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Economic Impact of Bt Corn in the Philippines

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A descriptive cost and returns analysis, a Cobb-Douglas Model and a two-step econometric procedure (that includes a Probit Model) were applied to a sample of corn farmers in selected regions of the Philippines in order to determine the economic impact of the Bt corn variety. With and without type of analysis were used to establish the difference between Bt corn and non-Bt corn farms in two cropping seasons. Results showed that yield and income of Bt corn farmers were significantly higher than those of the non-Bt corn farmers. In addition, expenditure on insecticide was significantly lower among Bt corn farmers. Results in all study locations showed a significant welfare effect of using Bt corn variety among corn farmers. Educational level and farm income were among the significant factors that influenced the adoption of Bt corn.

Key Words: economic impact, biotechnology, Bt corn adoption

Abbreviations: Bt – *Bacillus thuringensis*, MAV – minimum access volume, PhP – Philippine peso

INTRODUCTION

A major economic pest of corn in the Philippines is the Asian corn borer of the stem borer complex. Yield reduction due to a 40–60 % corn borer infestation can reach as high as 27% (Logroño 1998). In 1986, Bt corn, originally developed to control the European corn borer, was proven to also confer a high level of resistance against the Asian corn borer (Fernandez et al. 1997). Bt stands for *Bacillus thuringiensis*, a bacteria that produces a powerful insecticide. The gene traits of the bacteria have been integrated into the corn genes to resist the corn borer. However, the introduction of Bt in the Philippines has been controversial due to environmental and consumer concerns.

The first commercial release of Bt corn in the Philippines was approved by the Department of Agriculture in 2002. An *ex-ante* analysis also revealed a yield advantage of as much as 41% of Bt corn over non-Bt varieties with profitability gains of 15–86% (Gonzales 2002).

While initial studies indicated the strong potentials of Bt corn in the Philippines under controlled conditions, yield, costs, resource use and profitability may significantly vary from experimental results under farmers' fields and management. This study therefore critically examined evidences on the farm level impact of Bt corn in the Philippines after 1 yr of commercialization.

METHODOLOGY AND DATA SOURCES

The study used the data from the International Service for the Acquisition of Agri-biotech Applications (ISAAA) corn survey of four major Bt-corn-adopting provinces of the Philippines, namely: Isabela, Camarines Sur, Bukidnon and South Cotabato. The survey interviewed a total of 107 Bt and 363 non-Bt corn farmers during the wet and dry seasons of crop year 2003-2004 using a pretested questionnaire.[1] In each province, at least three towns and three barangays (smallest political unit) per town were chosen based on the density of Bt corn adopters. Complete enumeration was used in Camarines Sur and Bukidnon due to the small number of Bt corn users while simple random sampling was used in other barangays.

On the assessment of the economic impact, the with and without approach was used, i.e., comparing farms using Bt corn with non-users. To minimize agro-climatic variability across the two farm groups, non-Bt farms adjacent to Bt corn farms were randomly selected. Physical and socio-economic factors were compared to include yield, area, farm-

[1]Because of inconsistent and erroneous data from some surveyed farms, only 407 questionnaires were used in the analysis.

ing environment, input use, pesticide use, costs and returns, reasons for adoption, knowledge about Bt corn, information sources and perceptions in planting Bt corn.

To estimate the effects on corn yield, the mean corn yield between Bt and non-Bt users were compared. While this measure provides indicators of absolute advantages, a more appropriate measure to assess the rate of technological progress induced by the Bt corn adoption is the use of production functions. The production function specified was the Cobb-Douglas form that is linear in the natural log of the variable. The model in linear form is as follows:

$$\ln Q_i = \ln A + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \lambda C_i + \gamma V_i + \delta Y_i + \sum_{j=2}^{4} \theta L_{ij} + u_i$$

where:

Q_i is the corn output of the i^{th} farm
X_{1i} is the labor input in total man-days of farm i
X_{2i} is the fertilizer input in kg of farm i
X_{3i} is the area cropped in hectares of farm i
X_{4i} is the chemicals used in pesos/ha of farm i
C_i is a cropping dummy (1 = wet season, 0 = dry season)
V_i is a technology dummy (1 = Bt corn, 0 = non=Bt)
Y_i is a farm specific dummy for management (1 = good, 0 = bad)
L_i is a location dummy for Camarines Sur, Isabela, Bukidnon and South Cotabato
u_i is the disturbance term with the usual classical properties
$i = 1, 2, \ldots n$

The model, however, has limited properties with regard to input substitutability and the requirements to satisfy the second order maximization conditions. Potential selectivity and simultaneity biases are other inherent limitations in using the ordinary least squares in estimating the Cobb-Douglas model. The simultaneity bias arises out of estimating one equation which is embedded in a larger decision-making model and selectivity bias out of omitting farm specific management factors. By assuming that farms aim to maximize the mathematical expectation of profits and incorporating farm specific dummy variables, the above biases can be avoided (Lingard et al. 1991). The simplicity and flexibility of this approach prompted its widespread use in agricultural economics and is a good first step in quantifying the yield effect of the Bt corn technology.

The impact of Bt corn on farm financial performance is assessed by accounting for the other factors of production through the use of a profit function. A two-stage econometric model was used following the technique of Heckman (1979) where the first stage consists of an adoption decision model describing the factors that influence the likelihood of Bt corn adoption (Fernandez-Cornejo and McBride 2002). The probit model used is given as follows:

$$Y_i^* = \beta' X_i + u_i$$

where Y_i^* is a latent variable representing an unobservable index of the willingness of the farmer to adopt Bt corn; β is a vector of unknown parameters; X is a vector of the factors affecting adoption; u_i is the disturbance term assumed to be independently and normally distributed with zero mean and constant variance; and i = 1, 2, ….n representing the number of observations.

The results of the Probit model are used to calculate the predicted probabilities (P_i) of Bt corn adoption, excluding the net farm income variable. The second stage of the model consists of a multiple regression analysis that estimates the impact of Bt corn adoption on net returns. The predicted probabilities in the first stage and the inverse Mills ratio (λ_i) are added as regressors given as[2]:

$$\pi_i = \alpha_0 \Sigma \alpha_j X_{ij} + \delta_1 P_{i1} + \eta_1 \lambda_{i1} + u_i$$

where π is a vector representing net returns; X, a matrix of variables affecting financial performance; and, u_i as the error term (see Appendix Table 1 for the variable definition). The coefficient of the predicted probability of adoption can now be used to estimate the adoption elasticities.

For the market effects, the standard consumer–producer surplus model was used in assessing the impact of Bt corn (Alston et al. 1995; Qaim 1999a and b; Pray et al. 2001). The adoption of bioengineered crops like Bt corn reduces the use of insecticide cost and, hence, induces a downward shift of the supply curve. The model is shown in Figure 1. It is assumed that supply and demand curves are linear and the use of Bt corn results in a parallel shift of the corn supply curve from S_0 to S_1. This results in an increase in production equivalent to Q_1-Q_2. In this partial equilibrium framework, the additional producer surplus due to the supply shift is represented by the area **abcd**. The market demand curve is given by D and domestic consumption is at Q3. Since the country is small in corn trade and remains to be a net-importer of corn in the world market, the price to reckon in the domestic market is given by Pd = Pw(1 + t) where Pw is the world price of corn and t represents the import tariff per unit (see Alston et al. 1995). To protect the domestic market in the Philippines, corn imports have been tariffied at 35% within the minimum access volume (MAV) and 50% beyond the MAV. The government also intervenes in the domestic market through quantitative restrictions and price support. To estimate the

[2]The inverse Mills ratio is added to correct for the selectivity bias (Heckman 1996) as Bt corn adopters and non-adopters have selected the group to which they belong and that neither group can be assumed as random sample (Hidalgo 2001).

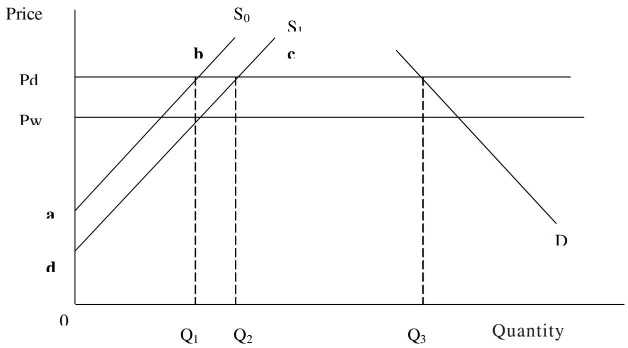

Fig. 1. Market effects of Bt corn adoption.

supply curve shifter, the data on costs and returns from farmers using and not using Bt corn were used (Pray et al. 2001). The total benefits also include the revenues derived by the supplier of Bt corn seeds and was estimated by deriving the gross revenues of the seed company.

RESULTS AND DISCUSSION

The commercial introduction of Bt corn in the domestic market presents considerable options to farmers in improving their financial performance by lowering cost of production and increasing yields. The experiences in many countries revealed that the resistance of corn plants to the corn borer reduces pesticide application and damage to corn plants, thereby, increasing yields. After one year of commercial adoption, has the Filipino farmer benefited from this biotechnology?

This section presents the economic impact of Bt corn adoption in the Philippines. Selected characteristics of the corn farming households included in the survey are presented in Table 1. There are some noticeable differences in the characteristics between the Bt and non-Bt corn farmers in the sample. The Bt corn farmers owned larger farms, devoting an average of 2.64 ha to Bt corn. They were also better educated (with about 10 yr of formal schooling as compared to 8 yr for non-Bt users) and earned more from sources other than farming by more than PhP 2,000 per month. Off-farm income is very important to corn farmers as a major source of capital to finance farming operations. Although fewer Bt corn farmers were members of farmers' organizations, many (91%) have frequent contact with extension workers. It is obvious that Bt corn farmers spent less on pesticides but hired more labor particularly at harvest time. Only 25% of the total sample used Bt corn varieties.

Effect on Corn Yield

A comparison of mean yield per hectare of Bt and non-Bt corn farms across locations revealed the substantial absolute advantage of Bt corn (Table 2). This procedure, however, does not allow for controlling other factors that may have affected yield differences. In all locations and for both cropping seasons, the Bt corn farms had a yield advantage of 34% over the non-Bt users with a high of 37% in Camarines Sur and South Cotabato. The average yield of Bt corn farms was 4,850 kg/ha as compared to only 3,610 kg/ha for the non-users. Favorable growing conditions, experienced particularly in Isabela and South Cotabato during the second (dry) season, contributed significantly to better corn production. Except for Bukidnon, the yield differences between Bt and non-Bt corn farms were statistically significant for all locations, at 1% level for the first cropping and 5% level for the second cropping. Yield difference in Bukidnon was very minimal (26% for the first

Table 1. Selected characteristics of farming households, Bt Corn Study, Philippines, 2003-2004.

Characteristic	Bt	Non-Bt	All
Farm size (ha)	4.04	2.47	2.82
Corn area (ha)	2.64	1.64	1.86
Planted corn area (ha)	2.32	1.55	1.72
Age (yr)	45.38	46.77	46.46
Years of schooling	9.65	7.81	8.22
Income from other sources (per month)	4,066.79	1,088.56	1,766.58
Membership in farmer organization (%)	47.66	57.02	54.89
Contact with extension worker (%)	91.04	84.89	86.30
Chemical expense (PhP/ha)	267.21	406.52	371.69
Hired labor (Man-days/ha)	51.99	46.98	48.22
Variety used (%)	25	75	100

Source of data: ISAAA Corn Survey, 2003-2004

Table 2. Yield differences between Bt and non-Bt corn farms, 407 farmers, Philippines, 2003-2004.

Cropping/Location	Bt	Non-Bt	% Difference
1st cropping			
Camarines Sur	4516.67	3287.46	37.39 **
Bukidnon	4215.90	3324.18	26.83 n.s.
All locations	4301.83	3307.75	30.05 **
2nd cropping			
Bukidnon	2868.36	3566.30	(19.57) n.s.
Isabela	5303.85	4483.77	18.29 ***
South Cotabato	4793.55	3486.31	37.50 ***
All locations	4890.28	3789.96	29.03 ***
Both croppings	4849.50	3610.31	34.32 ***

*** = significant at 1% ** = significant at 5% n.s. = not significant
Source of data: ISAAA Corn Survey, 2003-2004

Table 3. Estimated coefficients of the Cobb-Douglas production function on factors affecting corn output, Bt Corn Study, Philippines, 2004.

Variables	Coefficients	Standard error
Intercept	0.303 *	0.163
Labor (total man-days)	0.016 n.s.	0.035
Fertilizer (kg)	0.061 ***	0.016
Area cropped (ha)	0.919 ***	0.036
Chemical input (PhP)	0.008 *	0.004
Dummy variables (0,1)		
Cropping dummy (1=1st crop)	0.032 n.s.	0.055
Varietal dummy (1=Bt, 0=NonBt)	0.225 ***	0.035
Farm specific dummy (1=above ave. yield)	0.587 ***	0.028
Location dummy 1 (1=Bukidnon)	0.010 n.s.	0.053
Location dummy 2 (1=S. Cotabato)	0.193 ***	0.071
Location dummy 3 (1=Isabela)	0.376 ***	0.074
R^2	0.879	
n	407	

*** = significant at 1% * = significant at 10%
n.s. = not significant
Source of data: ISAAA Corn Survey, 2003-2004

cropping and negative in the second cropping) due to the reported widespread incidence of stalk rot and drought. In the first cropping, Isabela was dropped from the sample as corn plants were extensively damaged by a strong typhoon during the corn-growing season.

While yield differences can provide meaningful indicators to evaluate the importance of using Bt corn, a more appropriate measure is to assess the rate of technological progress induced by the innovation. The upward shift in the production function already indicates the reduction in per unit cost of production.

The estimated parameters of the Cobb-Douglas production function are shown in Table 3. The explanatory power of the model is good with 88% of the yield variation

Table 4. Expenditures on insecticide use, 407 Bt and non-Bt corn farmers, Philippines, 2003-2004

Location/Cropping	Insecticide Cost (PhP/ha)			
	No. of observations	Bt	Non-Bt	Difference
1st Cropping				
Camarines Sur	53	149	328	179.00
Bukidnon	68	134	56	(78.00)
2nd Cropping				
Bukidnon	51	0	47	47.00
South Cotabato	103	206	652	446.00
Isabela	132	149	281	132.00
ALL	407	156	324	168.00

Source of data: ISAAA Corn Survey, 2003-2004

explained by the functional relationship and the coefficients have the expected signs and magnitude. The results indicated that variety, the farm specific variable and the location dummies are obvious dominant variables. The farm-specific dummy represented management where yield per hectare above the average indicates good management. A 1% increase in area planted to crops resulted in a 0.92% increase in corn output. Of particular interest is also the large contribution of variety. Using the Bt corn variety with good management shifts the production function upward significantly, thereby, reducing per unit costs. Farms in Isabela had better yields primarily due to good weather conditions during the second cropping. For the inputs, area planted to crops provided the most significant contribution to yield.

Effect on Insecticide Use

The main purpose for the development of Bt corn is to provide effective resistance/protection against pests. One of the major pests that is dominant in Philippine corn farms is the Asian corn borer. Studies have shown that yield losses due to corn borer infestation could range from a low of 4.3% to a high of 30.9%. The damage was more pronounced during the wet season (Gonzales 2000). Farmers commonly apply insecticides to protect corn plants against the Asian corn borer. But this practice has now become less appealing due to health and environmental concerns. It is therefore expected that farmers using Bt corn can substantially reduce insecticide use and cost and, at the same time, increase yield.

The previous section revealed that farmers using Bt corn were successful in increasing their yields. Table 4 shows that insecticide use by Bt corn farmers was also reduced based on the amount spent on insecticides per hectare. Due to the wide variety of insecticides used and the difficulty of farmers to recall types used, expenditure on insecticides was instead used. As much as PhP 168 per hectare was saved on insecticide expenditure by Bt corn users. This implies that farmers sprayed less frequently and used less insecticides. The amount spent by non-Bt farms on insecticides was relatively high in Isabela and Camarines Sur where the reported incidence of the Asian corn borer was also prevalent. This cost advantage was not observed in Bukidnon, particularly during the second (dry) season when the incidence of the Asian corn borer was slight. More insecticide expenditures were reported during the wet season in Bukidnon where corn borers were quite prevalent.

Effect on Cost and Income

Farmers adopt new technologies mainly to improve their financial performance in farming. At the farm level, the reduction in pest damage translates to better yield and income in corn farming.

Table 5 shows that the cost of production per kilo of Bt corn was lower by 23 centavos than the non-Bt varieties but cash costs were higher. The net income per kilo showed a difference of only 10 centavos for the Bt corn. The Bt variety had an advantage of more than PhP 1.00 per kilo in returns over the non-Bt varieties. The Bt corn also received

Table 5. Prices, net income and returns to labor and management, 407 Bt and non-Bt corn farms, Philippines, 2003-2004.

Corn/Location	Price (1)	Cost of Production (2)	Net income (3)	Cash costs (4)	Returns to Labor and Management (1-4)
		Pesos/kg			
Bt					
Camarines Sur	8.00	5.86	2.14	5.38	2.62
Bukidnon 1st crop	6.86	5.99	0.87	5.27	1.59
Bukidnon 2nd crop	9.80	10.08	(0.28)	9.30	0.50
South Cotabato	8.83	4.61	4.22	4.29	4.54
Isabela	8.92	4.27	4.66	4.10	4.82
All locations	8.82	4.97	3.85	4.66	4.16
Non-Bt					
Camarines Sur	6.84	6.10	0.74	5.66	1.18
Bukidnon 1st crop	6.66	5.31	1.36	4.30	2.36
Bukidnon 2nd crop	8.19	5.16	3.02	4.23	3.96
South Cotabato	8.11	4.92	3.20	4.36	3.76
Isabela	8.68	4.77	3.90	4.52	4.16
All locations	7.71	5.20	2.51	4.56	3.15
Difference	1.11	-0.23	1.34	0.10	1.01

Table 6. Income and cost advantages of Bt corn farm adopters, 407 Bt and non-Bt corn farmers, Philippines, 2003-2004.

Cropping/Location	Change (Philippine Peso/ha)				BC Ratio (total returns/ total cost)
	Total Revenue	Pesticide Application	Seed Cost	Profit	
1st Cropping					
Camarines Sur	13,833.00	(179.00)	2,202.00	4,462.00	1.363
Bukidnon	7,210.00	78.00	2,626.00	(701.00)	1.201
2nd Cropping					
Bukidnon	(710.00)	(47.00)	2,649.00	(6,283.00)	1.365
Isabela	8,680.00	(132.00)	1,741.00	7,910.00	2.285
South Cotabato	14,046.00	(446.00)	2,289.00	7,669.00	1.991
All locations	14,849.00	(168.00)	2,047.00	10,132.00	2.014

a premium price in the market due to better quality and less impurities. Bt corn farmers, particularly in Camarines Sur and Bukidnon (second crop), received premium prices by as much as PhP 1.61/kg. Many farmers reported that the Bt corn kernels and ears were bigger, cleaner and of uniform size.

The financial advantage of Bt corn over the non-Bt varieties is summarized in Table 6. The results showed that at the margin, the use of Bt corn had a positive impact on the financial performance of corn farmers from 2003 to 2004. The increase in total revenue amounted to PhP 14,849 per hectare with a realized savings of PhP 168 per hectare in

Table 7. Results of the Probit estimation on factors affecting Bt corn adoption in the Philippines, 2004.

Variables	Coefficient	Standard Error	Marginal Effect
Constant	-3.119***	0.499	
Age	-0.002	0.007	-0.0004
Education (yr in school)	0.065**	0.025	0.0141
Area (hectares)	-0.075	0.049	-0.0163
Insecticie exp. (PhP/ha)	-0.001	0.0003	-0.0001
Hired labor (man-days)	0.002**	0.0008	0.0004
Net income (PhP/ha)	0.0003***	0.000007	0.000008
Dummy Variables (0.1)			
Training (1=with agricultural training	0.418**	0.181	0.0937
Risk (1=no risk)	1.861***	0.207	0.4357
LR chi^2	185.52		
Log Likelihood	-127.63		
Psuedo R^2	0.41		
No. of observations	407.00		

*** Significant at 1% level ** Significant at 5% level

Source of data: ISAAA Corn Survey, 2003-2004.

Table 8. Regression estimates of the financial impact model of Bt corn adoption, 2004.

Variables	NFI		MNFI	
	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	73271.93***	3352.05	81092.64***	4105.50
Age	116.49***	25.06	56.51	30.69
Area	'2044.1***	168.82	1366.04***	206.77
Hired Labor	-39.56***	3.18	-22.99***	3.90
Season	20441.09***	1502.07	20222.88***	1839.70
Schooling	-940.31***	99.29	-773.8218***	121.60
Insecticides	13.31***	1.25	11.75***	1.54
Risk	-41409***	1362.86	-38244.44***	1669.19
Tenure	-737.77	826.43	-2288.91**	1012.19
Bukidnon	3597.37	1145.52	-2139.90	1403.00
Gensan	1682.56	1741.27	176.57	2132.66
Isabela	558.08***	1839.63	6399.95***	2253.13
P	26482.82***	8410.65	13550.40	10301.14
P*Gensan	10493.17	17630.38	6286.54	9345.49
P*Isabela	4679.79	7598.49	7697.51	9306.43
P*Bukidnon	12838.24	1795.51	3684.15	9180.29
Lambda	-28006.01***	1013.91	-25035.39***	1241.81
R^2	0.82		0.77	
Sample size	405.00		405	

*** Significant at 1% level ** Significant at 5% level

Source of data: ISAAA Corn Survey, 2003-2004.

insecticide expenditure. Although seed costs were twice higher than those of the non-Bt varieties, the profit advantage was almost doubled. The benefit-cost ratio of 2.014 clearly indicates the better financial performance of the Bt corn farms in the Philippines.

The results of the Probit parameter estimates indicate that Bt corn adoption was significantly influenced by education, hired labor, net income, agricultural training and farmer's risk perception (Table 7). Adoption can be enhanced by increases in educational level and income, exposure to agricultural training programs and, more importantly, when adopting a practice is less risky on health and environment. Although not a significant factor, the negative coefficients for age, area and insecticide expenditure showed that older farmers with larger farm sizes and farmers who spent more on insecticides were less likely to adopt Bt corn. Farm size had an inverse relationship as farmers were still trying the Bt corn and only a small portion of the farm was planted to Bt corn. The major influence on adoption was observed for the risk perception factor, indicating that the greater the farmer's risk perception, the less they were likely to adopt Bt corn.

In the adoption impact model, several key variables were observed to significantly influence net farm income (NFI). These include age, area, hired labor, season, schooling, insecticide expenditures, risk perception, location and probability of adoption. For example, an increase in the area devoted to Bt corn contributes positively to net farm income while increases in hired labor and risk perception reduce significantly the economic benefits. The impact of Bt corn on the net farm income is shown by the highly significant influence of the probability of adoption (Table 8). The estimated adoption elasticity was 0.41, indicating that, as the probability of adoption increases by 10%, net farm income increases by 4.1%. The adoption elasticity was lower for the modified net farm income at 0.12. The greatest impact of Bt corn adoption was observed in Isabela. Except for age and the probability of adoption, the same variables were observed to significantly influence the modified net farm income (MNFI) where only cash expenditures were included in the cost.

Welfare Effects

Using the concept of the producer's surplus, the results showed that the net benefit to farmers was largest in Northern Luzon with PhP 20.95 million due to a larger area planted to Bt corn and cost reduction per unit. Farmers in other regions received lesser benefits due to less area devoted to Bt corn and minimal reported cost reduction per unit of production. Negative benefits were realized by farmers in Northern Mindanao as more costs were reported on fertilizers, chemicals and hired labor. Farms in these areas also experienced drought and stalk rot infestation.

After one year of commercialization, the net benefit to farmers aggregated PhP 46.44 million. This was estimated using the area planted to Bt corn and the reduction in per unit costs. The estimated gross revenue by the seed company was PhP 43.48 million and already includes the cost of the technology. Many non-Bt corn farmers were willing to try Bt corn but were constrained by its price. They said the price of seeds was too exorbitant compared to that of the regular hybrid varieties.

Expectedly, further reduction in the price of Bt corn seeds will certainly result in an increase in the net benefit to farmers. The current effects are still minimal, considering an adoption rate of only 1%. However, an improvement in the adoption rate may be expected in the future as new seed companies plan to enter the market. This will certainly improve the overall benefits derived from Bt corn. It should be understood that the welfare benefits presented here represent the direct and immediate impact to the corn industry. It does not cover the indirect and dynamic effects on the other industries like livestock where corn has strong economic linkages.

Table 9. Welfare effects of Bt corn adoption, by location, Philippines, 2003-2004.

Item	Northern Luzon	Southern Luzon	Northern Mindanao	Southern Mindanao	All locations
Area (ha)[a]	7,901	2,257	130	481	10,769
Yield/ha (kg)	5,304	4,516	4,215	4,794	4,850
Price (PhP/kg)	8.68	8.00	8.33	8.11	8.82
Cost reduction (PhP/kg)	0.50	0.24	(0.68)	0.31	0.23
Net benefit to farmers (million pesos)[b]	20.95	2.45	(0.37)	0.71	46.44
Estimated gross revenue to seed companies (million pesos)	30.61	10.16	0.62	2.09	43.48

*** Significant at 1% level ** Significant at 5% level

Source of data: ISAAA Corn Survey, 2003-2004.

CONCLUSION

The Asian corn borer remains to be a major corn pest in the Philippines, reducing unit yields by as much as 27%. Due to the worsening damage by the Asian corn borer, Bt corn, a transgenic corn variety resistant to this pest, was recently introduced in Philippine commercial farms to control the pest and increase yields.

After one year of commercial adoption, only about 10, 000 ha have been planted to Bt corn in the Philippines, representing only 1% of the total area planted to yellow corn. The major factors influencing adoption included risk perception, education, training and hired labor. The perceived risks by farmers on the use of Bt corn played a significant role in adoption, particularly for the non-users, while users frequently mentioned the benefits, like resistance to corn borer and high yield. The most important perceived risk factor was the harmful health effects on man and animals. The main sources of information, however, were farmers, friends and the church groups that seemed to emphasize more of the perceived risks rather than the benefits. Unless there is a radical change in the farmers' perception about Bt corn, greater adoption of the technology may not be expected in the future.

Substantial unit yield increases of as much as 37% were realized by the Bt corn farms. This translates to an additional profit of PhP10,132 per hectare with a reduction in insecticide expenditures of 60%. An incremental net income of PhP 1.34 per kilo was gained by Bt corn users, although seed cost was twice that of the ordinary hybrid. Many farmers complained about the exorbitant price of seed and expressed willingness to try the Bt corn if only the price of seed was lower. The adoption of Bt corn showed a significant impact on the farm financial performance as shown by the adoption elasticities that were even higher than those observed in the developed countries. Increasing the probability of adoption by 10% increased net farm income by 4.1%. These results clearly favor the current national policy agenda of increased productivity and income for small corn farmers but adoption levels need to be increased.

The Bt corn technology has also brought about significant welfare gains to corn producers and seed companies, albeit the adoption is still low. To further realize the benefits of Bt corn through higher adoption rates, public support is badly needed in the areas of information dissemination, development of the Bt corn seed market and, more importantly, the government incentives that facilitate farmers' access to the technology. At present, the availability of Bt corn seeds is still limited and domestic seed production capacity is still low. As the seed market is opened to other entrants, the adoption rate and welfare gains are expected to increase in the future.

The results presented in this paper should be interpreted carefully as they are based on just one year of cropping experience. Although tangible results have been presented, these may change over time as changes occur in technology, farmers' and consumers' perception, public support and seed stakeholders' participation.

Appendix Table 1. Means and definition of variables used in the financial impact model, 2004.

Variable	Definition	Means	Standard Dev.
Age	Age of farm operator (yr)	46.12	12.12
Area	Corn farm size (ha)	2.03	3.12
Hired Labor	in man-days	98.51	210.01
Season	First crop=1, 0 otherwise	0.29	0.45
Schooling	Years in formal schools	8.35	3.39
Insecticides	Expenditures on insecticides (PhP/ha)	135.43	245.03
Perceived Risk	1=no risk, 0 = risky	0.45	0.49
Tenure	1=owner operated, 0 otherwise	0.84	0.36
Bukidnon	Farm location (1=Bukidnon, 0 oth.)	0.29	0.45
Gensan	Farm location (1=Gensan, 0 oth.)	0.32	0.46
Isabela	Farm Location (1=Isabela, 0 oth.)	0.25	0.43
NFI	Net farm income, Total returns less total costs	15886.82	13014.49
MNFI	Modified net farm income = Total ret. less cost on seeds & insecticides	27415.5	14046.89
P	Probability of Bt corn adoption	0.25	0.29
Lambda	Inverse mills ratio	1.77	0.93

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