. Impact of bt brinjal on pesticides with Romano-Wolf p-values

	(1) Number of pesticide applications	(2) Quantity of pesticides used (ml or gm per ha)	(3) EIQ-FUR	(4) EIQ-Consumer	(5) EIQ-Farm Worker	(6) EIQ-Ecological	(7) PUTS
Treatment: bt brinjal	-7.37***	-4,621.77***	-4.61***	-0.70***	-1.18***	-12.01***	-7.16***
Standard Error	(1.22)	(1,095.05)	(1.62)	(0.13)	(0.25)	(4.53)	(1.56)
Model p-value	0.000	0.000	0.005	0.000	0.000	0.009	0.000
Romano-Wolf p-value	0.001	0.001	0.001	0.001	0.001	0.002	0.001

Table S2.7. Descriptive Statistics, 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, all observations		
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
	Mean	
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. *Note*: Sample size is 2,531.

Table S2.8a. Impact of Bt brinjal on self reported illness and its consequences with Romano-Wolf p-values

	(1) Any symptom of pesticide exposure	(2) # symptoms of pesticide exposure	(3) Lost days of work b/c symptoms of pesticide exposure	(4) Sought medical treatment for any of these symptoms?	(5) Incurred cash expenses associated with treating symptoms?
Treatment: Bt brinjal	-0.062**	-0.136	-0.024	-0.062*	-0.048
	(0.031)	(0.092)	(0.025)	(0.034)	(0.031)
Model p-value	0.040	0.114	0.298	0.062	0.107
Romano-Wolf p-value	0.132	0.248	0.338	0.175	0.248

Table S2.8b. Impact of Bt brinjal on self-reported illness and its consequences, conditional on pre-existing chronic condition relating to pesticide exposure with Romano-Wolf p-values

	(1) Any symptom of pesticide exposure	(2) # symptoms of pesticide exposure	(3) Lost days of work b/c symptoms of pesticide exposure	(4) Sought medical treatment for any of these symptoms?	(5) Incurred cash expenses associated with treating symptoms?
Treatment: Bt brinjal	-0.115***	-0.374**	-0.046	-0.122**	-0.109**
	(0.042)	(0.166)	(0.050)	(0.050)	(0.044)
Model p-value	0.005	0.002	0.280	0.012	0.009
Romano-Wolf p-value	0.031	0.055	0.365	0.055	0.055

Table S2.9. Pesticide Handling Practices by Treatment Status and Survey Round

	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.