Genetically modified (GM) corn in the Philippines : Ecological impacts on agroecosystems, effects on the economic status and farmers' experiences

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Summary

Genetically Modified (GM) Corn in the Philippines: *Ecological impacts on agroecosystems, effects on the economic status and farmers' experiences*

Genetically modified corn has become the prototype crop to answer the increasing demand for food or feed production. The Asian corn borer (ACB), *Ostrinia furnacalis* (Guenée), has become the most damaging pest in corn in Southeast Asia. Corn farmers in the Philippines have incurred great yield losses in the past decades because of ACB infestation. *Bacillus thuringiensis* (*Bt*) and *Bt* Herbicide Tolerant (*Bt*HT) corn have been developed to reduce borer attacks worldwide. Introduction of other transgenic crops for increased food production are likewise being field tested but *Bt* corn field testing has generated the most controversy among the products of biotechnology because of fears with regards to its bio-pesticide content. Sorting out scientifically validated claims of both protagonists and antagonists proves difficult. Concerning biodiversity, few and unpublished studies have been conducted in a humid tropical environments like the Philippines. This is also true for the socioeconomic effects on farmers. With almost a decade of GM corn cultivation in the country, post technology adoption assessments becomes necessary to better understand if indeed the goals for which it was promoted and adopted were fully or nearly satisfied.

To seek answers to the issues surrounding the introduction and nationwide adoption of GM corns in the Philippines, the thesis focused to find answers on the general question: How can genetically modified corn and its attributed changes in agricultural practices affect the agro-ecosystem's biodiversity and the economic status and social life of the farmers?

Biodiversity

As indicators for biodiversity, both beneficial (i.e. non-pest) and non-beneficial (ACB and non-ACB pests) infield invertebrates were assessed. In particular, this study focused on the issue of how efficient is the continued adoption of GM corn technology to resolve the question on ACB infestation in the Philippines (Chapter 2). The study involved preparatory interviews with farmers, site selection, field scouting and visual inspection of 200 plants along 200 m transect lines through 198 cornfields. *Bt* corn can efficiently reduce the ACB pest problem and reduce borer damage to plants by 44%, to damage levels in *Bt* and *Bt*HT corn of 6.8% and 7% of the plants, respectively. No secondary pest outbreak was found in ACB-free *Bt* cornfields. Reduced cob damage by ACB on *Bt* fields could mean smaller economic losses even with ACB infestation. The occurrence of ACB in *Bt* and *Bt*HT cornfields, though at a moderate and insignificant level, could imply the potential development of resistance to *Bt* toxin.

Also, this study presents the field experimental results measuring the effects of GM corns and its associated changes of agricultural practices (pesticide and weeding managements) to the invertebrate community (Chapter 3). The GM effects on biodiversity were studied in a six-hectare field experiment in Cabagan, Isabela, during the 2009 dry and wet cropping seasons. Our findings showed that the total invertebrate abundance, surface dweller abundance and species richness of surface dwellers and soil dwellers were significantly higher in non-GM cornfields than in *Bt* and *Bt*HT cornfields. Insecticide-sprayed non-GM cornfields harbored more invertebrates than unsprayed *Bt* or *Bt*HT cornfields.

Finally, the study likewise focused on the longterm effects of GM corn on species richness and abundance of infield invertebrates (i.e. aerial, surface and below-ground dwellers) (Chapter 4). This chapter includes the survey of cornfields with a minimum of two years cultivation of GM corn. The field abiotic factors that served as confounding factors included soil pH, soil fertility and soil nutrient contents which were controlled as permissible or taken into account during data analysis. The study was conducted in 30 fields, including non-transgenic cornfields for comparison, and distributed over three lowland sites in 2008. The transgenic corn varieties *Bt* and *Bt*HT in this study were introduced to the area in 2002 and 2005. The non-*Bt* cornfields had significantly higher abundance and species richness of non-target invertebrates than the *Bt* and *Bt*HT fields. Likewise, the abundance and species richness of aerial and abundance of soil dwelling non-target invertebrates were notably higher in the non-*Bt* cornfields. The effects of confounding variables did not take away this effect of corn varieties.

Socio-Economics

Chapter 5 presented the economic domain of this study. This paper tried to provide some realistic answers to issues and concerns on whether GM corn is worth investing, especially for small scale farmers. The producers of GM corns' claim that GM corn could alleviate farmer's lives, encouraged critics from various groups to refute it in the media for they believe that it is an empty promise to the farmers. Hence, to help shed light to the issues, an updated economic evaluation of crop impacts and investment analysis of both GM and non-GM corn productions were dealt in this part of the thesis. Data were collected of 114 farmers in Isabela province including non-GM, *Bt*, *Bt*HT and HT corn farmers. We analyzed the effects of agriculture inputs (labor, seed, and fertilizer costs) on the difference between GM and non-GM corn in production output, net income, production-cost ratio and return on investments per ha. Results showed that non-GM corn was not statistically different from GM *Bt*, *Bt*HT and HT corn in terms of production output, net income, production-cost ratio and return on investments per ha. Also, a Blinder-Oaxaca analysis was used to decompose the mean gaps of return on investment and net income between GM and non-GM corn. Results using this analysis showed that among the independent variables tested, corn borer occurrence, labor cost, seed cost and fertilizer cost manifested the highly influential determinants for return on investment. For net income, corn borer occurrence, labor cost and corn borer severity count as the most influential determinants. In conclusion, our data demonstrates that at present GM corn hybrids do not explicitly manifest economic advantage compared to non-GM corn hybrids.

The social aspect presented in Chapter 6 focussed on the documentation of corn farmers' attitudes, standpoints and predicaments on the release and adoption of GM corn technologies. The hurdles faced by the farmers in adopting GM corn and why some farmers did not plant GM corn despite various massive advertisements made by seed producers gave particular outlook on farmer's willing/unwillingness to adopt GM corn technology. A total of 188 corn farmers (using *Bt* corn, HT corn, *Bt*HT corn, non-GM corn and mixed cultivation) from 15 municipalities in Isabela province were interviewed for this study. The level of GM corn adoption proved to be influenced by the perceived economic advantage, extent of knowledge, level of satisfaction and extent of first-hand experience. Respondents affirmed that corn borers and weeds are problematic pests, but levels of concern and standpoints of the severity of damage differed. The foremost reason for not adopting GM corn was the cost of seed. Although there was a negative shift in the attitudes of the farmers after GM corn adoption, they kept using it, for reasons that need to be explored.

Conclusions and recommendations

Overall, the following main conclusions and recommendations can be drawn from this thesis:

a. Conclusions:

1. *Bt* and *Bt*HT corn hybrids containing the Cry1Ab protein performed well in Isabela province. This was manifested by the significant reduction (by 44%) of ACB damage in inspected *Bt* cornfields.
2. No secondary pest outbreak was found in ACB-free *Bt* cornfields.
3. The current study clearly highlights the advantage of non-GM cornfields in terms of the abundance and species richness of invertebrates. Between the two GM corn varieties, GM *Bt* corn poses less of an environmental risk to invertebrate ecosystem populations than *Bt*HT corn.
4. Long-term and continuous cultivation of transgenic corn has an impact on humid tropical corn-based agro-ecosystems, in terms of reducing the abundance and species richness of non-target invertebrates.
5. Production output did not statistically differ between GM and iso-hybrid non-GM corn.
6. GM corn adoption does no longer directly give economic advantage against non-GM corn considering all the variables studied.
7. Farmers switched to GM corn due to their perceived yield increases, better insect control, reduced costs of inputs. Knowledge about GM corn and accessibility of GM corn seeds influenced the adoption of GM corn.
8. High price of GM seeds formed a barrier for non-GM farmers to switch to GM corn.
9. After *Bt* corn adoption, respondents perceived reduction in pesticide inputs, but not on labor/time. Also, they viewed *Bt*HT to be comparable to non-GM in terms of fewer agricultural interventions and market prices of the produce, and that its toxin content may affect non-target organisms. After HT adoption, respondents have negative standpoints on the emergence of other pests and on the storage life of the corn produce. A negative shift in the standpoints after adopting GM corn cultivation occurred, but the farmers tended to go on using it.

b. Recommendations:

1. *Bt* and *Bt*HT corn are recommended for planting in the areas where there is high infestation of ACB.
2. Presence of non-ACB pests in surveyed *Bt* cornfields may indicate potential development of secondary pest. Hence it is highly recommended that close monitoring be done not only on ACB pests but as well on non-ACB pests to ensure no secondary pest outbreaks in the future.
3. Similar study must be conducted on new developed and commercialized corn lines of *Bt* and *Bt*HT. The use of herbicides in a HT corn must be minimized to maintain at least 30-50% weed cover needed to support the survival of weed dependent invertebrates.
4. As large-scale monocropping of transgenic corn is currently highly prevalent in the Philippines, precautionary measures or effective refuge areas should be considered to abate serious implications for the biodiversity and sustainability of corn agro-ecosystems.
5. More research is needed to enable continuous monitoring and to address some emanating ecological issues about recently released *Bt*, HT and *Bt*HT corn lines.
6. Farmers need to consider all economic variables in their decisions to adopt GM corn
7. The Philippine government should look into possibilities to lower high cost of GM corn seeds.