Agham Mindanaw, 2003, Volume 1, pp. 3-13. Ateneo de Davao University

THE USE OF GENETICALLY MODIFIED ORGANISMS IN AGRICULTURE: BLESSING OR CURSE?

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One of the most important issues that confront us today is the use of genetically modified organisms (GMO) in agriculture. It has become a strategic issue for many because the outcome of this debate has many implications beyond agriculture. The GMO debate inevitably brings up questions about the environment, food safety, sustainability, and ultimately, our relationship to nature.

But while many arguments have been raised both for and against GMO, these debates do not always illuminate the issue because they do not always address the same questions, and often, they do not adequately present the facts.

This feature article is an attempt to provide the venue for a clearer discussion of the issues. We prepared four statements that touch on the most important concerns about GMO. Then we invited one expert from either side to present their positions on these statements and to support their position with appropriate evidence. The statements that we posed were:

- Will the use of genetically modified (GM) crops improve yields sustainably?
- Are GM crops environment friendly?
- Are GM crops safe for human consumption?
- Is the use of GM crops beneficial to the farmer?

We are very fortunate to have been able to enlist Dr. Saturnina Halos and Engr. Roberto Verzola to write the position papers for us. Dr. Halos' experience in biotechnology spans 25 years of research. She started the work on the tissue culture work of forest species in the country and is co-inventor of a microbial preparation that improves nutrient uptake by plants. She is former professor and Coordinator of the Molecular Biology and Biotechnology Program, University of the Philippines. She initiated the establishment of and presently heads the DNA Analysis Laboratory, UP Diliman, the first fully functional forensic DNA laboratory in the country. As Senior Project Development Adviser of the Bureau of Agricultural Research, she currently provides the Department of Agriculture advice on biotechnology policies and programs.

Engr. Verzola served as community representative and member of the National Committee on Biosafety of the Philippines (NCBP), the government body that oversees local GMO experiments, for nearly two years (1998-2000). He has done policy studies for NGOs on such topics as nuclear power, renewable energy, intellectual property rights, transportation issues, genetic engineering, and organic farming. He is a member of the Philippine Greens and is an electrical engineer by training.

We are very grateful to Dr. Halos and Engr. Verzola for taking the time and effort to share their expertise with us. We hope that this provides some constructive input to this very important debate.

1. Will the use of GM crops improve yields sustainably?

The GMO debate: the pro-position

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The ability to improve crop yields at sustained levels depends upon the design of the GM crop and its management. Not all currently planted or future GM-crops are designed to improve yield. Some may have lower yields than their conventional parents like the herbicide tolerant soybean bred for simpler cultural management. Laurate canola, prolonged shelf life tomato, high oleic acid soya and the tomato vaccine are bred for quality products, not quantity.

There are two general classes of GM crops bred to increase yields: those resistant to biotic and/or abiotic stresses, and those that have specific genes that increase yields. GM crops showing yield improvements are pest (biotic stress) resistant GM crops such as virus-resistant and Bt crops. Yield increases are due to savings from yield losses caused by the pests. If the pest is absent, the expected yields from GM and non-GM varieties are the same. The 40% reported average yield advantage of Bt corn (Monsanto Philippines) approximates the savings from the expected yield loss of 5-95% due to corn borer. Several surveys found US growers achieving higher yields with Bt crops (Carpenter & Gianessi 2001).

The ability of pest resistant GM crop to sustain its yield advantage depends upon the interaction of the crop and the evolution of the pest. Based on experience with conventionally bred pest resistant crops, in time the pest gains back its ability to infest the crop. Thus, breeding for pest resistance by conventional means or by genetic engineering is always a race between the breeder and the pest. To avoid this problem, new Bt crops are being developed to reduce the capability of the pest to evolve into a Bt resistant strain.

To abate the evolution of a Bt corn resistant corn borer, planting a refuge is mandatory. A refuge is a stand of plants near the Bt corn crop that allows the pest to multiply without being exposed to the Bt toxin. The insect is not forced to evolve into a Bt-corn resistant strain, remains susceptible to the Bt toxin, mates with those exposed to the Bt corn and produces Bt susceptible progenies. In the Philippines where corn fields are very small, alternate host plants surrounding corn fields or non-transgenic varieties protected with biocontrol agents might serve as refuges.

Conversely, GM plants resistant to abiotic stresses such as drought, poor soil or water logging are expected to give sustainable and improved yields. Owing to the more efficient C_4 over the C_3 photosynthetic machinery, the transfer of crucial photosynthetic genes from C_4 plants like corn to C_3 plants like rice or potato (Tobias et al. 1999) is expected to increase yields at a more sustained level.

The GMO debate: the anti-position

Engr. Roberto Verzola
Secretary General (1996-present), Philippine Greens

Rice: IRRI is doing GM experiments on Vitamin A rice, bacterial blight-resistant rice, Bt rice. Vit. A rice makes no yield ceilings improvement claim. Bt and BB rice will not extend yield ceilings either; only control a rice disease or pest. But simpler and more sustainable non-GM alternatives exist: eating the right vegetables and fruits for Vit. A; timing the planting properly, planting multiple varieties side-by-side, and other cultural or organic practices to control diseases and pests.

For true sustainable yield ceiling improvement, an organic approach called system of rice intensification (SRI) exists that can increase rice yields to 8-10 tons/hectare. First tried in the 1980s by Jesuit agriculturist Fr. Henri de Laulanie in Madagascar and popularized in the 1990s by Prof. Norman Uphoff of Cornell University, SRI involves seven practices which are synergistic: (Uphoff 1999) transplant early (8-10 days, before third leaf appears); transplant single plants, not clumps; transplant carefully with a semi-horizontal pull, not vertical push, to avoid J-shaped or damaged roots; plant with wider distances (25-40 cm or more); do frequent mechanical weeding; keep the soil alternately moist and dry; not flooded, during vegetative growth; and use compost, not chemical fertilizers.

Using SRI, farmers in Madagascar, Philippines, Cambodia, China, Indonesia, Sri Lanka, and Bangladesh have managed to improve yields dramatically, with more room for improvement. Uphoff says in a personal communication that IRRI has known about SRI as early as 1993. Yet, neither IRRI, Philrice nor the DA have popularized it.

Soya: In more than 8,200 university-based U.S. studies in 1998, GM soya yielded on the average nearly 7% lower than conventional soya (USDA 1999).

Corn: Monsanto's claim of a 30-70% yield improvement with Bt corn, based on the first field-test in General Santos City in 1999, is questionable because:

- Bt corn doesn't raise yield ceilings; it only reduces yield damage from pests. Without pest infestation, natural and Bt corn yields are comparable. Farmers can control pest infestation with cultural practices and pest-resistant varieties.
- Pests can also develop resistance to the Bt corn's built-in poison, just as they did with sprayed pesticides. In fact, the Bt corn strategy of releasing a high-dose toxin in every cell of the plant, in every Bt corn plant in the field, 24 hours a day throughout the growing season is like spraying a pesticide throughout the field throughout the season, whether infestation occurs or not. It is the best way to select for resistant pests, and is as unsustainable as chemical spraying.
- Monsanto did not simulate true field conditions, the purpose of the field test. Non-Bt yields were lower because trial plants were *artificially infested three times* with corn borer larvae, biasing the experiment in favor of Bt corn. To claim 30-70% yield improvement based on this experiment alone is dishonest. Not even U.S. Bt corn researchers have made this fantastic claim (LCSA 1998).
- Theoretically, GM crops would be expected to show a yield drag, because instead of maximizing use of all matter and energy available in the plant to increase yield, some are diverted to produce a toxin or to breakdown a herbicide (Benbrook 1999).

2. Are GM crops environment friendly?

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By its very nature, agriculture is environmentally damaging. Some, but not all, GM crops are bred to address environmental concerns. Bt crops are bred to avoid or reduce insecticide use. Decreases in insecticide use by as much as 80% with Bt crops have been reported in North America and China (Carpenter & Gianessi 2001; Teng 2000). No insecticide was used and many beneficial insects thrived in the Bt corn planted in all field trials in the Philippines. The herbicide tolerant Round-up Ready™ soybean protects the topsoil by allowing for zero tillage and uses less of the faster degrading glyphosate in place of three or more persistent herbicides (Carpenter 2001).

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HT crops (soya, corn, cotton, canola): These alone comprised nearly 80% of all commercial GM crops in 2000 (CMOMP 2001). Because HT crops tolerate herbicides that damage conventional crops, farmers can now spray against weeds not only before planting their crop but anytime throughout the growing season, enabling farmers to spray more and chemical companies to sell more herbicides. In fact, Monsanto's HT soya (Roundup Ready™) is tolerant *only* to Monsanto's Roundup™ herbicide.

Is herbicide spraying environmentally friendly? Caroline Cox, editor of the *Journal of Pesticide Reform*, describes Monsanto's Roundup (glyphosate) herbicide (Cox 1998):

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To ensure that GM crops remain environment friendly, a regulatory system has been put in place to identify the risk associated with each type of GMO. The regulatory system should compare the risk from GM crops with the risk from alternative practices, require mitigating measures, and monitor the compliance and effect of the mitigating measures. Further, the regulatory system should explain the risks and mitigating measures to affected parties. Halos (Halos 2001) reviewed the unintended environmental risks posed by GM crops that regulation and research mitigate:

1. *Gene flow* - The natural transfer of genes among varieties and related species can also transfer genes from the GM crop to a weedy relative, making the latter more difficult to control. To avoid this risk, GM-crops are not planted in fields where the wild relative grows. Fortunately in the Philippines, hybridizing wild relatives do not grow in rice or corn fields. One problem that arises is the position of organic farmers against GM crops. For cross-pollinated crops like corn, varieties growing near each other easily exchange genes. To avoid this risk, the organic crop needs to be temporally or spatially isolated, a practice similarly used in certified seed production.

2. *Risks associated with antibiotic resistance genes in transgenic crops* - Early GM crops contained antibiotic resistance genes which were used as indicators of successful gene transfer. These genes could be transferred to the gut or soil bacteria and eventually into pathogenic microbes. This risk is avoided by not using antibiotic resistance genes.

3. *Possible cascading adverse effect on the ecosystem triggered by the introduction of transgenics* such as adverse effects on non-target organisms, rapid development of resistance in target insects (such as Bt resistance) and the possible accumulation of toxic products of the transgene and its adverse effect on other organisms. No other GM crop has received as much research and public attention as Bt corn in this regard. Reports of adverse effects of Bt corn pollen on monarch and swallowtail butterflies carried out under laboratory conditions have been recently negated by field studies for all Bt corn varieties except those containing Bt176 (Losey et al. 1999; Sears et al. 2001; Hellmich et al. 2001; Stanley-Horn et al. 2001; Oberhauser et al. 2001; Pleasants

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- Extremely persistent; half lives of over 100 days have been measured; has been found in streams following agricultural, urban, and forestry applications;
- Acutely toxic to fish; reduces populations of beneficial insects, birds, and small mammals by destroying vegetation on which they depend for food and shelter;
- Increases plants' susceptibility to disease and reduces the growth of nitrogen-fixing bacteria
- Toxic to earthworms, rhizomatic fungus and bacteria (all essential to long-term soil health)

The claim that HT crops have reduced herbicide use does not make any sense. When farmers buy Roundup Ready™ seeds, they also sign an agreement that they will use the Roundup herbicide (and only Roundup™) to control weeds. How can binding farmers to use a herbicide reduce herbicide use? This claim is further belied by corporate reports, which show up to 20% annual growth in Roundup sales from 1996 when HT crops were introduced to 2000 (Bailey 2001). From 1995 to 1998, glyphosate use (in pounds per acre) went up 7.3 times (Wolfenbarger & Phifer 2000). In short, GMOs have helped Monsanto sell more herbicides.

Bt crops (corn, cotton): In 2000, Bt and HT crops together comprised 99% of all commercial GM crops. Monsanto claims that pest control with GMOs is environmentally friendlier than chemical pest control. The GMO vs. chemical comparison is a false choice between two products sold by the same chemical companies. The third choice is best — the organic approach, which uses neither GMOs nor chemicals.

GMO pest control involves the same paradigm of poisoning the pest. Bt crops do not reduce pesticide use; they simply replace sprayed pesticides with GM pesticides produced within the plant itself. Bt corn is actually registered at the US EPA as a pesticide. It is as environmentally questionable as chemical spraying because:

- The steady presence of a high-dose toxin in the field encourages the development of pest resistance (Tabashnik 1997).

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et al. 2001; Wraight et al. 2000). The recommended mitigating measure is to stop planting Bt176 corn. The rapid development of Bt-resistant insects is mitigated by maintaining refuges. Another risk posed by Bt corn but negated by field research is the accumulation of the Bt gene product in the soil (Tapp & Stotsky 1997).

4. *Loss of biodiversity* - Previous experience with improved varieties resulted in the reduction of varieties being widely planted. To mitigate this biodiversity loss, collection and seed banking of varieties must continue.

Comparison of risks

Different GM-crops may or may not pose any of the above risks. When the risk is real, the risk is compared with risks from alternative practices. For example, in evaluating the use of Bt corn and its possible environmental damage, the public health and environmental damage caused by pesticide use must be considered. Human pesticide poisoning is a major public health concern as this may cause death, loss of work hours, cancer and other diseases. Bt crops not only reduce insecticide use but they also reduce the incidence of human poisoning (See table below).

Table 1. Reduction in herbicide use (Palm et al. 1993, 1994, 1996).

Variety	Insecticide load (kg/ha)	Insecticide poisoning reported (% of farmers)
Only Bt	10.3	4.0
Bt + non-Bt	29.4	10.0
Only non-Bt	57.8	22.0

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- The Bt corn toxin can harm non-target species such as butterflies and lacewings (Losey et al. 1999; Hilbeck et al. 1998).
- Corn roots exude the Bt toxin into the soil, where the toxin stays active for more than eight months (Tapp & Stotzky 1998).

Genetic contamination is a serious environmental threat. Contamination can occur in many ways: 1) GM ingredients used in food processing; 2) GM crops mixed with non-GM crops; 3) GM seeds mixed with non-GM seeds; 4) GM plants cross-pollinating non-GM plants; 5) transgenic genes transferring to bacteria and then to other microorganisms (horizontal gene transfer) (Greenpeace Germany n.d.).

Living organisms reproduce, multiply, mutate and evolve. Under the right conditions, GMO populations can persist and even increase. Genetic contamination, because it can be irreversible, can therefore be more serious than nuclear or chemical contamination. Even field-tests can result in contamination. For instance, although Mexico has allowed only field-tests and no commercialization, its remote areas have tested positive for Bt corn contamination (Global Exchange 2002).

While the environmental safety debate is unresolved, GMO contamination has become a near certainty where GMOs are field-tested or commercialized. To avoid the risk of irreversible contamination, live GMO experiments should in the meantime be done only in contained laboratories.

3. Are GM-crops safe for human consumption?

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A regulatory framework is necessary to ensure that all foods whether GM or not are safe for human consumption.

In the US, the FDA works closely with any company intending to develop GM food so that when such food eventually reaches the market, it is safe for human consumption.

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The food safety debate also remains unresolved. No feeding tests on human volunteers had been done at all. Yet, many grounds for concern exist.

Most commercial GM crops contain either the Bt poison in every cell or residues left by herbicide spraying. Are these poisons safe?

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The WHO/FAO expert panel recommended measures on how to assess the safety of GM foods. The panel recommended the use of the concept of substantial equivalence to assess the safety of these foods.

Substantial equivalence is a concept used to identify similarities and differences between the genetically modified food and a comparator with a history of safe food use which subsequently guides the safety assessment process.

Very few foods consumed today have been subject to any toxicological study, and yet are generally accepted as being safe to eat. Food is considered safe if there is reasonable certainty that no harm will result from its consumption under anticipated conditions of use (OECD).

In practice, the GM food crop is compared with its isogenic parental line in terms of its identity, source, composition, effects of processing/cooking, and transformation process. The GM food crop's recombinant DNA is studied in terms of the stability of insertion, and potential for gene transfer.

Protein expression products of the inserted DNA are analyzed in terms of effects on function, potential toxicity, potential allergenicity, possible secondary effects from the gene expression or disruption of the host DNA or metabolic pathways. This includes composition of critical macro-, micro-nutrients, anti-nutrients, endogenous toxicants, allergens, and physiologically active substances, and potential impact and dietary impact of the introduction of the genetically modified food.

If available data are deemed insufficient, animal feeding studies are undertaken. The data on these parameters are then assessed by the regulatory agency and approval is based on the similarity of the GM food with its conventionally bred counterpart.

Hence, commercially produced GM food crops having undergone such regulation are described as "as safe as their conventionally bred counterparts" (WHO/FAO, USNAS, OECD) - that is, commercially grown GM food crops are as safe as the food crops we have been eating all along.

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Consider the following data on Monsanto's Roundup herbicide (Cox 1998).

- Acutely toxic to animals, including humans. Symptoms include eye and skin irritation, headache, nausea, numbness, elevated blood pressure, and heart palpitations. The surfactant used in Roundup is more toxic than glyphosate itself; the combination of the two is yet more toxic.
- Adverse effects in all standard categories of laboratory toxicology testing, including medium-term toxicity (salivary gland lesions), long-term toxicity (inflamed stomach linings), genetic damage (in human blood cells), effects on reproduction (reduced sperm counts in rats; increased frequency of abnormal sperm in rabbits), and carcinogenicity (increased frequency of liver tumors in male rats and thyroid cancer in female rats).
- Recombinant Bovine Growth Hormone (rBGH) is banned in all dairy-producing countries except the U.S., where Monsanto sells it to increase the milk production of dairy cows, despite the links between rBGH, IGF-1 and various cancers (Thom 1994; OCA 2002). Yet we are still importing U.S. milk products.
- Scientists have called for the phaseout of antibiotic resistance genes (BMA 1999), found in many GMOs. Yet, IRRI wants to field-test here Bt, BB and Vit. A rice, all of which still contain such genes. Some have also called for the phaseout of the Cauliflower Mosaic Virus (CaMV) promoter, because it contains a "hot spot" that can cause it to recombine with other viruses (Ho et al. 1999). Yet, these GMO rice and also Monsanto's Bt corn still use the CaMV promoter. Recently, physicians have also called attention to the dangers of another bacterial DNA element commonly used in GMOs, the so-called "CpG motif", which has been shown in animals to stimulate the immune system, leading to inflammations and other problems (Cummins 2001; de Visser et al. 2000).

On the safety issue in general: the food and environmental safety or nonsafety of GM crops remain a matter of scientific debate. No consensus

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exists today in the scientific community. More experiments are needed to settle the issues (Brown 2001).

A thorough refereed review of scientific literature published by Plant Research International recognizes that many controversies surrounding GMO remain to be resolved (email: post@plant.wag-url.nl).

That "key experiments on both the environmental risks and benefits are lacking" was also noted by Wolfenbarger in a published review of scientific literature primarily from academic peer-reviewed journals (Wolfenbarger & Phifer 2000). Wolfenbarger likewise noted conflicting or inconclusive data on non-target effects, bioaccumulation, propensity for outcrossing, invasiveness and other key issues.

The *Scientific American*, PRI, and Wolfenbarger articles clearly show that scientific consensus does not yet exist on the safety or non-safety of GM crops, in the way it already exists, for instance, on the dangers of tobacco or DDT. Some of the early assumptions in favor of safety have already been invalidated by recent research (RCGM 2001).

4. Is the use of GM-crops beneficial to the farmer?

A genetically modified crop is beneficial to the farmer if it is designed to provide a better solution to an existing farming problem. A better solution means that the technology is very effective in solving the problem, easy to use, affordable and more profitable than other technologies.

GM-crops provide better solutions to farmer's problems. The rapid rate of adoption from 1.9 million hectares in 1996 to 44.2 million hectares in 2000 and the increased planting of GM crops indicate that farmers find GM-crops beneficial. US farmers gave the following reasons for planting GM-crops: cost reductions in pest management, yield increases, improved risk management and better assurance against pests, savings in management time, reduction in equipment outlays associated with no-tillage production systems and land use efficiency gains from improved plant spacing (Pimentel and Raven 2000).

Monsanto has sued scores of U.S. and Canadian farmers for the presence in their fields of Monsanto's Roundup Ready™ soya or canola which they did not purchase and therefore had no authority to use. Despite farmers' explanation that their fields were contaminated by neighbors or passing trucks, Monsanto won some of the suits (USDA 1994).

While the scientific debate may be unresolved and the risks unquantified, the market has made itself clear: consumers shun GM food (ISUED 1999). Monsanto's UK employees themselves insisted on GM-free food in their cafeteria (*The Guardian* 1999). Novartis, which sells GM crops, declared in 2000 that its food products worldwide will be GM-free (OCA n.d.). Today, only if GM foods are unlabelled can they find a market among unsuspecting consumers.

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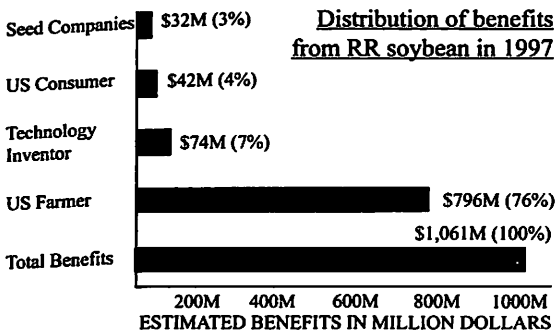

From Falck-Zepada, Traxler and Nelson, 2000, Funded by USDA – Economic Research Service

Filipino farmers who observed the Bt corn trials said they want to plant Bt corn because it avoids corn borer damage, avoids insecticide use, and does not require new skills.

Total benefit accrued from GM-crops by the economy is huge, with the biggest portion accruing to farmers (See figure above). For Roundup Ready™ soybeans, total benefits were calculated at about US$ 1 billion in 1997 (Carpenter & Gianessi 1999; Fulton & Keyowski 1999; Kalaitzandonakes 1999; Klotz-Ingram et al. 1999; Fallck-Zepeda et al. 2000).

Concluding statements

GM crops are of different types depending upon the species and the gene they acquired, some GM crops are used as food, some engineered to produce pharmaceuticals. The gene transferred to each GM crop solves a specific problem such as the farmer's problem of a pest or the need of a poor country to provide cheap and readily available medicine. Each type of GM crop poses different types of risks depending upon the new trait that has been transferred. These risks are also posed by conventionally-bred crops having the same trait. A regulatory system identifies these risks and enforces mitigating measures to avoid or reduce possible damage. Most countries recognize only the risks posed by GM crops but Canada recognizes the risks due to novelty and regulates any new food crop whether developed through genetic engineering or by conventional breeding. All scientific panels organized by different international and national agencies arrived at a single consensus about GM food crops - that these crops are as safe as conventionally bred crops.

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Why then do many U.S. farmers continue to plant GM crops? Because the U.S. government reimburses their market losses through farm subsidies. U.S. lawmakers have enacted more than $24 billion in farm bailouts since late 1998; farm groups requested another $9 billion in 2001. Without subsidies, U.S. farmers would have responded quickly to these market signals or gone bankrupt a long time ago.

If GM corn, rice, potato, mango, banana, or papaya contaminate Filipino farmers' fields, these crops will be harder to sell. Farmers will also incur more expenses in buying corporate-controlled seeds, testing for contamination, and segregating the GM crops. They will eventually be required to label them too. More expenses, but lower prices. Unlike the Americans, however, Filipino farmers cannot expect a similar subsidy from their government.

If our farmers want to be competitive, GM-free is better; organic is best. Organic farming involves lower production costs, is safer to consumers as well as to farmers and their families, and is friendlier to the environment. Demand is also growing faster than the supply. Unfortunately, one of the most serious threats to this promising sector is GMO contamination.

Concluding statements

Are the environmental and food safety risks of GMOs worth taking? It is too early to tell. Rational quantitative risk assessment and comparison cannot be made yet due to insufficient data: risk events are still being identified; the probability and cost of each event are not yet accurately established; probabilities and costs are not fixed, but increase over time as the GMO multiplies; if widespread contamination occurs, the risk can become a permanent problem. A clear indication that risks are inadequately known is that insurance companies today refuse coverage for GMOs (USDA 1999).

What is a rational policy in the face of this scientific uncertainty and unquantified risk? Since living GMOs cannot be recalled once released, we should adopt the precautionary principle (assume that GMOs are not safe unless proven otherwise) instead of substantial

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The latest information about the health and environmental safety of currently commercially grown GM crops are available at www.agbios.com.

REFERENCES

Bailey, D. 2001. Roundup sales boost Monsanto Q2 earnings. Reuters, 25 July 2001. http://www.mindfully.org/Pesticide/Monsanto_Roundup_Sales.

Benbrook, C. 1999. Output trait yield drag. http://www.biotech_info.net/output_trait.html.

Carpenter, JE & LP Gianessi. 1999. Herbicide-tolerant soybeans: Why growers are adopting round-up ready varieties. *AgBioForum* 2(2): 65-72. http:///www.agbioforum.org/vol2no2/carpenter.html.

Carpenter, JE. 2001. Agricultural biotechnology in the U.S.: Economic and environmental impacts. Paper presented at the APEC-JIRCAS Joint Symposium-Workshop on Agricultural Biotechnology, 5-7 September 2001, Bangkok, Thailand.

CMOMP (The Cotton Gin and Oil Mill Press). 2001. Mexican crop yield monitoring system being initiated. http://www.utexas.edu/depts.

Falck-Zepeda, JB, G Traxler & RG Nelson. 2000. Rent creation and distribution from biotechnology innovations: The case of Bt corn and herbicide-tolerant soybeans in 1997. Report. United States Department of Agriculture, USA.

Fulton, M & L Keyowski. 1999. The producer benefits of herbicide-resistant canola. *AgBioForum* 2(2): 85-93. http: //www.agbioforum.missouri.edu (Accessed: 15 July 1999).

Halos, SC. 2001. Current concerns and emerging issues on environmental biosafety. Paper presented at the APEC-JIRCAS Joint Symposium-Workshop on Agricultural Biotechnology, 5-7 September 2001, Bangkok, Thailand.

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equivalence (assume that GMOs are safe unless proven otherwise). No environmental release of live GMOs through field tests or commercialization should be allowed. All food products with GM ingredients should be clearly labelled and their side-effects closely monitored.

While each GMO has to be reviewed on its specific benefits and risks, three general concerns exist: 1) genetic privatization, 2) genetic contamination, and 3) market rejection.

Genetic privatization refers to the claims of exclusive ownership, through patents and plant variety protection by private individuals or firms, over microorganisms, seeds, plants and animals, and even natural gene sequences. All these used to be considered resources for the entire community. Through privatization, our food supply may end up tightly controlled by big foreign firms.

Genetic contamination occurs when a less desirable (GMO) crop or ingredient is inadvertently mixed with a more desirable (GMO-free or organic) crop or ingredient, or when a GMO of questionable safety escapes to the environment. Environmental contamination by live GMOs can be irreversible.

Market rejection is the fate of GM foods and ingredients in countries with mandatory GMO labelling: they fetch a lower price, if they can be sold at all. In the food market, GMOs are considered contaminants. Market surveys in various countries show a consistent result: consumers avoid GMOs.

REFERENCES

BMA (British Medical Association). 1999. The impact of genetic modification on agriculture, food and health. (May 1999).

Brown, K. 2001. Genetically modified foods: Are they safe? *Scientific American* (April).

Cox, C. 1998. Glyphosate factsheet. *Journal of Pesticide Reform* 108(3).

Cummins, J. 2001. The fate of food genes and the DNA CpG motif and its impact. A presentation at the Toxicology Forum, University of Guelph, 3 March 2001.

PRO

Hellmich, RL, BD Siegfried, MK Sears, DE Stanley-Horn, MJ Daniels, HR Mattila, T Spencer, KG Bidne & LC Lewis. 2001. Monarch butterfly sensitivity to *Bacillus thuringiensis* - purified proteins and pollen. http://www.pnas.org/cgi/doi/10.1073/pnas. 211297698.

Kalaitzandonakes, N. 1999. A farm-level perspective on agrobiotechnology: How much value and for whom. *AgBioForum* 2(2): 61-64. http://www.agbioforum.org/vol2no2/editor.html.

Klotz-Ingram, C, S Jans, J Fernandez-Cornejo & W McBride. 1999. Farm-level productiion effects related to the adoption of genetically modified cotton for pest management. *AgBio Forum* 2(2): 73-84. http://www.agbioforum.org/vol2no2/klotz.html.

LCSA (Leopold Center for Sustainable Agriculture). 1998. 1998 Crop survey shows equal returns GMO, non-GMO crops. http://www.leopoldiastate.edu/news.

Losey, JE, LS Rayor & ME Carter. 1999. Transgenic pollen harms Monarch larvae. *Nature* 399: 214.

Oberhauser, KS, MD Prysby, HR Mattila, DE Stanley-Horn, MK Sears, GP Dively, E Olson, JM Pleasants, W-KF Lam & RL Hellmich. 2001. Temporal and spatial overlap of monarch larvae and corn pollen. http://www.pnas.org/cgi/doi/10.1073/pnas. 211329998.

Palm, CJ, DL Schaller, KK Donegan, & RJ Seidler. 1996. Persistence in soil of transgenic plant-produced *Bacillus thuringiensis* var. *kurstaki* delta-endotoxin. *Can. J. Microbiol.* 42: 1258-1262.

Palm, CJ, KK Donegan, D Harris & RJ Seidler. 1994. Quantitation in soil of *Bacillus thuringiensis* var. *kurstaki* delta endotoxin from transgenic plants. *Mol. Ecol.* 3: 145-151.

Palm, CJ, RJ Seidler, KK Donegan & D Harris,. 1993. Transgenic plant pesticides: Fate and persistence in soil. *Plant Physiol. Suppl.* 102: 166.

ANTI

de Visser AJC, EH Hijhuis, JD van Elsas & TA Dueck. 2000. Crops of uncertain nature? Controversies and knowledge gaps concerning genetically modified crops: An inventory. http://www.mindfully.org/GE/Knowledge_Gaps_Greenpeace-Wageningen.htm.

Global Exchange. 2002. Freak of "nature" or institutional breakdown?: Outlining the roles and responsibilities for genetic contamination of corn in Mexico. http://www.globalexchange.org/countries/mexico/biodiversity/gx042502.html.

Greenpeace Germany. n.d. Gene transfer from GE rapeseed to bacteria and fungi in guts of honey bees. http://www/psrast.org/beesgutht.htm.

Hilbeck, A, M Baumbartner, PM Fried & F Bigler. 1998. Effects of transgenic Bt corn-fed prey on mortality and development time of immature *Chrysoperla carnea* (Neuroptera: Chrysopidae). *Environmental Entomology* 27: 480-487.

Ho, MW, A Ryan & J Cummins. 1999. Cauliflower mosaic viral promotor: A recipe for disaster. Microbial ecology in health and disease. December 1999.

ISUED (Iowa State University Economics Department). 1999. Economic Perspectives on GMO Market Segregation. http://www.econ.iastate.edu/research/webpapers.

Losey, JE, LS Rayor & ME Carter. 1999. Transgenic pollen harms monarch larvae. *Nature* 399: 214.

OCA (Organic Consumer Association). n.d. Biotech giant Novartis bans GE ingredients from HS brand-name food products. http://www.organicconsumer.org/ge/novartisnoge.cfm.

OCA (Organic Consumers Association). 2002. Alarming news on rBGH - IGF-I increase cancer risks. http://www.vaccinationnews.com/DailyNews.

RCGM (Royal Commission on Genetic Modification). 2001. Dr. E. Ann Clark Witness Brief. http://www.gmcommission.govt.nz/pronto_pdf/green_party.

PRO

Pimentel, DS & PH Raven. 2000. Bt corn pollen impacts on nontarget *Lepidoptera*: Assesssments of effects in nature. PNAS (USA) 97: 8198-8199.

Pleasants, JM, RL Hellmich, GP Dively, MK Sears, DE Stanley-Horn, HR Mattila, JE Foster, TL Clark & GD Jones. 2001. Corn pollen deposition on milkweeds in and near corn fields. http://www.pnas.org/cgi/doi/10.1073/pnas.211287498.

Sears, MK, RL Hellmich, DE Stanley-Horn, KS Oberhauser, JM Pleasants, HR Mattila, BD Siegfried & GP Dively. 2001. Impact of Bt corn pollen on monarch butterfly populations: A risk assessment," *PNAS (USA)* 98:11937-11942.

Stanley-Horn, DE, GP Dively, RL Hellmich, HR Mattila, MK Sears, R Rose, LCH Jesse, JE Losey, JJ Obrychi & L Lewis. 2001. Assessing the impact of Cryl Ab – expressing corn pollen on monarch butterfly larvae in field studies. http://www.pnas.org/cgi/doi/10.1073/pnas. 211277798.

Tapp, H & G Stotsky. 1997. Persistence of insecticidal toxins from *Bacillus thuringiensis* subsp. *kurstaki* in soil. *Soil Biol. Biochem* 30: 471-476.

Teng, P. 2000. Agricultural biotechnology: What is in it for the developing countries: Perspective from the private sector. Proceedings of the Regional Conference on Biotechnology, 29-30 June 2000, Bangkok, Thailand. http://www.searca.org/~bic.

Wraight, CL. AR Zangeri, MJ Carroll & MR Berenbaum. 2000. Absence of toxicity of *Bacillus thuringiensis* pollen in black swallowtails under field conditions. *PNAS (USA)* 97: 7700-7703.

ANTI

Tabashnik, B. 1997. Insect resistance to Bt revisited. *Nature Biotechnology* 15: 1324.

Tapp, H & G Stotzky. 1998. Persistence of the insecticidal toxin from BT subsp. Kurstaki in soil. *Soil Biology & Biochemistry* 30(4): 471-476.

The Guardian (London). 1999. Firm's own canteen bans GM products—Monsanto. http://www.mindfully.org/GE/Monsanto_Bans_GMOs.htm.

Thom, M. August 1994. rBGH, Monsanto and Corporate Agricultural Information About Intellectual Property Rights. http://www/mindfully.org/GE/Monsanto_rBGH_Corporate_ Agriculture .htm.

Uphoff, N. 1999. Agroecological implications of the system of rice intensification (SRI) in Madagascar. *Environment, Development and Sustainability* 1(3-4): 297-313. Web search: Uphoff on Madagascar SRI.

USDA (United States Department of Agriculture). 1999. *Genetically engineered crops for pest management*. USDA Economic Research Service, Washington, D.C.

USDA (United States Department of Agriculture). 1994. USDA determines soybean line safe for deregulation. http://www.nal.usda.gov/bic/Federal_Biotech/news/1994news.

Wolfenbarger, LL & PR Phifer. 2000. The ecologic risks and benefits of genetically engineered plants. *Science* 290: 2088-2093.