Honduras and *Bt*/HT maize – a small country model for GM crop adoption?

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To understand the role that genetically modified (GM) maize may offer in supporting increases in agricultural productivity and production in Honduras, the International Food Policy Research Institute (IFPRI), Zamorano University and University of California, Davis-PIPRA implemented a joint project examining the potential gains from adopting and using *Bt* (insect-resistant) and HT (herbicide-tolerant) maize in Honduras, and the institutional issues that help define impact. This chapter examines some key outcomes of the study.

Background to maize production in Honduras

Agriculture continues to be an important sector for the Honduras economy, with agriculture representing 13.4 per cent of total gross domestic product (GDP) in 2013.[1] Maize is the main staple crop and in 2012 generated 6 per cent of all gross crop production value.[2] With some fluctuation, maize production exhibited a steady increase during the 1960s–1990s, reaching a historic peak of 672,000 tonnes in 1995 (Figure 1). However, yields plummeted from 1.6 tonnes per hectare annually during

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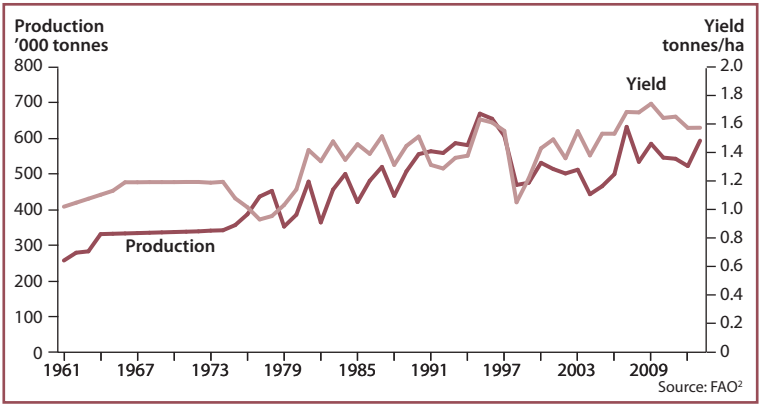
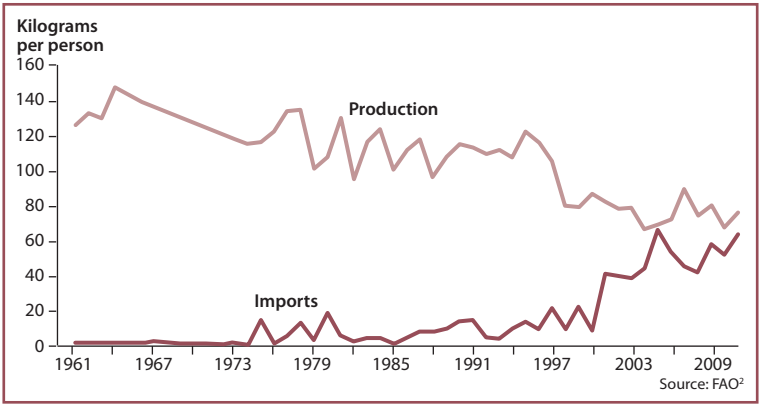
Figure 1. Maize production and yields, Honduras, 1961–2013



1995–1997 to little more than 1.0 tonne per hectare in 1998, a number that had not been seen since 1979. The sudden drop in both yield and overall production in 1998 reflected the devastating effects of hurricane Mitch, which negatively affected all sectors of the Honduras economy. It took several years to recover to pre-Mitch yield levels, and only in 2003 was the country able to reach yields similar to those registered in 1995. While yields have in fact recovered, production continues to be lower than in 1997.

Maize production is hampered by constraints including damage from pests and diseases, drought and climate change, and limited access to inputs as well as institutional and infrastructure issues.[3] Falling internal production has resulted in increasing dependence on maize imports to feed the growing population, for animal feed and industrial uses. While in 1961 Honduras imported less than 1 kilogram of maize per person, by 2011 this had grown to 62 kilograms, just below the amount it produced per person (Figure 2).

Figure 2. Maize production and imports, Honduras, 1961–2011



Given that maize is the main staple crop in the country, the increasing dependence on imports has created a food security concern for the government. For this reason Honduras has a strategic interest in aligning agricultural policies with major economic and trade partners but also needs to increase its own production and productivity.

A major constraint on increasing maize production in Honduras and Mesoamerica is the damage caused by lepidopteran insects, which is estimated to affect 40–70 per cent of total production.[4] Other relevant pests and diseases have increased as well, including fungal diseases along with the presence of mycotoxins.[5, 6, 7]

The Honduran government has expressed the need to significantly increase maize production by reducing pest and disease damage through a wider use of technology and by providing an enabling policy and regulatory

environment that will help address the institutional constraints that dampen the country's maize production and productivity. The government has therefore initiated the implementation of an enabling set of policies that help facilitate the adoption of new technologies for maize and for the agriculture sector in general.

A systematic assessment of descriptive statistics shows that maize producers in Honduras have benefited from GM maize adoption

Enabling policies to support the adoption of modern biotechnologies implemented by the Honduran government include the establishment of a functional Biosafety Framework and Regulations in 1998, the establishment of a National Biosafety Committee in 2000, the incorporation of biotechnology into its National Food Self Sufficiency Strategy in 2008, and ensuring coordination and convergence towards a joint agricultural and environmental political agenda.[8] The establishment of these policies, in addition to the signature of free trade agreements and other international protocols regulating technology, genetic resources and varietal use, contributes to the overall goal of increasing the use of modern technologies such as hybrid and GM seeds as part of the formal Public Agricultural and Food Sector Strategy, which was set by the Ministry of Agriculture in 2012. These policy developments contributed to a functional biosafety system that was established in 2003 with the first commercial approvals for GM maize.

Adoption of GM maize in Honduras

Honduras started cultivating GM maize in 2002. By 2013, of the country's 400,000 hectares of maize, 29,000 hectares were planted to GM varieties.[9] The National Institute of Statistics in Honduras has estimated that approximately

Table 1. Producers sampled in Honduras, 2012

Type of producer	Plot size				Total	
	Less than 7 ha		More than 7 ha			
	No.	%	No.	%	No.	%
Non-adopters of GM	58	54	25	25	83	40
Adopters of GM	39	36	57	56	96	46
Partial adopters	11	10	19	19	30	14
All	**108**	**100**	**101**	**100**	**209**	**100**

75,000 hectares are cultivated with improved varieties – both conventional and GM hybrids – representing some 15 per cent of the total area planted.[10]

The GM hybrids planted in Honduras have insect-resistance and/or herbicide-tolerance traits. Strains approved for commercialisation with either single or stacked traits include the *Bt* strains MON810, Herculex® (Cry35Ab1 DAS-59122-7) and YGVTPro® (MON89034), as well as one glyphosate-tolerant strain, NK603.

Results from the first round of the survey and field studies conducted in a project funded by Canada's International Development Research Centre, implemented jointly by Zamorano University and IFPRI in 2008, showed that GM maize provided excellent target pest control in Honduras.[11] The *Bt*/HT maize yield advantage was 856–1,781 kilograms per hectare. Based on risk-adjusted estimations, the use of GM maize was preferred even by risk-averse producers. There was no significant evidence supporting overall pesticide reduction due to GM maize adoption, although there was significant statistical evidence that adopters achieved a higher net income than non-adopters in spite of GM seed costs being twice those of the conventional hybrids available in the market.

GM maize in Honduras: a descriptive analysis

In the IFPRI 2012 case study, a systematic assessment of descriptive statistics shows that maize producers in Honduras have benefited from GM maize adoption, at least for the producers sampled for this study (Table 1). In our sample, which was drawn from farmers who already used improved varieties (conventional or GM hybrid), adoption of GM maize was far less common among those with less than 7 hectares than for those with larger plots.

In line with the study done in 2008, the 2012 study shows that GM-adopting farmers tend to be commercial, progressive, and have more income as well as access to both credit and other productive inputs. However, the data collected fail to show the exact reasons why adoption has been mainly limited to commercial farmers, so a comparison between adopters and non-adopters in this study should not be used to extrapolate to a comparison between commercial and smallholder or subsistence farmers. In fact, adopters and non-adopters of GM maize in Honduras may be two distinct groups with unique characteristics that may be explained by variables unobserved in this study. Thus making a robust comparison between these two groups in terms of yield, net income and other metrics continues to be a challenge.

Table 2. The benefits of GM adoption in Honduras, 2012

Item	Plot type	Average	
		Raw	Adjusted
Yield (tonnes/ha)	a. GM	5.3	4.78–5.02
	b. Conventional	3.7	3.7
	c. Difference (a-b)	*1.6*	*1.08–1.32*
Income (US$/ha)	a. GM	1,774	1,584–1,754
	b. Conventional	1,244	1,244
	c. Difference (a-b)	*530*	*340–510*

More study is required to further elucidate the unique and specific characteristics of adopters and non-adopters, and to understand why smallholder or subsistence farmers may not be adopting this technology.

An econometric analysis of GM maize use in Honduras

We performed advanced econometric procedure to deal with bias and outliers in order to adjust estimates of the explanatory variables on yield and net income. The adjusted results are more conservative than the averages estimated during the preparatory descriptive analysis. Results from the descriptive analysis (Table 2) of the 2012 survey data show GM maize plots had on average a yield advantage of 1.6 tonnes per hectare over conventional maize plots. In turn, our econometric results, adjusted for statistical bias or outliers, indicate a GM maize yield advantage of 1.08–1.32 tonnes per hectare. Statistical biases and outliers were relevant in our sample, as using (raw) averages would overestimate the impact of GM maize on yields by 17–32 per cent.

In turn, as presented in Table 2, the descriptive analysis of the 2012 data showed that there was a difference in income of US$ 530 per hectare between GM and non-GM plots. As in the case of yield, adjusting these averages for statistical bias or outliers results in a more conservative advantage of GM maize, ranging from US$ 340 to US$ 510 per hectare. These results are consistent with other assessments done with *Bt* and/or HT maize elsewhere.[12]

Farmers who participated in our study who had planted only conventional maize had little, if any, knowledge of GM maize

Small-scale farmers' perceptions and attitudes and the maize value chain

Results from qualitative assessments carried out during our study, using small group

discussions and other qualitative techniques, gave interesting preliminary results in explaining small-scale farmer behaviour towards GM technology in Honduras. Our first-step assessment indicated that farmers who participated in our study who had planted only conventional maize had little, if any, knowledge of GM maize.

Qualitative assessments of seed distributors seem to indicate that it is not economically viable to reach dispersed small-scale and resource-poor farmers

Qualitative assessments of seed distributors seem to indicate that it is not economically viable to reach dispersed small-scale and resource-poor farmers. An important remaining question for future research would be whether small-scale farmers with accessible information and access to GM seeds would adopt the technology. The small sample of farmers in the qualitative analysis seems to support a positive response to this question.

A clear conclusion among the participants in small group discussions includes the importance of taste in determining the direction that maize varietal technology should take. There appears to be a significant connection between taste perceptions and preferences for varieties deemed traditional. A proper and systematic comparison between traditional improved varieties, hybrids and GM hybrids would be appropriate to further elucidate this difference. The results of our study appear to imply that taste preferences favour traditional varieties, while economic and agronomic factors favour GM maize.

We also conducted farmer consultations using structured group work. Results from this exercise need to be taken with some caution, as it was only possible to consult with a limited range of growers. The exercise appears to show that

Institutional issues such as lack of information, finance, credit and seed availability appear to limit adoption

small-scale farmers in areas farther away from Olancho, the main commercial production area, seem to have weaker links with the rest of the actors in the value chain. There appears to be a set of institutional issues such as lack of information, finance, credit and seed availability that limit adoption.

Churches were identified in the structured group work as one key actor in disseminating information and shaping perceptions. Thus any policy designed to increase availability of the new technologies and disseminate relevant information would benefit by taking this fact into consideration. Further explorations that consider the influence of food-use maize processors, feed mills and other industrial processors as well as small-scale producer associations will be warranted. It will be prudent for future work to consider the actual and potential role played by current seed distribution and conditional cash programmes regarding small-scale producers.

Initial consultations with food and feed processors show that there are differentiated market value chains for white and yellow maize. The major use of white maize is for human consumption whereas yellow maize is also used for animal feed and industrial purposes. Negotiated price agreements between government, producers and processors exist for both white and yellow maize.

The Central American Free Trade Agreement (CAFTA) is expected to enable the free import of yellow maize by 2016. However, increasing price volatility and dependence on imports have motivated animal feed processors to

develop plans to increase local yellow maize production. This will help ensure less dependence on imports while opening up the potential for the expansion of domestic yellow maize production.

Summary and concluding reflections

The adoption and use of GM maize in Honduras has demonstrated positive economic benefits for adopters. The 2008 and 2012 studies show that GM maize reduces insect damage and in some cases increases yields by 29–35 per cent compared to the non-GM hybrid and conventional varieties. In both studies, production costs per hectare of GM maize were higher than for conventional hybrid and traditional varieties. However, with the reduction in damage and in some cases reduced pesticide application, the use of GM seed gives a positive net income for adopters. The higher cost of hybrid GM maize seed compared to conventional seed does not affect net income as seed costs represent a relatively small proportion of total production costs. This can nevertheless be a limiting factor for resource-poor farmers who have no access to credit or savings.

Multiple institutional and policy issues need to be addressed in order to answer a seemingly perplexing question, at least from a conventional economics point of view: why is the aggregate adoption rate in Honduras low and growing relatively slowly when the yield and financial return on the GM technology is so high? This discussion leads us quite prominently to constraints that are typical in the early

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Countries that want to promote GM and other biotechnologies need an enabling policy and regulatory environment

stages of the process, including a lack of adequate information and knowledge about modern maize varieties, which is a particularly important consideration for some farmers, farm size, liquidity or budget constraints and access to farm inputs.

We observed a growing issue of serious problems with pests and diseases beyond the target pest controlled by the GM maize. Black tar spot disease, caused by the pathogens *Phyllachora maydis* and *Monographella maydis* in association, affects conventional and GM maize alike. Farmers may be reticent to pay a premium for GM maize when they know that black tar spot disease is still likely to infect plants and damage production.

Seed companies may be constrained in their ability to deal with infrastructural and seed market issues given the geographical dispersion of small-scale producers. Indeed, Honduras is a small outlet for both GM and conventional hybrid maize, operating in a market where there are multiple maize processors linked to government programmes, with a differentiated (white and yellow) maize market and government/processor/producer pricing agreements tied to international prices. The latter opens the market to the potential impact of international price fluctuations and availability.

These studies have identified robust evidence that the adoption of GM and conventional new variety technology increases economic benefits. Understanding the limitations to further expansion is important to future research efforts to examine small-scale farmers' attitudes to GM technology adoption and potential impact.

Studying the adoption of GM maize in Honduras has provided robust but limited evidence of the benefits of expanding the technology to other segments of the agriculture sector. One clear lesson is that countries who want to promote the adoption and commercialisation of GM and other biotechnologies need to set in place an enabling policy and regulatory environment that supports technology research and development, transfer and adaptation to the specific country's needs. Honduras has a functional biosafety and regulatory system that may serve as a working example of an enabling environment that is eminently pragmatic in its implementation. We expect the lessons learned through this and previous studies to shed some light on the application of GM and other hybrid maize technologies, as well as other advanced innovations in other developing countries.

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