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

Mabutol-Afidchao, M.B.

Author: Mabutol-Afidchao, Miladis B.
Title: Genetically modified (GM) corn in the Philippines : ecological impacts on agroecosystems, effects on the economic status and farmers' experiences
Issue Date: 2013-11-20

7

Conclusions, Recommendations and Future Research

Conclusions

In the context of an earth ecosystem under continuous threat with the attendant rapid loss of biodiversity at all levels, the need for continuous assessment of the potential repercussions of new innovations to our ecosystem becomes necessary. This must be done, not to prevent or hamper the advancement of innovations, but to improve them.

In particular, the claimed pecuniary benefits of GM corn (Chapter 1) reflect its fast adoption worldwide. GM corn technology was shown to have low risk for biodiversity in temperate regions. But, scientifically based evidence in a humid tropical country such as the Philippines is very meager. The country is one of the few identified biodiversity hotspots in the world with a huge segment of its agricultural areas now dominated by GM crops.

The known efficacies of *Bt* and *Bt*HT corn to eradicate corn borers have been supported by numerous field trials and large-scale cultivations worldwide. Nevertheless there are emerging issues relative to the introduction and cultivation of *Bt* corn. One is the development of corn borer resistance to *Bt* toxin. Secondly, the potential emergences of secondary pests (non-ACB) in fields where the primary pest (ACB) is eradicated. With a decade of *Bt* corn cultivation in the country, a reinvestigation of the efficacy of *Bt* corn against ACB is timely and necessary. The study presented in Chapter 2 once again has shown that *Bt* corn is a variety that can help farmers to reduce ACB pest problem. Nevertheless, the noted incidence of ACB at 7% both for *Bt* and *Bt*HT cornfields is remarkable. The observed ACB damage of the 4th to 5th instar larvae leads us to the premise that ACB survived and spent a large portion of their lifetime in a *Bt* corn plant. Hence, development of *Bt* toxin resistance by ACB may soon be occurring in Isabela province of the Philippines.

Furthermore, in GM cornfields, ACB damage was low whilst non-ACB damage was high. In non-GM cornfields the ACB damage was high and the non-ACB damage low. Yet, regression analyses showed no interaction between corn type and ACB or non-ACB damage, which means that no development of secondary pest can be assessed yet.

To assess if the findings of Marvier *et al*. (2007) also holds true in a tropical humid environment, an experimental study was done on the corn agriecosystem under GM corn cultivation and its associated agricultural managements (Chapter 3). The study directly follows the assumptions that when using corn containing *Bt* toxin, no insecticides must be applied because the plants are protected against ACB pest. In the case of herbicide tolerant crops, herbicides sprayings were done following the recommendations of the manufacturers and practices of the farmers. This means that when using HT corn, weed cover is drastically reduced or eradicated hence, freeing the farmers from the weed pest problem.

Our results did not conform to the findings of Marvier *et al*. (2007) and the comparison of insecticide-free *Bt* corn and non-GM corn treated with insecticides in Chapter 3 clarifies that in tropical environments such as in our study, insecticide-free GM corn can elicit more risks to invertebrate communities than non-GM corn treated with insecticides. The modification of agricultural practices associated with GM corn cultivations does not warrant the safety of the environment as claimed or ensure a more biodiverse field ecosystem.

In Chapter 4 the results obtained indicated that in a tropical environment, GM corn containing *Bt* toxin does in the long term affect other non-target organisms in the actual field setting. Although, soil chemical characteristics seem to have an effect, these effects did not take away or dampen the influence of corn variety which among the tested variables manifested the strongest negative effect on the abundance and species richness of invertebrates. Furthermore, the aerial and soil-dwelling invertebrates that are likely to play key ecological roles in the field agro-ecosystems seem to be the most affected. The findings of this study did not directly contradict local researches done by Javier *et al* (2004) and Alcantara *et al*. (2008) that showed *Bt* corn is environment friendly as claimed. This study was conducted after over five years of *Bt* corn cultivation in the Philippines whilst their studies were experimental field evaluations when a *Bt* toxin effect was still premature to investigate. The meta-analysis of Marvier *et al* (2007) showed that *Bt* corn is more beneficial compared to non-GM corn treated with insecticides. This applies under the assumption that with *Bt* corn use, the plants are protected from damage brought about by pests and hence does not require insecticide inputs. In real field situations, however, there are other pests that could also cause great damage to corn plants and this justifies farmers' use of insecticides even with *Bt* corn adoption.

The cornfields inspected in Chapter 4 showed no variation in terms of pesticides used. This is because some GM corn farmers claimed that they sprayed pesticides when they observe pests other than ACB. Finally, the conclusion in Chapter 3 was reinforced by the study presented in Chapter 4 wherein non-target organisms are affected. Short-term cultivations of GM corn affected surface dwellers (Chapter 3) whilst its long-term effect was manifested in aerial and soil dwellers (Chapter 4). This does not contradicts Javier *et al*. (2004) who found that beneficial insects mostly foliage or aerial dwellers were not affected in a GM cornfield but it enhanced previous findings that other groups of invertebrates not covered by their study were found to be affected. Finally, these studies illustrate that other groups of invertebrates usually neglected must be given attention and considered to be as important as aerial invertebrates as they may play key functions in the agroecosystem's stability or sustainability. The ending message of Chapter 3 and 4 is that GM corn widely cultivated in the Philippines could reduce the infield biodiversity of invertebrates and hence the necessity of other controls measures or alternative strategies that can mitigate or prevent the impact of GM corn to the agro-ecosystem.

Chapter 5 focused on answering the question whether GM corn is worth investing by the farmers. Among the important considerations of farmers to adopt a technology is the assurance that they can obtain a higher crop yield. Past studies have shown that adoption of GM corn increases yield and provide more profits to farmers. Nonetheless, the results of interviews of the farmers showed no difference in production output between corn varieties. This study has shown that among the independent variables tested, corn borer occurrence, labor cost, seed cost and fertilizer cost manifested the highly influential determinants for production output. 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 the moment, GM corn hybrids do not explicitly have an economic advantage to farmers compared to conventional non-GM corn hybrids and that GM corn adoption does no longer directly give economic advantage against non-GM corn in the Philippines.

On the issue raised by opponents of GM technology that GM corn manufacturers extract all monetary gains from the farmers (Greenpeace 2000). This is unreasonable because farmers have to make their own decisions or choice on what corn variety they would like to purchase. Farmers are not obliged to buy any variety of GM corn and could stick to their traditional variety if they opted to. However, there are strong driving forces that influence them to decide whether to adopt GM corn or not (Chapter 6). Like any technology introduced to the farmers, the claimed pecuniary and non-pecuniary benefits convinced the farmers to try GM corn. If farmers are satisfied with their first-hand experience with the new technology they will continue to use the same corn variety. Finally, in Chapter 6, the study demonstrated that the level of GM corn adoption by farmers was shown to be influenced by the perceived economic advantage, extent of knowledge, level of satisfaction and extent of first-hand experience. Respondent farmers surveyed and interviewed affirmed that corn borers and weeds are problematic pests, but levels of concern and perceptions of the severity of damage differed. The foremost reason for not adopting GM corn was the cost of seed. Lastly, there was a perceived negative shift in the standpoints of the farmers after GM corn adoption, yet they kept using it, for reasons that need to be explored.

Final Conclusion

Based on actual field evidences gathered for this thesis, it can be stated that GM corn may not be the innovation that can solve problem on yield losses attributed to ACB and weed pests without any negative environmental effects. This statement may appear simplistic but the data gathered and analyzed are consistent and significant enough to be ignored.

Based on the ecological studies:

1. *Bt* and *Bt*HT corn hybrids containing the Cry1Ab protein performed well in Isabela province Philippines.
2. *Bt* leaves are more susceptible to ACB attack.
3. The occurrence of ACB in *Bt* and *Bt*HT cornfields, though at a moderate and insignificant level, could however indicate the gradual potential development of resistance to *Bt* toxin.
4. No secondary pest outbreak was found in ACB-free *Bt* cornfields.
5. Non-GM cornfields harbor more invertebrates.
6. Between the two GM corn varieties, GM *Bt* corn poses less of an environmental risk to invertebrate ecosystem populations than *Bt*HT corn.
7. Insecticide-sprayed non-GM fields were more favorable for invertebrates than unsprayed GM fields.
8. Regimes with no herbicide application generally favor invertebrates, whereas chemical weeding greatly reduces their populations.
9. Long-term and continuous cultivation of transgenic corn has an impact on humid tropical corn-based agroecosystems, in terms of reducing the abundance and species richness of non-target invertebrates.
10. Our results seem to contradict earlier studies in temperate regions, where endotoxin from *Bt* and *Bt*HT corn affected only the targeted pest species (ACB).

Based on the economic study:

1. Production output did not statistically differ between GM and iso-hybrid non-GM corn.
2. GM corn adoption does no longer directly give economic advantage against non-GM corn considering all the economic variables studied.
3. The influential independent variables (i.e. labor cost, seed cost, fertilizer cost and farm size) that are noted using the Blinder-Oaxaca decomposition technique confirmed the results of our econometric analysis.

Based on the social study:

1. Farmers switched to GM corn due to their perceived yield increases, better insect control, reduced costs of inputs and curiosity.
2. Knowledge about GM corn and accessibility of GM corn seeds influenced the adoption of GM corn.
3. High price of GM seeds formed a barrier for non-GM farmers to switch to GM corn.
4. After *Bt* corn adoption, respondents perceived reduction in pesticide inputs, but not on labor/time, and indicated concerns about potential repercussions for human health and the environment.
5. After *Bt*HT adoption, respondents 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.
6. After HT adoption, respondents have negative perceptions on the emergence of other pests and on the storage life of the corn produce.
7. A negative shift in the standpoints after adopting GM corn cultivation was perceived by the farmers but they tended to go on using it.

Recommendations

1. *Bt* and *Bt*HT corn are recommended for planting in the area where there is high infestation of ACB.
2. Since the most susceptible plant part to ACB attacks is the corn leaves then it is recommended that new *Bt* seed technology must develop in which the *Bt* toxin is mostly concentrated on leaves to narrow the target pest.
3. Refuge strategies must be fully and strictly implemented by the farmers especially to areas with monocropping and large-scale plantation of GM corn as vital mitigating measure for ACB resistance development to *Bt* toxin.
4. Presence of non-ACB pests in surveyed *Bt* cornfields may indicate potential development of secondary pest hence, it is highly recommended that close monitoring not only on ACB pest but as well on non-ACB pests to ensure no secondary pest outbreak in the future.
5. 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.
6. Development of GM corn hybrid that is selectively efficient to compete with weeds for soil mineral, water and nutrients so that spraying of herbicide becomes unnecessary.
7. 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 agroecosystems.
8. More research is needed to enable continuous monitoring and to address some emanating ecological issues about recently released *Bt*, *Bt*HT and HT corn lines.
9. This study can be undertaken on a larger scale to obtain more information that are not otherwise inconformity with our present findings that may show changes in the economic benefits from GM corn technology overtime viz a viz its wide scale adoption in different economic settings and locations.
10. Farmers need to consider all economic variables in their decisions to adopt GM corn.
11. Assessment of *Bt* and *Bt*HT corn specifically on the aspect of perceived risk on human health and environmental health.
12. The Philippine government should look into possibilities to lower high cost of GM corn seeds.

Future Research

1. Since the study presented in Chapters 3 and 4 found varying groups of invertebrate fauna that were affected at different periods of GM corn cultivation i.e. surface dwellers were found affected at short-term cultivation and aerial and soil-dwelling found affected by long-term cultivation of GM corn, a longer duration of time is necessary to document the changes to allow for a better understanding of the dynamics of corn plant and invertebrate interactions and come up with bioindicators for environmental changes in corn agroecosystems.
2. Many GM crops are on the verge of introduction in the Philippines. There are many crucial issues emanating especially the commercial release of *Bt* rice and *Bt* eggplant which are both on the green house evaluations. Experiences from the case of GM corn where there is almost a decade of experience of crop production should serve well to provide a post technology assessment of the impact of GM crops on the lives of people and the environment.
3. Introduction, implementation and proper monitoring of insect refuges as a mitigating management scheme to prevent the development of ACB resistance to *Bt* toxin and still allow for invertebrate biodiversity flourishing is needed.
4. Prior to renewal of any GM seed permit there must be a nationwide post evaluation that ensures GM crop does not pose a graver threat to biodiversity and that baseline information from the initial risk assessment process conducted prior to the commercial approval shall serve as basis for comparison. This also includes a proper accounting of all invertebrate species and populations present prior to new GM crops introduction.
5. An independent body of the government, and not one funded by the GM seed company, should be tasked with primary responsibilities for the post risk assessment of GM corn so that credibility of the findings would not be questioned by opposing bodies. This is because the issues are public interests issues with implications for environmental safety, human health and biodiversity. As it stands now almost all post risk assessments for GM crops are fully funded by GM companies in partnerships with local governments, government agencies or local academia.
6. Techniques developed for risk assessments applicable to the humid tropical country should be standardized and shall serve as a uniform tool or techniques for pre- and post-evaluation processes.

References

Alcantara, E.P., Mostoles, M.D.J., Caoili, B.L. and Javier, P.J., 2008. Arthropod abundance and diversity in commercial *Bt* corn farms and adjacent riparian areas in the Philippines. Poster for XXIII International Congress of Entomology, Durban, South Arica. July 6-12.

Alcantara, E., 2004. Monitoring insect abundance and diversity in *Bt* corn. *In:* Impact assessment of *Bt* corn in the Philippines. Terminal Report. International Service for the Acquisition of Agribiotech Applications (ISAAA), UPLB, Philippines.

Greenpeace magazine, 2000. Food fight: The truth about genetically modified organisms. Cited in: http://www.thirdworldtraveler.com/Health/Food_Fight_GP.html. Accessed on December 7, 2011.

Javier, P.A., 2004. *Bt* corn is safe to beneficial arthropods. *AgriNotes* College of Agriculture, UPLB, Philippines.

Marvier, M., McCreedy, C., Regetz, J. and Kareiva, P., 2007. A meta-analysis of effects of *Bt* cotton and maize on nontarget invertebrates. Science 316(5830): 1475-1477.

Chapter 7